Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion

Continued Prosecution of Fisheries Research Conducted and Funded by the Southwest Fisheries Science Center; Issuance of a Letter of Authorization under the Marine Mammal Protect Act for the Incidental Take of Marine Mammals Pursuant to those Research Activities; and Issuance of a Scientific Research Permit under the Endangered Species Act for Directed Take of ESA-Listed Salmonids.

NMFS Consultation Number: 2015-2455

Action Agencies: National Marine Fisheries Service, Southwest Fisheries Science Center and National Marine Fisheries Service, Office of Protected Resources

Affected Species and NMFS' Determinations:

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species?[1]	Is Action Likely To Jeopardize the Species?	Is Action Likely to Adversely Affect Critical Habitat[1]	Is Action Likely To Destroy or Adversely Modify Critical Habitat?
Marine Mammals					
Blue whale (*Balaenoptera musculus*)[2]	Endangered	No[1]	N.A.	N.A.	N.A.
Fin whale (*Balaenoptera physalus*)[2]	Endangered	No[1]	N.A.	N.A.	N.A.
Humpback whale (*Megaptera novaeangliae*)[2]	Endangered	No[1]	N.A.	N.A.	N.A.
Sei whale (*Balaenoptera borealis*)[2]	Endangered	No[1]	N.A.	N.A.	N.A.
Sperm whale (*Physeter macrocephalus*)[2]	Endangered	No[1]	N.A.	N.A.	N.A.
Killer whale, Southern Resident DPS (*Orcinus orca*)	Endangered	No[1]	N.A.	No	N.A.
Gray whale, western North Pacific population (*Eschrichtius*	Endangered	No[1]	N.A.	N.A.	N.A.

robustus)[2]					
North Pacific right whale (*Eubalaena japonica*)[2]	Endangered	No[1]	N.A.	N.A.	N.A.
Guadalupe fur seal (*Arctocephalus townsendi*)[2]	Threatened	No[1]	N.A.	N.A.	N.A.
Steller sea lion (*Eumetopias jubatus*)[3]	Threatened	N.A.	N.A.	No	N.A.
Vaquita (*Phocoena sinus*)[2]	Endangered	No[1]	N.A.	N.A.	N.A.
Southern right whale (*Eubalaena australis*)[2]	Endangered	No[1]	N.A.	N.A.	N.A.
Sea Turtles					
Leatherback turtle (*Dermochelys coriacea*)	Endangered	Yes	No	No	N.A.
Loggerhead turtle, North Pacific Ocean DPS (*Caretta caretta*)[2]	Endangered	Yes	No	N.A.	N.A.
Olive ridley (*Lepidochelys olivacea*)[2]	Endangered /Threatened	Yes	No	N.A.	N.A.
Green turtle (*Chelonia mydas*)[4]	Endangered /Threatened	Yes	No	N.A.	N.A.
Hawksbill turtle (*Eretmochelys imbricate*)	Endangered	No[1]	N.A.	N.A.	N.A.
Marine Fish					
Green sturgeon, Southern DPS (*Acipenser medirostris*)	Threatened	No[1]	N.A.	No	N.A.
Pacific eulachon, Southern DPS (*Thaleichthys pacificus*)	Threatened	Yes	No	No	N.A.
Canary Rockfish, Puget Sound/Georgia Basin DPS *(Sebastes pinniger)*	Threatened	No[1]	N.A.	N.A.	N.A.
Scalloped	Endangered	Yes	No	N.A.	N.A.

hammerhead shark, Eastern Pacific DPS (*Sphyrna lewini*)[2]					
Totoaba (*Totoaba macdonaldi*)[2]	Endangered	No[1]	N.A.	N.A.	N.A.
Marine Invertebrates					
White abalone (*Haliotis sorenseni*)[2]	Endangered	No[1]	N.A.	N.A.	N.A.
Black abalone (*Haliotis cracherodii*)	Endangered	No[1]	N.A.	No	N.A.
Coral spp.[5]	Endangered /Threatened	No[1]	N.A.	N.A.	N.A.
Salmonids					
Sacramento River winter-run Chinook (*Oncorhynchus tshawytscha*)	Endangered	Yes	No	No	N.A.
Central Valley spring-run Chinook	Threatened	Yes	No	No	N.A.
California Coastal Chinook	Threatened	Yes	No	No	N.A.
Snake River fall Chinook	Threatened	Yes	No	No	N.A.
Snake River spring/summer Chinook	Threatened	Yes	No	No	N.A.
Lower Columbia River Chinook	Threatened	Yes	No	No	N.A.
Upper Willamette River Chinook	Threatened	Yes	No	No	N.A.
Upper Columbia River spring Chinook	Endangered	Yes	No	No	N.A.
Puget Sound Chinook	Threatened	Yes	No	No	N.A.
Hood Canal summer run chum (*Oncorhynchus keta*)	Threatened	Yes	No	No	N.A.
Columbia River chum	Threatened	Yes	No	No	N.A.
Central California Coast coho (*Oncorhynchus kistuch*)	Endangered	Yes	No	No	N.A.

S. Oregon/N. California Coast coho	Threatened	Yes	No	No	N.A.
Oregon Coast coho	Threatened	Yes	No	No	N.A.
Lower Columbia River coho	Threatened	Yes	No	No	N.A.
Snake River sockeye (*Oncorhynchus nerka*)	Endangered	Yes	No	No	N.A.
Lake Ozette sockeye	Threatened	Yes	No	No	N.A.
Southern California steelhead (*Oncorhynchus mykiss*)	Endangered	Yes	No	No	N.A.
South-Central California Coast steelhead	Threatened	Yes	No	No	N.A.
Central California Coast steelhead	Threatened	Yes	No	No	N.A.
California Central Valley steelhead	Threatened	Yes	No	No	N.A.
Northern California steelhead	Threatened	Yes	No	No	N.A.
Upper Columbia River steelhead	Endangered	Yes	No	No	N.A.
Snake River Basin steelhead	Threatened	Yes	No	No	N.A.
Lower Columbia River steelhead	Threatened	Yes	No	No	N.A.
Upper Willamette River steelhead	Threatened	Yes	No	No	N.A.
Middle Columbia River steelhead	Threatened	Yes	No	No	N.A.
Puget Sound steelhead	Threatened	Yes	No	N.A.	N.A.

[1] Please refer to section 2.2.1 for the analysis of species or critical habitat that are not likely to be adversely affected.

[2] Critical habitat has not been designated for these species.

[3] The Eastern DPS of Steller sea lions were delisted on November 4, 2013 (78 FR 66140); however, critical habitat for Steller sea lions remains designated.

[4] On March 23, 2015, NMFS proposed to revise the listing of green sea turtles worldwide to 11 DPSs, including listing the East Pacific DPS as threatened (80 FR 15271)

[5] 15 species of Indo-Pacific corals were listed as threatened in 2014 (79 FR 53852)

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

Issued By:

FOR William W. Stelle, Jr.
Regional Administrator

Date: August 31, 2015

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1. INTRODUCTION

1.1 Background

In April 2013, the Southwest Fisheries Science Center (SWFSC) completed a draft Programmatic Environmental Assessment (DEA) on the full program of all fisheries research conducted and funded by the SWFSC. In addition to fulfillment of obligations for all Federal agencies to comply with the National Environmental Policy Act (NEPA) when carrying out the business of the Federal government, the purpose of the DEA was to provide necessary documentation regarding a request and application for rulemaking and a Letter of Authorization (LOA) from NMFS under section 101(a)(5)(A) of the Marine Mammal Protection Act (MMPA) for the incidental take[1] of marine mammals during their research activities. In March, 2015, the SWFSC also submitted an application for a research permit under section 10(a)(1)(A) of the ESA for directed take[2] of ESA-listed salmon during some of these same research activities.

As described in the DEA, the SWFSC proposes to continue their research programs, in conjunction with the mitigation and monitoring measures for marine mammal takes as described in the LOA rulemaking. This biological opinion (opinion), developed through consultation with the Protected Resources Division (PRD) of NMFS West Coast Region (WCR), will: (1) analyze the incidental impact of SWFSC research programs on all ESA-listed species and designated critical habitats that may be affected by SWFSC research across the full range of activities and locations those where they occur; (2) consider the effects of issuance of an MMPA LOA by the NMFS Office of Protected Resources' (OPR) to the SWFSC for incidental take of marine mammals as defined by the MMPA during their research activities on ESA-listed species and designated critical habitats; and (3) consider the impact of proposed directed research on ESA-listed salmon during activities that are also authorized under the proposed MMPA LOA issuance, and part of the research program described in the DEA. These actions are all related to full environmental regulation compliance by the SWFSC while conducting research, with

[1] [1] "Take" is defined under the MMPA as "harass, hunt, capture, or kill, or attempt to harass, hunt capture or kill."
[2] "Take" is defined under the ESA "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct."

overlapping scope and timelines for completion, such that it is appropriate to include all these actions together in this one opinion.

NMFS prepared the opinion and incidental take statement (ITS) portions of this document in accordance with section 7(b) of the 1973 ESA (16 USC 1531 et seq.), and implementing regulations at 50 CFR 402.

On April 24, 2013, an essential fish habitat (EFH) consultation was concluded on SWFSC research activities included in this 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. The EFH consultation concluded that impacts to Pacific coast groundfish, coastal pelagic species, Pacific coast salmon, and highly migratory species EFHs were no more than minimal and temporary. No new information has been provided that changes the analysis conducted during that EFH consultation and no additional EFH analysis will be provided in this Opinion.

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 (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). The document will be available through NMFS' Public Consultation Tracking System [https://pcts.nmfs.noaa.gov/pcts-web/homepage.pcts]. A complete record of this consultation is on file at the NMFS WCR's Long Beach Office.

1.2 Consultation History

In spring 2008 the NMFS Science Board asked the Office of Science and Technology to establish a working group to develop and implement a process to document how much incidental take of protected species was occurring by NMFS-supported survey activities. Although mechanisms exist in both the MMPA and ESA to assess the effect of incidental takings and to authorize appropriate levels of take, NMFS Science Centers' use of these mechanisms had been inconsistent up to this point. The first phase of this national process to achieve full environmental compliance on NMFS's research activities included a data call to the Science Centers requesting information on takes of protected species during the past five years. The analysis of this information was intended to serve as the basis for issuing the appropriate authorizations to the Science Centers by OPR. Additionally, each Science Center was required to work with their Regional Offices' NEPA Coordinators to develop the required NEPA documentation and other consultations under the MMPA and ESA to support their applications for an LOA in the course of pursuing their fisheries research. Given the complexity of this task, especially from the national perspective, and to encourage consistency of NEPA documents across regions, the National Regional NEPA Coordinators were tasked to work closely with their Science Center staff to develop the required documentation for the authorization process.

In June, 2010, NMFS initiated the development of NEPA documents for individual Science Centers. Shortly thereafter, the SWFSC began to work through the process of gathering the necessary information and generating the DEA to support their environmental compliance effort. Over the course of the next 3 years, a process of draft, review, discussion, coordination, and revision of documents and analytical methodologies ensued, involving various staff and managers from offices all across NMFS. Given that the SWFSC was the first Science Center to progress towards a completed DEA and application for an LOA, many issues that were understood or assumed to have some impact on how the overall national effort from NMFS would progress had to be resolved. Notably amongst those was the overall framework for development and presentation of the DEA, the rationale used to estimate future incidental takes of marine mammals during research activities, and analytical approaches used to calculate potential harassment of marine mammals from acoustic sources.

Since the early stages of this effort, NMFS has been aware of the need to consult under section 7 of the ESA on the entire research program of the SWFSC, as well as the issuance of any authorizations under the MMPA to the SWFSC. The WCR PRD was given the responsibility for handling the ESA section 7 consultation for both actions. As the process of developing the DEA and LOA application unfolded, numerous informal calls, emails, and exchanges of information between staff from the SWFSC, OPR, and WCR occurred. The WCR PRD was able to provide input into the development of the DEA to support initiation of formal consultation when these actions, and the MMPA process in particular, were fully developed.

The notice of receipt of an LOA application and DEA for the SWFSC research programs was published in the Federal Register on May 2, 2013 (78 FR 25702). The SWFSC received comments only from the Marine Mammal Commission on the LOA application, and received no substantive comments on the DEA. On March 7, 2014, the SWFSC sent a letter to the WCR PRD requesting that PRD staff: (1) review the DEA; (2) provide technical assistance before initiating formal consultation under section 7(a)(2) of the ESA; and (3) help prepare a finalized programmatic Environmental Assessment as required in 50 CFR 402.14. During the summer of 2014, numerous exchanges between the SWFSC and WCR PRD staff occurred to clarify and exchange information regarding the potential impacts of research on ESA-listed species. On October 10, 2014, the WCR PRD sent a letter to the SWFSC indicating that WCR staff had reviewed the DEA and other information and concluded that sufficient information was available to proceed with initiation under section 7 consultation. On November 13, 2014, the WCR received a formal ESA consultation initiation request from the SWFSC. On December 9, 2014, the WCR notified the SWFSC that the request had been reviewed and accepted as complete, and that consultation had been initiated. A proposed rulemaking on the LOA was published by the OPR on February 13, 2015 (80 FR 8166). On March 23, 2015, WCR received an ESA consultation initiation request from the OPR regarding the proposed issuance of the LOA, as published on February 13, 2015. In the ESA consultation initiation request, the OPR indicated that the LOA was expected to be finalized in the summer of 2015, and would be effective for a period of five years from the date of issuance. On March 26, 2015, the WCR notified the OPR that the request had been reviewed and accepted as complete, and that consultation had been initiated.

In December, 2014, the SWFSC submitted a draft ESA section 10 research permit application for directed capture of ESA-listed salmonids in pelagic survey trawls off the U.S. west coast to the WCR PRD Permits Office in Portland, Oregon. The permit application was subsequently reviewed for completeness and comments exchanged between the WCR PRD and the SWFSC staff during the early months of 2015. On April 8, 2015, NMFS published a notice of receipt for proposed ESA section 10 permit #19320 (80 FR 18820), effectively initiating consultation under the ESA on that date. Any incidental take associated with that research activity has been included in the proposed action of SWFSC research activities already considered in this opinion, as well as an activity being covered under the proposed MMPA LOA. Given: (a) the relationship and overlap between all the activities being analyzed and exempted or permitted through the ESA and MMPA LOA processes essentially simultaneously; (b) the ESA consultation on SWFSC's incidental impacts on ESA species which includes analysis of ESA-listed salmon take as incidental in some SWFSC research activities, (c) the authorization of the take of the same ESA-listed salmonids as directed in other SWFSC research activities; and (d) that all of these SWFSC activities are being included under the proposed LOA, WCR staff began discussion about combining these related actions all together in one opinion in February, 2015, as a matter of efficiency, simplicity, and to ensure that all potential impacts to ESA-listed are both complete and also not duplicative. As a result, this opinion is constructed to consider the impacts of all these actions together.

1.3 Proposed 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).

The proposed action for this opinion contains three distinct but related activities:

- The SWFSC proposes to administer and conduct the survey programs described below in section 1.3.1 during the next 5 year period.
- The NMFS OPR proposes to issue an LOA under the MMPA to the SWFSC covering these research activities for a 5 year period (section 1.3.2).
- The NMFS WCR proposes to issue a section 10 permit for the directed take of ESA-listed salmon during a juvenile salmon survey to the SWFSC for a 5 year period (section 1.3.3).

- The extent of the research activities conducted by the SWFSC or its research partners that are covered in this opinion include those that:
- Contribute to fishery management and ecosystem management responsibilities of NMFS under U.S. law and international agreements.
- Take place in marine waters in the California Current Ecosystem (CCE), the Eastern Tropical Pacific (ETP), and the Scotia Sea in the Southern Ocean off Antarctica[3].
- Involve the transiting of these waters in research vessels, observational surveys made from the deck of those vessels (e.g., marine mammal and seabird transects), the deployment of fishing gear and scientific instruments into the water in order to sample and monitor living marine resources and their environmental conditions, and/or use active acoustic devices for navigation and remote sensing purposes.
- Have the potential to interact adversely with marine mammals and protected species of fish, sea turtles, seabirds, and invertebrates.

In all surveys considered in this opinion but one, the adverse interaction noted in the last bullet above would be in the form of incidental take - both under the MMPA and the ESA. The exception is the juvenile salmon survey. Taking ESA-listed salmon in the survey would be direct, intentional take and authorized under section 10 of the ESA. For all other interactions, the take would be incidental (like any of the other surveys) and the survey would be covered by any MMPA authorization that OPR issues, or would appear in the incidental take statement accompanying this opinion. To treat this one survey differently from the others simply because of purpose (looking at listed fish) would be unnecessarily duplicative: it uses the same methods, in the same areas, and at the same times as many of the other surveys discussed here, so separating it would complicate the analysis to an unwarranted degree.

This opinion does NOT cover:

- Directed research on protected species that involves intentional pursuit or capture of marine mammals, fish (other than juvenile salmon in the CCE), sea turtles, seabirds, and invertebrates for tagging, tissue sampling, or other intentional takes under the MMPA or ESA which require directed scientific research permits. Directed research on ESA-listed species is covered by other environmental review processes and consultations under applicable ESA regulations. The one exception is directed take of salmon in the juvenile salmon survey.
- In addition to the research described in the DEA and covered under this opinion, scientists from the SWFSC regularly collaborate with scientists in other NMFS regions.

[3] The California Current Ecosystem specified geographical region extends outside of the U.S. Exclusive Economic Zone (EEZ), from the Mexican EEZ (not including Mexican territorial waters) north into the Canadian EEZ (not including Canadian territorial waters). The Eastern Tropical Pacific specified geographical region extends into the EEZs of the various ETP nations (not including the territorial waters of ETP nations).

The potential effects of research conducted with the help of the SWFSC scientists in these other NMFS Regions will be covered in separate analyses for those regions.

- Other activities of the SWFSC that do not involve the deployment of vessels or gear in marine waters, such as evaluations of socioeconomic impacts related to fisheries management decisions, taxonomic research in laboratories, fisheries enhancements such as hatchery programs, and educational outreach programs.

In the future, additional research activities may propose to use methods that were not considered in the evaluation of impacts in the DEA and this opinion. Some of these proposed projects may require further environmental impact assessment or satisfaction of other consultation, approval, or permitting requirements before being allowed to proceed. As the details of any such research activities are presently unavailable, they cannot be assessed here. After new projects are sufficiently well defined and their potential environmental consequences are understood, specific impacts will be evaluated as necessary.

The SWFSC conducts research and provides scientific advice to manage fisheries and conserve protected species along the U.S. west coast, throughout the eastern tropical Pacific Ocean, and in the Southern Ocean off Antarctica (Figure 1). Within the area covered by SWFSC research programs, NMFS manages finfish and shellfish harvest under the provisions of several major statutes, including the Magnuson-Stevens Fishery Conservation and Management Act (MSA), the Tuna Conventions Act, the ESA, the MMPA, the International Dolphin Conservation Program Act, and the Antarctic Marine Living Resources Convention Act. Accomplishing the requirements of these statutes requires the close interaction of numerous entities in a sometimes complex fishery management process. The entities involved include: the SWFSC; NMFS WCR; NMFS OPR, Sustainable Fisheries, and Science and Technology; the Pacific Fisheries Management Council (PFMC) and the Western Pacific Regional Fisheries Management Council (WPFMC); the Western and Central Pacific Fisheries Commission; and five International Fisheries Management Organizations.

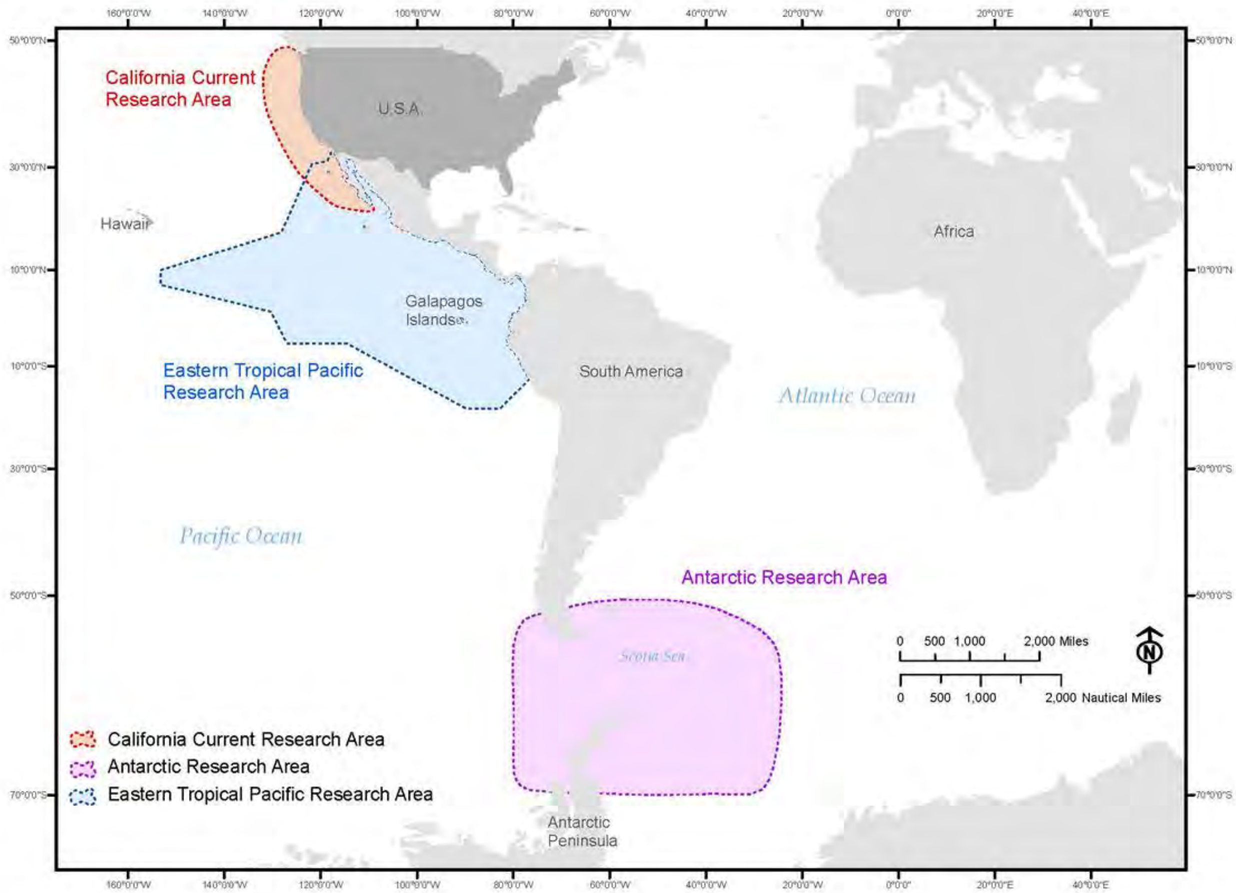

Figure 1. SWFSC research areas.

Role of Fisheries Research in Federal and Regional Fisheries Management

The SWFSC provides scientific information and advice to assist with the development of fishery management plans (FMPs) prepared by the PFMC, WPFMC, and a variety of Federal and non-Federal entities. The councils, which include fishing industry representatives, fishers, scientists, government agency representatives, Federal appointees, and others, are designed to provide all resource users and managers a voice in the fisheries management process. Under the MSA, the Councils are charged with developing FMPs and management measures for the fisheries occurring within the EEZ adjacent to their constituent states. Data collected by Fisheries Science Centers are often used to inform FMPs, as well as to inform other policies and decisions promulgated by the Councils. Such policies and decisions sometimes affect areas that span the jurisdictions of several Councils, and make use of data provided by multiple Fisheries Science Centers.

In addition to providing information to domestic fisheries management councils, the SWFSC provides scientific advice to support numerous international fisheries councils, commissions, and conventions including the Western and Central Pacific Fisheries Commission, International Scientific Committee for Tuna and Tuna-like Species (ISC), Inter-American Tropical Tuna Commission (IATTC) and the Convention for the Conservation of Antarctic Marine Living Resources. Research conducted by the SWFSC has also been critical in the development and successful implementation of ecosystem-based management in Antarctica in order to fulfill the objectives of the Antarctic Treaty.

SWFSC Research Divisions

The SWFSC is the research arm of NMFS in the southern part of the West Coast Region. The SWFSC plans, develops, and manages a multidisciplinary program of basic and applied research to inform management of the region's marine and anadromous fish and invertebrate populations to ensure they remain at sustainable and healthy levels. Responsibilities include maintaining healthy fish stocks for commercial and recreational fishing; sustaining ecosystem services; and coordinating with domestic and international organizations to implement fishery agreements and treaties. SWFSC research efforts are divided among five research divisions that are tasked with different roles in collecting scientific information on living marine resources and the ecosystems that sustain them. The SWFSC headquarters is located in La Jolla, California. The Fisheries Ecology Division is based in Santa Cruz, California, adjacent to University of California Santa Cruz's Long Marine Laboratory, and the Environmental Research Division is based in Santa Cruz and Monterey, California. The SWFSC operates two field stations in California located in Arcata and Granite Canyon. On the Antarctic Peninsula, the SWFSC's Antarctic Ecosystem Research Division maintains two field stations located at Cape Shirreff on Livingston Island and at Copacabana in Admiralty Bay on King George Island.

1. Fisheries Resources Division

The SWFSC Fisheries Resources Division (FRD) develops the scientific foundation for the conservation and management of marine resources in the CCE and ETP. The division conducts seagoing surveys, genetic and morphometric research to define stock structure, life history studies to estimate production of eggs and larvae and adult vital rates, engineering work to develop advanced survey technologies, oceanographic studies to define critical habitat and population response to climate change, quantitative population assessments, and economic studies to define the value of fisheries and alternative management options. The division responds to the information needs of the PFMC's Coastal Pelagic Species FMP, Highly Migratory Species FMP, and Groundfish FMP. FRD scientists also participate on international working groups and provide scientific advice to the ISC, IATTC, and WCPFC.

2. Fisheries Ecology Division

The Fisheries Ecology Division (FED) conducts research on the ecology of groundfish, economic analysis of fishery data, Pacific salmon studies (including 10 endangered salmon and steelhead runs), and coastal habitat issues affecting the San Francisco Bay and the Gulf of Farallones. Results from FED research are used by the PFMC to manage fisheries, and by NMFS to manage threatened and endangered species. FED scientists study causes of variability in abundance and health of fish populations, analyze ecological relationships in marine communities, and study the economics of exploiting and protecting natural resources. They also assess the stocks of species targeted by various fisheries, and assist in evaluating potential impacts of human activities on threatened or endangered species.

3. Antarctic Ecosystem Research Division
The Antarctic Ecosystem Research Division (AERD) manages the U.S. Antarctic Marine Living Resources Program (AMLR), which provides information for U.S. policy on the management and conservation of Antarctic living resources and supports U.S. participation in international efforts to protect the Antarctic and its marine life. Research is directed toward gathering ecological and biological information to quantify the functional relationships between finfish and krill, their environment and their predators; to develop an ecosystem approach to ensure sustained harvesting of krill, fish and crabs; and to protect predator populations of seals, penguins, and pelagic seabirds resident in the Southern Ocean surrounding Antarctica.

4. Marine Mammal and Turtle Division
The Marine Mammal and Turtle Division (MMTD) promotes and conducts research that contributes to the conservation and management of U.S. and international populations of marine mammals and their designated critical habitats. Provisions of the MMPA and the ESA guide the division's activities, which include monitoring the abundance of pinniped and cetacean stocks and sea turtles, assessing and helping to minimize the effect of fishing operations and other human activities on these populations, determining stock structure and population dynamics, and conducting research on "dolphin-safe" tuna fishing methods. Research efforts span the entire migratory range of marine mammal and turtle populations. MMTD monitors the life history, condition and health of populations, performs regular abundance estimates, advances studies of marine mammal acoustics, and strives to interpret these results in an ecosystem context. Ecosystem data are collected to characterize habitat and its variation over time in context with the distribution and abundance of prey fishes and squids, seabirds, and marine turtles.

5. Environmental Research Division
The Environmental Research Division (ERD) conducts a flexible research program to assess, understand, and predict climate and environmental variability and its impacts on marine fish populations and ecosystems. ERD provides science-based, globally integrated, fisheries-relevant environmental data, products, and information to meet the research and management needs of the SWFSC, NMFS, and the National Oceanic and Atmospheric Administration (NOAA).

1.3.1 SWFSC Fisheries Research Activities

Following is a summary of fisheries and ecosystem research activities conducted by the SWFSC that are part of this proposed action (See Appendix 1; Tables 2.2-1 and 2.3-1 *in* DEA for summary tables). The SWFSC is requesting rulemaking and subsequent Letters of Authorization under the MMPA for all of these proposed activities that have the potential to take marine mammals incidentally to research activities, and has applied authorization the ESA for directed take of salmon in a juvenile salmon trawl survey. The descriptions below include the location, time of year the surveys occur and gear used. Additional information and detail for each survey and the associated mitigation measures for protected species are in section 1.3.4 in this opinion and Appendix A *in* the DEA.

A component of the SWFSC fisheries research is conducted cooperatively with commercial fisheries to address questions of mutual interest, often utilizing commercial vessels as research platforms. Because the SWFSC staff is present for all components of its fisheries research activities, the SWFSC does not distinguish in this application between cooperative research activities and those that are not considered cooperative. For clarity the following surveys are conducted cooperatively with commercial fisheries: Remotely operated vehicle (ROV) habitat surveys for rockfish and white abalone, adult rockfish, thresher shark longline survey, highly migratory species (HMS) longline survey, sablefish life history survey and deep-set buoy gear for swordfish tagging.

1.3.1.1 Surveys conducted in the California Current Ecosystem (CCE)

Coastal Pelagic Species Surveys (i.e., sardine surveys). This survey is conducted annually in the spring (April-May) or the summer (June-July) and extends from San Diego, CA, to Cape Flattery, WA, as well as occasionally into waters offshore Canada and Mexico; it is broken into southern and northern portions on two survey vessels. The southern portion is done in conjunction with the spring or summer California Cooperative Oceanic Fisheries Investigations (CalCOFI) survey. Possible marine mammal takes during these conjoined CalCOFI/sardine surveys occur during trawl operations for the sardine component of the survey. Results of the sardine survey inform the annual assessment of sardine and the corresponding harvest guidelines. Research is conducted using either two NOAA ships or a NOAA ship and a charter vessel. The survey requires about 70 survey days per year.

The protocol for the sardine survey includes deploying a NETS Nordic 264 two-warp rope trawl for 30 minute tows in the upper 10 m of the water column at 3 knots at night in order to sample adult sardines (*Sardinops sagax*). Estimates of daily fecundity are derived from the samples and combined with estimates of daily egg production to produce an estimate of spawning stock biomass. Additional protocols for this survey are similar to the CalCOFI surveys described below.

Juvenile Salmon Survey. This survey is conducted annually in June and/or July, and occasionally requires a second cruise in September. The study range extends from central California to southern Oregon and complements similar surveys conducted by the Northwest Fisheries Science Center (NWFSC). This survey measures ocean survival of juvenile salmon (Coho; *Oncorhynchus kisutch* and Chinook; *Oncorhynchus tshawytscha*) and produces early estimates of adult salmon returns. The juvenile salmon survey is usually conducted on a charter vessel and requires 20 to 40 survey days.

The protocols for this survey include deployment of a two-warp NETS Nordic 264 rope trawl for 30-minute tows at 15-30 m depth during daylight hours. It should be noted that the deployment protocol for this trawl is different than the sardine surveys, in that these tows are conducted during the day and deeper in the water column. An alternative method of juvenile salmon capture is the occasional use of a beach seine along the coast between San Francisco and the CA/OR border. This method extends the survey into very shallow habitat inaccessible by boat or trawl, into areas where early juvenile Chinook salmon are known to reside in some parts of their range. Beach seining, if it occurs, is a minor and ancillary method of capture and does not require authorization of any additional directed take beyond what is included for the surface trawl component of the project. Depending on vessel capabilities, additional operations may include multi-frequency single-beam active acoustics for measuring biological and environmental conditions, conductivity, temperature, and depth (CTD) profiles, Bongo plankton tows, and single-warp Tucker mid-water trawls (Appendix 1).

Juvenile Rockfish Survey. This survey is conducted annually from May to mid-June and extends from southern CA to WA; it targets the pelagic phase of juvenile rockfish. Results of this survey inform assessments of several rockfish populations. It is either conducted on a NOAA ship or a charter vessel and requires about 45 survey days.

The protocols for this survey include using a Modified-Cobb mid-water trawl deployed for 15-minute tows at 2 knots during the dark hours at 15-30 m depth. Protocols also include underway multi-frequency single-beam active acoustics, two-warp midwater trawls, various plankton tows, and CTD profiles at fixed stations (Appendix 1).

CalCOFI Survey - Winter. This survey is conducted annually during January and February and extends from San Diego to San Francisco; it captures early spawning hake and some rockfish. It is usually conducted on a NOAA ship and requires about 25 survey days. In total, all four seasonal CalCOFI surveys require about 90 days total.

The survey describes the physical and biological characteristics of the southern portion of the CCE epipelagic habitat. Surveys include the use of multi-frequency single-beam active acoustics (Appendix 1). These surveys also include a Continuous Underwater Fish Egg Sampler (CUFES), various plankton nets (Bongo, Pairovet, Manta, and PRPOOS), CTD with an array of vertically profiling instruments and bottles to collect water samples at discrete depths, marine mammal and seabird observations, meteorological observations using a wide-range of passive sensors, trawls for sampling mesopelagic organisms at selected stations. See Appendix A *in* the DEA and the CalCOFI website http://www.calcofi.org/ for additional information.

CalCOFI Survey - Spring. This survey is conducted annually in April. It also extends from San Diego to San Francisco and captures spring spawning of small pelagic fish (e.g., anchovy, sardine, jack mackerel, and several hundred others). In general, the SWFSC uses a NOAA ship to conduct the survey. The purpose of the survey and the protocol are the same as for the Winter CalCOFI Survey above. See Appendix A *in* the DEA and the CalCOFI website http://www.calcofi.org/ for additional information.

CalCOFI Survey - Summer. This survey is conducted annually in July in the Southern California Bight solely on a Scripps Institution of Oceanography (SIO) University-National Oceanographic Laboratory System vessel. The survey describes the physical and biological characteristics of the southern portion of the CCE epipelagic habitat. Protocols are the same as for the winter and spring CalCOFI surveys. See Appendix A *in* the DEA and the CalCOFI website http://www.calcofi.org/ for additional information.

CalCOFI Survey - Fall. This survey is conducted annually in October in the Southern California Bight usually on a SIO vessel. The survey describes the physical and biological characteristics of the southern portion of the California Current epipelagic habitat. Protocols are the same as other CalCOFI surveys. See Appendix A *in* the DEA and the CalCOFI website http://www.calcofi.org/ for additional information.

PaCOOS Central CA (MBARI). This survey is conducted annually in July and October. It incorporates the plankton and oceanographic surveys of CalCOFI survey line 66, extending offshore from the Monterey Bay Aquarium Research Institute (MBARI), and line 60, extending offshore from San Francisco Bay. It is usually conducted on Moss Landing Marine Laboratories Research Vessel (R/V) *Point Sur* and lasts about 6 survey days.

Protocols include the use of various plankton nets (Bongo, California Vertical Egg Tow (CalVET), Manta, Pairvet), CTD with an array of vertically profiling instruments and bottles to collect water samples at discrete depths, marine mammal and bird observations, and meteorological observations using a wide-range of passive sensors.

PaCOOS North CA Humboldt State University (HSU). This is monthly plankton and oceanographic surveys of a single line of stations off HSU in northern CA. It is usually conducted on HSU R/V *Coral Sea* and takes about 12 survey days. Protocols include the use of various plankton nets (Bongo, CalVET, Manta), CTD with an array of vertically profiling instruments and water samples at discrete depths, marine mammal and seabird observations, and meteorological observations using a wide-range of passive sensors.

Highly Migratory Species (HMS) Survey. This survey is conducted annually from June - July and extends from southern to central CA; it targets blue sharks, shortfin mako sharks, and swordfish and other highly migratory species. Historically it has been conducted on a NOAA ship but in recent years it has been conducted on a charter vessel and requires about 30 survey days.

Protocols include deployment of both shallow-set and deep-set pelagic longline at fixed stations with 2-4 hour soak times. Length of the mainline is 2-4 miles with 200-400 hooks spaced 50-100 feet apart, 12 foot long float lines, 18 foot long gangions, and 9/0 J-type hooks using a shallow-set configuration targeting sharks. When targeting swordfish using a deep-set configuration, the mainline may be up to 12 miles in length with 120 foot long float lines, 36 foot long gangions, and 16/0 circle-type hooks, with soak times may last up to 8 hours. The typical bait used is whole mackerel or market squid. Depending on vessel capabilities, additional protocols may include multi-frequency active acoustics, CTD profiles, and Bongo plankton tows (Appendix 1).

Thresher Shark Survey. This survey is conducted annually in September. It targets thresher shark pupping areas in coastal waters from the Southern California Bight up to Central California and is usually conducted on charter vessel requiring about 20 survey days. The protocols for this survey include deployment of an anchored longline at fixed stations with 2-4 hour soak times. Length of the mainline is 2-4 miles with 200-400 hooks spaced 50-100 feet apart, 12 foot long float lines, 12 foot long gangions, and 16/0 circle-type hooks. The typical bait used is whole mackerel or market squid. Depending on vessel capabilities, additional protocols may include the use of multi-frequency active acoustics, CTD profiling systems, and Bongo plankton tows.

Survey to Research Reproductive Life History Analysis of Sablefish. This survey to research reproductive life history analysis of sablefish is conducted monthly each year near Bodega Bay off the Central California coast. The primary objective of the survey is to collect adult sablefish for reproductive studies using small scale bottom longline gear. The gear is essentially a small scale longline with 75 hooks per line that are baited with squid and set at or near the bottom, usually at depths between 360 and 450m. Two to three sets are made per trip over the course of 30 days per year.

Swordfish Tagging Deep-Set Buoy Survey. The Swordfish tagging deep-set buoy survey is conducted annually June-November in the Southern California Bight region of the CCE. The survey's main objective is to investigate the use of this gear to capture swordfish while minimizing bycatch of non-target species. Approximately 300-600 sets are made annually.

The gear includes a buoy flotation system (i.e., a strike-indicator float/flag, a large, non-compressible buoy and a float affixed with a radar reflector). A set of "gear" consists of 250-400 m 500 pound (lb) mainline monofilament rigged with a 1-2 kilogram (kg) drop sinker to orient the mainline and terminal fishing gear vertically in the water column. Unlike longline gear which typically uses a long monofilament mainline suspended horizontally near the surface of the water, deep-set buoy gear does not involve the use of a horizontal mainline. Two monofilament gangions branch from the vertically oriented mainline at 250-400 m and are constructed of 400 lb monofilament leader containing a crimped 14/0 circle hook baited with either squid or mackerel.

The buoys are deployed in a restricted spatial grid such that all of the indicator buoys can be continuously monitored from the vessel (within a maximum 4 nm grid area). When an indicator flag rises, the buoy set is immediately tended and the animal caught is either released or tagged and released in order to increase post-hooking survivorship of all target and non-target animals.

Marine Mammal Ecosystem Surveys. This survey is conducted occasionally during August to December. These are large-scale surveys requiring substantial blocks of continuous time on two NOAA ships and about 60-120 survey days. Results inform status assessments of marine mammal populations. Surveys rotate among geographic areas, and include the ORCAWALE survey conducted in the west coast EEZ.

Protocols include line transect surveys of marine mammals and seabirds. For marine mammals, observations are made of schools or aggregations of animals. For a subset of observations, survey effort is suspended and aggregations are approached for estimation of aggregation size and species composition. Directed research permits are obtained for marine mammal and seabird surveys as required; currently this work is authorized under MMPA/ESA permit 14097. Additional protocols include the use of multi-frequency active acoustics, 2.5 m^2 single-warp Isaacs Kidd Midwater Trawl (IKMT) with 1 mm mesh net for sampling macro-zooplankton, 3 m^2 dip net with 2 mm mesh net for sampling flying fish, CTD with an array of vertically profiling instruments and bottles to collect water samples at discrete depths, and meteorological observations using a wide-range of passive sensors (Appendix 1).

White Abalone Survey. This survey utilizes still and video camera observations using ROVs to monitor population recovery of endangered white abalone. It is usually conducted on a charter vessel for about 25 survey days. The surveys are confined to offshore banks and island margins, 30-150 m depth, in the Southern California Bight. Since 2002, over 1,000 ROV transects have been conducted along the entire U.S. west coast. The average and maximum speed of the ROV was 0.49 and 2.43 knots, respectively. The tether that connects the ROV to the ship is 0.75 inches in diameter, and is securely attached to a stainless steel cable and down-weight to minimize slack in the tether and to prevent any loops.

Collaborative Optical Acoustical Survey Technology (COAST) Survey. These are multi-frequency acoustic and ROV optical surveys of offshore banks conducted in collaboration with charter boat fishing industry to monitor the recovery of rockfish. The COAST surveys are usually conducted on a NOAA ship augmented by a charter vessel and require about 40 survey days. The surveys are confined to offshore banks reported by fishermen as known rockfish habitat. Protocols include the use of multi-frequency active acoustics and still and video camera observations using an ROV (Appendix 1).

Habitat Surveys. The focus of these surveys includes adult rockfish Essential Fish Habitat and habitat use of a variety of other species. They are usually conducted on a NOAA ship for about fifty survey days. Survey protocols may include use of the Nordic 264 midwater trawl, pelagic longlines, plankton and other small mesoplankton trawls, CTD profiles, and visual observations from ships and submersibles..

Small Boats. Numerous field operations use small boats including for attaching tags to fish. These operations require about 75 survey days.

1.3.1.2 Surveys conducted in the Eastern Tropical Pacific (ETP)

Marine Mammal Ecosystem Surveys. These surveys are conducted occasionally during August to December. They are authorized under the MMPA (MMPA/ESA permit 14097), but the SWFSC is requesting an LOA for the incidental take of marine mammals associated with ecosystem sampling. As discussed previously for the marine mammal surveys in the CCE, these are large- scale surveys requiring substantial blocks of continuous time on two NOAA ships and about 60-120 survey days. Results inform status assessments of marine mammal populations. Surveys rotate among geographic areas and include the STAR survey conducted in the ETP,

The protocols for these surveys include line transect surveys of marine mammals and seabirds. The marine mammal component of the surveys focuses on observations of schools or aggregations of animals. For a subset of observations survey effort is suspended and aggregations are approached for estimation of aggregation size and species composition. As noted above, MMPA and ESA research permits are obtained for these surveys, as required.

Additional protocols include the use of multi-frequency active acoustics, 2.5 m^2 single-warp IKMT with 1 mm mesh net for sampling macro-zooplankton, 3 m^2 dip net with 2 mm mesh net for sampling flying fish, CTD with an array of vertically profiling instruments and bottles to collect water samples at specific depths, and meteorological observations using a wide-range of passive sensors (Appendix 1).

HMS Surveys. To date, these surveys have not been conducted in the ETP; however, the SWFSC believes they will likely occur during the period 2015-2019. They may be conducted up to 30 days annually during June-July. It is most likely that longline surveys in the ETP would involve more shallow-set longline gear configurations, but may also include deep-set longline configurations as well. In addition to deployment of pelagic longline gear identical to what has been used in the CCE, protocols include the use of multi-frequency active acoustics (Appendix 1).

1.3.1.3 Surveys conducted in the Antarctic Marine Living Resources area (AMLR)

Antarctic Survey. These surveys are conducted annually during January through March or in August and include the extended area around the South Shetland and South Orkney archipelagos in the Scotia Sea, the eastern section of the Bellingshausen Sea, and the northwestern section of the Weddell Sea. They are usually conducted on a charter vessel and required about 70 survey days.

Shipboard surveys are designed to map the distribution of Antarctic krill relative to the distributions of krill predators (including penguins, pinnipeds, and flying birds) as well as estimate krill biomass within the survey area. The physical and biological environment is also characterized. Survey protocols include the use of 2.5 m^2 single-warp IKMT with 505 micron mesh net, multi-frequency active acoustics, CTD with an array of vertically profiling instruments and water samples at discrete depths, marine mammal and bird observations, and meteorological observations using a wide-range of passive sensors (Appendix 1). The SWFSC is currently investigating use of 4 m^2 single-warp Tucker Midwater Trawl with two 505 micron mesh nets and one 5 mm mesh net for use on these surveys.

Every 2-3 years a bottom trawl is used to assess benthic invertebrates and fish on the continental shelf. Gear used is a towed camera array and a two-warp NET Systems Hard-Bottom Snapper Trawl.

1.3.1.4 Gear Used During SWFSC Research

Appendix A of the DEA provides a full description of sampling gear used during SWFSC research.

1.3.1.4.1 Trawl Nets

A trawl is a funnel-shaped net towed behind a boat to capture fish. The codend, or 'bag,' is the fine-meshed portion of the net most distant from the towing vessel where fish and other organisms larger than the mesh size are retained. In contrast to commercial fishery operations, which generally use larger mesh to capture marketable fish, research trawls often use smaller mesh to enable estimates of the size and age distributions of fish in a particular area. The body of a trawl net is generally constructed of relatively coarse mesh that functions to gather schooling fish so that they can be collected in the codend. The opening of the net, called the 'mouth', is extended horizontally by large panels of wide mesh called 'wings.' The mouth of the net is held open by hydrodynamic force exerted on the trawl doors attached to the wings of the net. As the net is towed through the water, the force of the water spreads the trawl doors horizontally apart. The trawl net is usually deployed over the stern of the vessel, and attached with two cables, or 'warps,' to winches on the deck of the vessel. The cables are payed out until the net reaches the fishing depth. Commercial trawl vessels travel at speeds between two and five knots while towing the net for time periods up to several hours. The duration of the tow depends on the purpose of the trawl, the catch rate, and the target species. At the end of the tow the net is retrieved and the contents of the codend are emptied onto the deck. For research purposes, the speed and duration of the tow and the characteristics of the net must be standardized to allow meaningful comparisons of data collected at different times and locations. Active acoustic devices incorporated into the research vessel and the trawl gear monitor the position and status of the net, speed of the tow, and other variables important to the research design.

Most SWFSC research trawling activities utilize 'pelagic' trawls, which are designed to operate at various depths within the water column. Because pelagic trawl nets are not designed to contact the seafloor, they do not have bobbins or roller gear, which are often used to protect the foot rope of a 'bottom' trawl net as it is dragged along the bottom. Trawl nets with the greatest potential for interactions with protected species such as marine mammals and the only nets with historical takes of ESA-listed species during previous SWFSC surveys include: the Nordic 264 trawl, manufactured by Net Systems Inc. (Bainbridge Island, WA); and the modified Cobb mid-water trawl. One of the main factors that contribute to the likelihood of protected species takes with these two nets is their relatively large trawl mouth-opening size. The NETS Nordic 264 trawl and the modified Cobb mid-water trawl have total effective mouth areas of 380 m^2 and 80 m^2 respectively, both of which are significantly larger in size relative to the mouth openings of other nets used by the SWFSC. For comparison, the IKMT net has a mouth size opening that is less than 9 m^2.

1.3.1.4.1.1 Nordic 264

Several SWFSC research programs utilize a Nordic 264 two-warp rope trawl, manufactured by Net Systems Inc. (Bainbridge Island, WA). The forward portion of this large two-warp rope trawl is constructed of a series of ropes that function to gather fish into the body of the net. The effective mouth opening of the Nordic 264 is approximately 380 m^2, spread by a pair of 3.0 m (9.8 ft) Lite trawl doors (Churnside et al. 2009). For surface trawls, used to capture fish at or near the surface of the water, clusters of polyfoam buoys are attached to each wing tip of the headrope and additional polyfoam floats are clipped onto the center of the headrope. Mesh sizes range from 162.6 cm in the throat of the trawl, to 8.9 cm in the codend (Churnside et al. 2009). For certain research activities, a liner may be sewn into the codend to minimize the loss of small fish. The SWFSC's La Jolla Laboratory uses a Nordic 264 pelagic rope trawl to sample adult coastal pelagic fish species during cruises along the U.S. west coast. The primary objective of these cruises is to measure population dynamics of Pacific sardine (*Sardinops sagax*) in order to set management goals for the coastwide U.S. sardine fishery. The Nordic 264 is also used in salmon (*Oncorhychus* spp.) research by the SWFSC Santa Cruz lab (Dotson et al. 2010). During Coastal Pelagic Species surveys, the Nordic 264 two-warp rope trawl is fished during night time hours in order to collect information on sardines, anchovy, Jack and Pacific mackerels, hake, and other species. The trawl is fished at depth for 30 minutes at a time at a speed of 2-4 knots.

1.3.1.4.1.2 Modified-Cobb

A modified-Cobb midwater trawl net is used for SWFSC Juvenile Rockfish Surveys. The net has a headrope length of 26.2 m (86 ft), a mouth of 80 m^2, and uses a 3/8-inch codend liner to catch juvenile rockfish. The net is towed for periods of approximately 15 minutes at depth at a speed of approximately 2.0 to 2.5 knots. The target headrope depth is 30 meters for the vast majority of stations, but 10 meters for some of the more nearshore (shallow) stations. There are historical and infrequently occupied depth-stratified stations that are also sampled to 100 meters depth. The fishing depth is monitored using an electronic net monitoring system, and is adjusted by varying the length of trawl line connecting the net to the boat.

1.3.1.4.1.3 Antarctic Bottom Trawl Gear

In addition to the nets described above, the SWFSC uses the two-warp NET Systems Hard-Bottom Snapper Trawl to capture fish at or near the seafloor as part of Antarctic survey activities. The lower edge of the bottom trawl net opening is normally protected by a thick footrope ballasted with heavy rubber discs or bobbins, often called 'roller gear' or 'tire gear,' while the upper edge of the trawl net opening is the 'headrope.' Floatation devices attached to the headrope hold the net open vertically as it is towed through the water. The AMLR bottom trawl net has a headrope length of 28.0 m (92.0 ft) and a footrope length of 38.9 m (127.6 ft) (Stauffer 2004).

1.3.1.4.1.4 Specialized Trawl Nets for Collection of Small Organisms

SWFSC surveys in all of the research areas utilize various small, fine-mesh, towed nets designed to sample small fish and pelagic invertebrates. The Oozeki net is a newly designed frame trawl with a 5 m^2 mouth area used for quantitative sampling of larval and juvenile pelagic fishes (Figure A-3 *in* DEA). Towing depth of the net is easily controlled by adjusting the warp length, and the net samples a large size range of juvenile fishes and micronekton (Oozeki et al. 2004). Micronekton is a term used for a large variety of free-swimming organisms, including small or juvenile fish as well as crustaceans and cephalopods, which are larger than current-drifting plankton but not quite large enough to swim against substantial currents. Similar to the Oozeki net, the IKMT net is used to collect deep water biological specimens larger than those taken by standard plankton nets. The net is attached to a wide, V-shaped, rigid diving vane that keeps the mouth of the net open and maintains the net at depth for extended periods. The IKMT is a long, round net approximately 6.5 m (21.3 ft) long, with a series of hoops decreasing in size from the mouth of the net to the codend, which maintain the shape of the net during towing (Yasook et al. 2007). The Tucker Trawl is a medium-sized single-warp net used to study pelagic fish and zooplankton. The Tucker trawl usually consists of a series of nets that can be opened and closed sequentially without retrieving the net from the fishing depth. Similarly the MOCNESS, or Multiple Opening/Closing Net and Environmental Sensing System, is based on the Tucker Trawl principle where a stepping motor is used to sequentially control the opening and closing of the nets. The MOCNESS uses underwater and shipboard electronics for controlling the device. The electronics system continuously monitors the functioning of the nets, frame angle, horizontal velocity, vertical velocity, volume filtered, and selected environmental parameters, such as salinity and temperature. The MOCNESS is used for specialized zooplankton surveys.

1.3.1.4.2 Longlines

Longline gear consists of baited hooks attached to a mainline or 'groundline'. The length of the longline and the number of hooks depend on the species targeted, the size of the vessel, and the purpose of the fishing activity. The longline gear used for SWFSC research surveys for Highly Migratory Species, thresher sharks, and swordfish typically use 200-400 hooks attached to a steel or monofilament mainline from 2 to 12 miles in length. Hooks are attached to the mainline by another thinner line called a 'gangion'. The length of the gangion, float line, and the distance between gangions depends on the purpose of the fishing activity, and may include both shallow-set and deep-set configurations. For SWFSC research the gangions are 12, 18, or 36 feet in length and are attached to the mainline at intervals of 50 to 100 feet between hooks. Buoys are used to keep pelagic longline gear suspended near the surface of the water. The lengths of lines attached to the buoy, called float lines, are 12 or 120 feet depending on the target. Flag buoys (or 'high flyers') equipped with radar reflectors, radio transmitters, and/or flashing lights are attached to each end of the mainline to enable the crew to find the line for retrieval.

In contrast to the pelagic longline gear used for surveys of HMS, bottom (or 'demersal') longline gear may be used to survey species in deeper water, including sablefish. Bottom longlines use fixed hooks strung along a weighted groundline. Bottom longlines used for commercial fishing can be up to several miles long, but those used for SWFSC research related to reproductive life history of sablefish off the coasts of California and Washington use shorter lines with approximately 75 hooks per line. The hooks are baited with squid and set at depths of between 1180 to 1480 feet (360 to 450 meters). Like pelagic longline gear, flag buoys (or 'high flyers') are attached to each end of the groundline to enable the crew to find the line for retrieval. The flag buoys used for bottom longline gear use long buoy lines to allow the weighted groundline to rest on the seafloor while the attached buoys float on the surface to enable retrieval of the gear.

The time period between deployment and retrieval of the longline gear is the 'soak time.' Soak time is an important parameter for calculating fishing effort. For commercial fisheries the goal is to optimize the soak time in order to maximize catch of the target species while minimizing the bycatch rate, and minimizing damage to target species caught on the hooks that may result from predation by sharks or other predators. Soak time can also be an important factor for controlling longline interactions with protected species. Marine mammals, turtles, and other protected species may be attracted to bait, or to fish caught on the longline hooks. Protected species may become caught on longline hooks or entangled in the longline while attempting to feed on the catch before the longline is retrieved.

1.3.1.4.3 Swordfish deep-set buoy gear

Swordfish deep-set buoy gear is used to capture and tag swordfish (*Xiphias gladius*) off the coast of Southern California and includes a buoy flotation system (i.e., a strike-indicator float/flag, a large, non-compressible buoy and a float affixed with a radar reflector). A set of "gear" consists of 250-400 m 500 pound (lb) mainline monofilament rigged with a 1-2 kilogram (kg) drop sinker to orient the mainline and terminal fishing gear vertically in the water column. Unlike longline gear which typically uses a long monofilament mainline suspended horizontally near the surface of the water, deep-set buoy gear does not involve the use of a horizontal mainline. Two monofilament gangions branch from the vertically oriented mainline at 250-400 m constructed of 400-lb. monofilament leaders containing a crimped 14/0 circle hook baited with either squid or mackerel.

The gear is set at a target depth below the thermocline (Figure A-5 *in* DEA), at depths of 250-400m, with fishing occurring only during daylight hours, which theoretically constrains the potential for interactions with many non-target species. Deep-set buoy gear research is conducted in the water column below the thermocline. The conditions at this depth consist of relatively cold, oxygen-poor waters that are inhospitable to most pelagic species, which are not physiologically equipped to continuously inhabit the water column at such depth. The buoys are deployed in a restricted spatial grid such that all of the indicator buoys can be continuously monitored from the vessel (within a maximum 4 nm grid area). When an indicator flag rises, the buoy set is immediately tended and the animal caught is either released or tagged and released in order to increase post-hooking survivorship of all animals. In addition, slack in the fishing line is minimized in order to maintain a vertical profile and keep hooks at or below 250 m depth to minimize potential for marine mammal interactions. Circle hooks are used, which have been shown in other hook-and-line fisheries to increase post-hooking survivorship with selected non-target species.

1.3.1.4.4 Various plankton nets (Bongo / Pairovet, Manta)

SWFSC research activities include the use of several plankton sampling nets that employ very small mesh to sample plankton and fish eggs from various parts of the water column. Plankton sampling nets usually consist of fine mesh attached to a weighted frame. The frame spreads the mouth of the net to cover a known surface area. The Bongo nets used for CalCOFI surveys have openings 71 cm in diameter and employ a 505 µm mesh. The nets are 3 meters in length with a 1.5 m cylindrical section coupled to a 1.5 m conical portion that tapers to a detachable codend constructed of 333 µm or 0.505 µm nylon mesh (Appendix A *in* DEA). The bongo nets are towed through the water at an oblique angle to sample plankton over a range of depths. During each plankton tow, the bongo nets are deployed to a depth of approximately 210 m and are then retrieved at a controlled rate so that the volume of water sampled is uniform across the range of depths. In shallow areas, sampling protocol is adjusted to prevent contact between the bongo nets and the seafloor. A collecting bucket, attached to the cod-end of the net, is used to contain the plankton sample. When the net is retrieved, the collecting bucket can be detached and easily transported to a laboratory. Some bongo nets can be opened and closed using remote control to enable the collection of samples from particular depth ranges. A group of depth-specific bongo net samples can be used to establish the vertical distribution of zooplankton species in the water column at a site. Bongo nets are generally used to collect zooplankton for research purposes, and are not used for commercial harvest.

The Pairovet is a bongo-type device consisting of two nets. The Pairovet frame was designed to facilitate comparison of nets constructed of various materials and to provide replicate observations when using similar nets. The frame is constructed of 6061-T6 aluminum with stainless steel fittings. The nets are nylon mesh attached to the frame with adjustable stainless steel strapping. Manta nets are towed horizontally at the surface of the water to sample neuston (organisms living at or near the water surface). The frame of the Manta net is supported at the ocean surface by aquaplanes (wings) that provide lift as the net is towed horizontally through the water (Appendix A *in* DEA). To ensure repeatability between samples, the towing speed, angle of the wire, and tow duration must be carefully controlled. The Manta nets used for CalCOFI surveys employ 505 µm nylon mesh in the body of the net and 303 µm mesh in the codend. The frame has a mouth area of 0.1333 m^2. For CalCOFI surveys, the Manta net is towed for periods of 15 minutes at a speed of approximately 2.0 knots.

1.3.1.4.5 Other Survey Equipment

The CUFES is used to collect pelagic fish eggs from the water column while the vessel is underway. The CUFES device consists of a water intake approximately three meters below the surface of the water connected to a high capacity pump capable of pumping approximately 640 liters of water per minute through the device. Particles in the bulk water stream are concentrated by an oscillating mesh. Samples are transferred to a collecting device at a rate of approximately 20 liters per minute, while the bulk water is discharged overboard. Samples are collected and preserved on mesh net over sequential sampling intervals. Ancillary data including temperature, salinity, chlorophyll-a fluorescence, time and location are also collected automatically.

The SWFSC maintains and deploys two ROVs. The ROVs are used to quantify fish and shellfish, photograph fish for identification, and provide views of the bottom habitat for habitat-type classification studies. Still and video camera images are used to monitor populations of the endangered white abalone, and also for assessment of southern California rockfish assemblages and ground-truthing of sonar surveys of groundfish habitats as part of the COAST program. Precise georeferenced data from ROV platforms also enables SCUBA divers to utilize bottom time more effectively for collection of brood stock and other specimens. The SWFSC has operated a Phantom DS4 ROV to collect video and still camera images at a maximum depth of 600 meters. Standard instrumentation on the ROV includes a directional hydrophone, a CTD, a differential Global Positioning System (dGPS), pitch and roll sensors, still cameras, and video cameras. The ROV platform also includes a reference laser system to facilitate in situ specimen measurements and to determine the distance of the ROV platform from underwater objects. The SWFSC has also recently designed and constructed a custom high-definition high-voltage (HDHV) remotely operated vehicle (ROV) for surveying groundfish and benthic invertebrates in deepwater environments. The HDHV ROV platform is equipped with video and still cameras, an illumination system, scanning sonar, CTD, a dissolved oxygen sensor, laser range-finding and laser caliper systems, and the capability to process data while underway to facilitate real-time georeferenced collection of oceanographic data.

As mentioned above, an alternative method of capture involved with the Juvenile Salmon Survey is the use of beach seines along the coast between San Francisco and the California/Oregon border. Seine dimensions are 1.5 m wide x 15 m long with a mesh of 10 mm stretched between a lead-weighted foot line and a buoyed float line. The beach seine is small enough to be operated by three persons wading out from shore. Approximately 5-10 seine stations may be sampled annually, with exact locations to be determined.

1.3.1.4.6 Active Acoustic Sources used by the SWFSC

A wide range of active acoustic sources are used in SWFSC fisheries surveys for remotely sensing bathymetric, oceanographic, and biological features of the environment. Most of these sources involve relatively high frequency, directional, and brief repeated signals tuned to provide sufficient focus and resolution on specific objects. Table 1 describes the important characteristics of these sources for each of the primary operational research vessels used by the SWFSC to conduct fisheries surveys, followed by descriptions of some of the primary general categories of sources, including all those for which acoustic harassment of marine mammals under the MMPA are calculated.

Table 1. Operating characteristics of active acoustic sources operated from SWFSC research vessels.

Active Acoustic System (product name and #)	Operating Frequencies (kHz)	Maximum Source Level in dB/1µPa (referenced to 1m)	Single ping duration (ms) and repetition rate (Hz)	Orientation/ Directionality	Nominal Beamwidth (degrees)
Simrad EK500 and EK60 Narrow Beam Scientific Echo Sounders	18, 38, 70, 120, 200, 333 kHz (or a subset). Primary frequencies are 38, 70, 120 and 200 kHz.	224 dB	Variable. Most common setting is 1 ms duration and 0.5 Hz repetition rate.	Downward looking	7°
Simrad ME70 Multi-Beam Echo Sounder	70-120 kHz	205 dB	0.06 to 5 ms, 1-4 Hz	Primarily Downward Looking	130°
Simrad MS70 Multi-Beam Sonar	75-112 kHz	206 dB	2 to 10 ms, 1-2 Hz	Primarily Side-Looking	60°
Simrad SX90 Narrow Beam Sonar	20-30 kHz	219 dB	Variable	Omni-Directional	4-5° (variable for tilt angles from 0 to 45° from horizontal)

Teledyne RD Instruments Acoustic Doppler Current Profiler (ADCP), Ocean Surveyor	75 kHz	224 dB	0.2 Hz rep rate	Downward looking	30°
Simrad ITI Catch Monitoring System	27-33 kHz	214 dB	0.05-0.5 Hz rep rate	Downward looking	40°
Simrad FS70 Third Wire Net Sonde	120 kHz	Unknown, maximum transmit power is 1 kW	Variable	Downward looking	40°

1.3.1.4.6.1 Multi-frequency Narrow Beam Scientific Echo Sounders (Simrad EK500 and EK60 Systems - 18, 38, 70, 120, 200, 333 kHz)

Similar to multibeam echosounders, multi-frequency split-beam sensors are deployed from NOAA survey vessels and used to acoustically map the distributions and estimate the abundances and biomasses of many types of fish; characterize their biotic and abiotic environments; investigate ecological linkages; and gather information about their schooling behavior, migration patterns, and avoidance reactions to the survey vessel. The use of multiple frequencies allows coverage of a broad range of marine acoustic survey activity, ranging from studies of small plankton to large fish schools in a variety of environments from shallow coastal waters to deep ocean basins. Simultaneous use of several discrete echosounder frequencies facilitates accurate estimates of the size of individual fish, and can also be used for species identification based on differences in frequency-dependent acoustic backscattering between species. The SWFSC uses devices that transmit and receive at six frequencies ranging from 18 to 333 kHz. The primary frequencies used with these echo sounders are 38, 70, 120 and 200 kHz.

1.3.1.4.6.2 Single Frequency Omnidirectional Sonars (Simrad SX-90)

Low frequency, high-resolution, long range fishery sonars including the SX-90 operate with user selectable frequencies between 20 and 30 kHz providing longer range and prevent interference from other vessels. These sources provide an omnidirectional imaging around the source with three different vertical beamwidths, single or dual vertical view and 180° tiltable vertical views are available. At 30 kHz operating frequency, the vertical beamwidth is less than 7 degrees. This beam can be electronically tilted from +10 to -80 degrees, which results in differential transmitting beam patterns. The cylindrical multi-element transducer allows the omnidirectional sonar beam to be electronically tilted down to -60 degrees, allowing automatic tracking of schools of fish within the whole water volume around the vessel. The signal processing and beamforming is performed in a fast digital signal processing system using the full dynamic range of the signals.

1.3.1.4.6.3 Multi-beam echosounder (Simrad ME70) and sonar (Simrad MS70)

Multibeam echosounders and sonars work by transmitting acoustic pulses into the water and then measuring the time required for the pulses to reflect and return to the receiver and the angle of the reflected signal. The depth and position of the reflecting surface can be determined from this information, provided that the speed of sound in water can be accurately calculated for the entire signal path. The use of multiple acoustic 'beams' allows for coverage of a greater area compared to single beam sonars. The sensor arrays for multibeam echosounders and sonars are usually mounted on the keel of the vessel and have the ability to look horizontally in the water column as well as straight down. Multibeam echosounders and sonars are used for mapping seafloor bathymetry, estimating fish biomass, characterizing fish schools, and studying fish behavior. The multibeam echosounders used by the SWFSC are mounted to the hull of the research vessels and emit frequencies in the 70-120 kHz range.

1.3.1.4.7 Other Devices

An Acoustic Doppler Current Profiler, or ADCP, is a type of sonar used for measuring water current velocities simultaneously at a range of depths. In the past, current depth profile measurements required the use of long strings of current meters. ADCP enables measurements of current velocities across an entire water column, replacing the long strings of current meters. An ADCP anchored to the seafloor can measure current speed not just at the bottom, but also at equal intervals all the way up to the surface (WHOI 2011). An ADCP instrument can also be mounted to a mooring, or to the bottom of a boat. The ADCP measures water currents with sound, using the Doppler Effect. ADCPs operate at frequencies between 75 and 300 kHz. High frequency pings yield more precise data, but low frequency pings travel farther in the water.

'CTD' is an acronym for Conductivity, Temperature, and Depth. A CTD profiler measures these parameters, and is the primary research tool for determining chemical and physical properties of seawater. A shipboard CTD is made up of a set of small probes attached to a large (1 to 2 m in diameter) metal rosette wheel. The rosette is lowered through the water column on a cable, and CTD data are observed in real time via a conducting cable connecting the CTD to a computer on the ship. The rosette also holds a series of sampling bottles that can be triggered to close at different depths in order to collect a suite of water samples that can be used to determine additional properties of the water over the depth of the CTD cast. A standard CTD cast, depending on water depth, requires two to five hours to complete.

The Simrad FS70 is a third wire trawl sonar used for monitoring of the net opening and trawl performance. It communicates with the vessel by means of a third wire system, and with wireless sensors mounted on the trawl by means of hydroacoustic links. It uses third wire system to establish communication between the submerged sonar head located behind the headrope and the vessel. Simultaneously, the submerged unit communicates with a number of sensors located on parts of the net such as the trawl doors and codend by means of hydroacoustic links. The visual presentation provided to the bridge gives a clear picture of the trawl opening, as well as information from the rest of the sensors.

1.3.2 Issuance of MMPA LOA

NMFS is responsible for administering the MMPA, with respect to direct or incidental impacts to all marine mammals from the actions of any person subject to the jurisdiction of the United States. Under the MMPA, section 101(a)(5), the Secretary of Commerce shall allow, upon request, for the incidental taking of small numbers of marine mammals, provided such take will have a negligible impact on such species or stocks affected.

The Permits and Conservation Division (PRl) of OPR has proposed to issue a Letter of Authorization (LOA) to the SWFSC, pursuant to section 101(a)(5)(A) of the MMPA (16 U.S.C. 1361 *et seq.)*, for taking marine mammals incidental to fisheries research in the CCE, ETP, and Antarctic over the course of five years, on February 13, 2015 (80 FR 8166). The LOA would be effective for a period of five years from the date of issuance, which is expected to occur during the summer of 2015. The proposed regulations specify the prescribed mitigation measures (described below), monitoring requirements, and necessary reporting, as well as proposed authorized levels of taking.

The proposed LOA covers all of the research activities that are described in section 1.3.1. The number of potential Level A (injurious) interactions with marine mammals resulting from incidental capture or entanglement in trawl or longline survey gear, or exposure to active acoustics from SWFSC vessels, has been estimated (review Appendix C *in* DEA and/or 80 FR 8166 for complete description of estimation process; also summarized in section 2.2.1.1.3 below). No ESA-listed marine mammals are expected to be injured by SWFSC research activities, and no Level A MMPA takes of ESA-listed marine mammals were requested by the SWFSC or proposed for inclusion in the LOA. The proposed LOA does anticipate that several ESA-listed species would potentially be exposed to sound levels produced by active acoustics from SWFSC vessels that may equate to Level B harassment[4] under the MMPA. Table 2 below

[4] Level B harassment under the MMPA is defined as "any act of pursuit, torment, or annoyance which has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering."

describes the extent of Level B harassment for ESA-listed marine mammals by survey area in the proposed LOA (see DEA Appendix C and/or 80 FR 8166 for complete description of the MMPA acoustic harassment estimation process; summarized in section 2.2.1.1.3).

Table 2. Total number of incidents[5] of acoustic harassment under the MMPA proposed for authorization in the SWFSC LOA for ESA-listed species, by research area.

ESA-listed Species	Incidents of MMPA Level B Acoustic Harassment
CCE	
Humpback whale	346
Sei whale	1
Fin whale	33
Blue whale	24
Sperm whale	65
Guadalupe fur seal	134
ETP	
Humpback whale	1
Blue whale	2
Sperm whale	4
Guadalupe fur seal	66
Antarctica	
Southern right whale	1
Humpback whale	92
Fin whale	114
Sperm whale	3

As part of the proposed LOA, the SWFSC is required to implement mitigation and monitoring measures to minimize impacts to marine mammals. The SWFSC has adopted these measures as part of their proposed action, and they are described in conjunction with all measures for protected species in section 1.3.4. Reporting requirements of the LOA are also reflected, as necessary, in the Terms and Conditions (section 2.10) of this opinion.

1.3.3 Issuance of ESA Section 10 Research Permit

NMFS is responsible for administering ESA with respect to most marine species, including marine mammals and sea turtles in the marine environment. Under section 10(a)(1)(A) of the ESA, NMFS may permit actions for scientific purposes or population enhancement related directly to listed species. As part of the proposed action of this opinion, NMFS is proposing to issue a research permit for the take of ESA-listed salmon during juvenile salmon surveys conducted off the coast of California and Oregon each year during the summer and fall (described above). As opposed to the incidental capture of ESA-listed salmon in other fish trawl

[5] Level B harassment is characterized in terms of the number of incidents based upon the density of animals in the area ensonified because it is possible the same individual could be exposed to the sound sources experience as both the SWFSC research vessels and marine mammals move around in the ocean.

surveys, this action is considered direct take of ESA-listed species, which may be permitted under section 10(a)(1)(A) of the ESA.

The new section 10(a)(1)(A) permit, Permit #19320, would authorize the SWFSC to perform research designed to: (1) determine the inter-annual and seasonal variability in growth, feeding, and energy status among juvenile salmonids in the coastal ocean off northern and central California as well as southern Oregon; (2) determine migration paths and spatial distribution among genetically distinct salmonid stocks during their early ocean residence; (3) characterize the biological and physical oceanographic features associated with juvenile salmon ocean habitat from the shore to the continental shelf break; (4) identify potential links between coastal geography, oceanographic features, and salmon distribution patterns; and (5) identify and test ecological indices for salmon survival. This research would benefit listed fish by informing comprehensive lifecycle models that incorporate both freshwater and marine conditions and recognize the relationship between the two habitats; it would also identify and predict sources of salmon mortality at sea and thereby help managers develop indices of salmonid survival in the marine environment. The permit would be effective from the date of issuance, which is expected to occur during the summer of 2015, and expire December 31, 2019.

Ten ESU/DPSs of listed salmonids would be captured primarily via surface trawling; however, beach seining would be used occasionally. Sub-adult salmonids (i.e., all salmon larger than 250 mm) that survive capture would have fin tissue and scale samples taken, and then be released. Any sub-adult salmonids that do not survive capture, and all juvenile salmonids (i.e., fish larger than 80 mm but less than 250 mm) would be lethally sampled (i.e., intentional directed mortality) in order to collect: (1) otoliths for age and growth studies; (2) coded wire tags for origin and age of hatchery fish; (3) muscle tissue for stable isotopes and/or lipid assays; (4) stomachs and contents for diet studies; and (5) other tissues including the heart, liver, intestines, pyloric caeca, and kidney for special studies upon request. Table 3 summarizes the annual requested take of ESA-listed salmon during the juvenile salmon survey by ESU/DPS, life stage, origin, and take action.

Table 3. Summary of annual requested take by ESU/DPS, life stage, origin, and take action for section 10(a)(1)(A) permit #19320.

Species	ESU/DPS	Origin	Life Stage	Take Action	Requested Take	Requested Mortality
Salmon, Chinook	California Coastal	Natural	Sub-adult	IDM	26	26
		Natural	Sub-adult	C/M,T,ST/R	34	0
		Natural	Juvenile	IDM	31	31
	Central Valley spring-run	Natural	Sub-adult	IDM	3	3
		Natural	Sub-adult	C/M,T,ST/R	8	0
		Natural	Juvenile	IDM	23	23

		Listed Hatchery Adipose Clip	Sub-adult	IDM	3	3
		Listed Hatchery Adipose Clip	Sub-adult	C/M,T,ST/R	6	0
		Listed Hatchery Adipose Clip	Juvenile	IDM	82	82
	Lower Columbia River	Natural	Sub-adult	C/M,T,ST/R	1	0
		Listed Hatchery Adipose Clip	Sub-adult	C/M,T,ST/R	1	0
	Sacramento River winter-run	Natural	Sub-adult	IDM	3	3
		Natural	Juvenile	IDM	2	2
	Snake River spring/summer-run	Listed Hatchery Adipose Clip	Juvenile	IDM	2	2
Salmon, coho	Central California Coast	Natural	Sub-adult	IDM	4	4
		Natural	Sub-adult	C/M,T,ST/R	3	0
		Natural	Juvenile	IDM	16	16
		Listed Hatchery Intact Adipose	Sub-adult	IDM	4	4
		Listed Hatchery Intact Adipose	Sub-adult	C/M,T,ST/R	3	0
		Listed Hatchery Intact Adipose	Juvenile	IDM	16	16
	Southern Oregon/Northern California Coast	Natural	Sub-adult	IDM	13	13
		Natural	Sub-adult	C/M,T,ST/R	10	0
		Natural	Juvenile	IDM	48	48
		Listed Hatchery Intact Adipose	Sub-adult	IDM	13	13
		Listed Hatchery Intact Adipose	Sub-adult	C/M,T,ST/R	10	0
		Listed Hatchery Intact Adipose	Juvenile	IDM	48	48
		Listed Hatchery Adipose Clip	Sub-adult	IDM	3	3
		Listed Hatchery Adipose Clip	Sub-adult	C/M,T,ST/R	11	0
		Listed Hatchery Adipose Clip	Juvenile	IDM	11	11
Steelhead	California Central Valley	Natural	Sub-adult	IDM	4	4
		Natural	Sub-adult	C/M,T,ST/R	1	0
		Natural	Juvenile	IDM	4	4
		Listed Hatchery Adipose Clip	Sub-adult	IDM	15	15
		Listed Hatchery Adipose Clip	Juvenile	IDM	2	2

	Central California Coast	Natural	Sub-adult	IDM	7	7
		Natural	Sub-adult	C/M,T,ST/R	1	0
		Natural	Juvenile	IDM	7	7
		Listed Hatchery Adipose Clip	Sub-adult	IDM	7	7
		Listed Hatchery Adipose Clip	Juvenile	IDM	1	1
	Northern California	Natural	Sub-adult	IDM	7	7
		Natural	Sub-adult	C/M,T,ST/R	1	0
		Natural	Juvenile	IDM	7	7

Notes: C/M,T,ST/R=Capture/Mark, Tag, Sample Tissue/Release; IDM = Intentional Directed Mortality.

Handling

All juvenile salmonids (80-250 mm fork length (FL)) are lethally sampled; these are individually frozen in plastic bags for transport back to shore. Scales, caudal fin clips, and in some cases blood plasma samples are taken from each juvenile salmonid before freezing. Sub-adult salmonids (>250 mm FL) are either kept or released, depending on their condition after capture. The mortality rate of this size class is about 40% during capture. Those that survive capture are released after the removal of a small piece of caudal fin (~5x5mm) in order to collect genetic data, and a few scales (~3-5) from the mid-dorsal region for ageing and growth. Sub-adult salmon that are lethally sampled are either kept intact and frozen or partially dissected in-situ for transport back to shore and subsequent analysis.

Once on shore, frozen salmon are thawed, weighed, and dissected to remove tissues for studies conducted by Division scientists and partner agencies. These tissues include otoliths (for age and growth studies), coded wire tags, if present (to identify hatchery and cohort), muscle tissue (for stable isotopes and/or lipid assays), stomachs and contents (diet and feeding studies), and other tissues (heart, liver, intestines, pyloric caeca, kidney) for special studies upon request. Sample tissues are refrozen for subsequent analysis, except stomachs which are preserved in formalin.

Because salmon stocks are mixed and indistinguishable at sea, genetic methods will used to determine listing unit/stock and run after a cruise is completed. Tissue samples (caudal fin clips) will be provided to a genetics lab within two weeks of survey completion. All retained tissues are discarded after analysis, with the exception of otoliths, dried DNA samples, fish scales, and coded wire tags which become part of a permanent archive stored at the NOAA SWFSC FED laboratory in Santa Cruz, California.

1.3.4 Proposed Mitigation and Conservation Measures

1.3.4.1 Trawl Surveys

Monitoring methods
The officer on watch, Chief Scientist (or other designated member of the Scientific Party), and crew standing watch on the bridge visually scan for marine mammals, sea turtles, and other ESA-listed species (protected species) during all daytime operations. 7X bridge binoculars are used as necessary to survey the area as far as environmental conditions (lighting, sea state, precipitation, fog, etc.) will allow. A member of the crew designated to stand watch for protected species (dedicated to that function) visually scans the waters surrounding the vessel at least 30 minutes before the trawl net is to be put into the water. This typically occurs during transit prior to arrival at the sampling station, but may also include time on station if other types of gear or equipment (e.g., bongo nets) are deployed before the trawl.

Operational procedures
"Move-On" Rule. If any marine mammals or sea turtles are sighted anywhere around the vessel in the 30 minutes before setting the gear, the vessel may be moved away from the animals to a different section of the sampling area if the animals appear to be at risk of interaction with the gear at the discretion of the officer on watch. Small moves within the sampling area can be accomplished without leaving the sample station. After moving on, if marine mammals or sea turtles are still visible from the vessel and appear to be at risk, the officer on watch may decide to move again or to skip the station. The officer on watch would consult with the Chief Scientist or other designated scientist (identified prior to the voyage and noted on the cruise plan) and other experienced crew as necessary to determine the best strategy to avoid potential takes of these species. Strategies are based on the species encountered, their numbers and behavior, their position and vector relative to the vessel, and other factors. For instance, a whale transiting through the area and heading away from the vessel may not require any move, or may require only a short move from the initial sampling site, while a pod of dolphins gathered around the vessel may require a longer move from the initial sampling site or possibly cancellation of the station if the dolphins follow the vessel. In most cases, trawl gear is not deployed if marine mammals have been sighted from the ship in the previous 30 minutes unless those animals do not appear to be in danger of interactions with the trawl, as determined by the judgment of the Chief Scientist or officer on watch. The efficacy of the "move-on" rule is limited during night time or other periods of limited visibility; research gear is deployed when visibility is poor, although operational lighting from the vessel illuminates the water in the immediate vicinity of the vessel during gear setting and retrieval.
Trawl operations are usually the first activity undertaken upon arrival at a new station in order to reduce the opportunity to attract marine mammals and other protected species to the vessel. However, in some cases, bongo or vertical nets may be deployed before the trawl in order to check for high densities of jellyfish and salps that may compromise the integrity of the trawl gear. Other exceptions include instances where trawls can only be conducted after night has fully fallen, but CTD's, bongo nets or other samples can be conducted during the crepuscular

period (e.g., the juvenile rockfish survey). The order of gear deployment is determined on a case-by-case basis by the Chief Scientist based on environmental conditions and sonar information at the sampling site. Other activities, such as water sampling and most plankton tows are conducted in conjunction with, or upon completion of, trawl activities.

Once the trawl net is in the water, the officer on watch, Chief Scientist, or other designated scientist, and/or crew standing watch continue to monitor the waters around the vessel and maintain a lookout for marine mammal and sea turtle presence as far away as environmental conditions allow (as noted previously, visibility can be limited for various reasons). If these species are sighted before the gear is fully retrieved, the most appropriate response to avoid incidental take is determined by the professional judgment of the officer on watch, in consultation with the Chief Scientist or other designated scientist and other experienced crew as necessary. These judgments take into consideration the species, numbers, and behavior of the animals, the status of the trawl net operation (net opening, depth, and distance from the stern), the time it would take to retrieve the net, and safety considerations for changing speed or course. Consideration is also given to the increase in likelihood of marine mammal interactions during retrieval of the net, especially when the trawl doors have been retrieved and the net is near the surface and no longer under tension. Acoustic pingers and excluder devices are not operational under these conditions. In some situations, risk of adverse interactions may be diminished by continuing to trawl with the net at depth until the marine mammals and/or sea turtles have left the area before beginning haul-back operations. In other situations, swift retrieval of the net may be the best course of action. The appropriate course of action to minimize the risk of incidental take of protected species is determined by the professional judgment of the officer on watch and appropriate crew based on all situation variables, even if the choices compromise the value of the data collected at the station.

If trawling operations have been delayed because of the presence of marine mammals or sea turtles, the vessel resumes trawl operations (when practical) only when these species have not been sighted within 30 minutes or else otherwise determined to no longer be at risk. This decision is at the discretion of the officer on watch and is situational dependent.

Care is taken when emptying the trawl, including opening the cod end as close to the deck as possible in order to avoid damage to protected species that may be caught in the gear but are not visible upon retrieval. The gear is emptied as quickly as possible after retrieval in order to determine whether or not protected species are present.

During juvenile salmon surveys, ESA-listed sub-adult salmon that survive initial capture in the trawl are immediately placed in live wells supplied with aerated seawater and kept on board only long enough to recover sufficiently for release. For unusually large hauls, researchers also make use of additional live wells, and shorten handling times by subsampling and reducing the number of caudal fin clips and scale samples taken before release.

During all trawl surveys, the priority will be to handle, sample, and release all ESA-listed species, including fishes, before the processing of non-ESA-listed species.

Tow duration

Standard tow durations have been reduced to 30 minutes or less at targeted depth, excluding deployment and retrieval time, to reduce the likelihood of attracting and incidentally taking protected species. These short tow durations decrease the opportunity for curious marine mammals to find the vessel and investigate. The resulting tow distances are typically less than 3 nautical miles, depending on the survey and trawl speed. Additionally, short tow times reduce the likelihood that captured sea turtles would drown.

In areas where salmon catch is higher than anticipated during juvenile salmon surveys, the duration of the tow is shortened by as much as 50% to avoid oversampling ESA-listed salmonids.

Marine mammal excluder devices

Potential for interactions with protected species, such as marine mammals, is often greatest during the deployment and retrieval of the trawl, when the net is at or near the surface of the water. During retrieval of the net, protected species may become entangled in the net while attempting to feed from the codend as it floats near the surface of the water. Recently, considerable effort has been given to developing excluder devices that allow marine mammals to escape from the net while allowing retention of the target species (e.g., Dotson et al. 2010). Marine mammal excluder devices (MMEDs) generally consist of a large aluminum grate positioned in the intermediate portion of the net forward of the codend and below an "escape panel" constructed into the upper net panel above the grate. The angled aluminum grate is intended to guide marine mammals through the escape panel and prevent them from being caught in the codend (Dotson et al. 2010). .

The SWFSC uses several different types of trawl nets for different surveys. The two types that have taken marine mammals in the past are the Nordic 264 and the Modified Cobb trawl. The Modified Cobb midwater trawl is smaller than the Nordic 264, is towed at slower speeds, at greater depths, and has historically had considerably lower rates of interactions with marine mammals compared to the Nordic 264 trawl which is generally operated closer to the surface. Currently, all Nordic 264 nets are outfitted with marine mammal excluder devices (MMEDs) developed for the SWFSC (Appendix A *in* DEA). Most marine mammals killed during SWFSC operations have been caught in surveys using this type of net before the excluder devices were installed. These excluder devices enable fish to pass through a grid and into the codend while preventing the passage of marine mammals, which contact the slanted grid and slide out through an escape opening or swim back out of the mouth of the net (See Appendix A *in* DEA).

While this excluder device was designed to minimize small cetacean and pinniped mortalities in trawl gear, the design is an adaptation of turtle excluder devices used in trawl gears in the Atlantic and Gulf of Mexico. The SWFSC believes that due to its similar configuration to turtle excluder devices, the excluder device may also be effective at reducing sea turtle capture and mortality in mid-water trawls. To date, the SWFSC has had no known interactions with sea turtles when using mid-water trawl gear with an excluder device in place.

The excluder device is an aluminum grate weighing 17 kilograms (38 pounds), 155 centimeters (cm) (61 inches) long and 112 cm (44 inches) wide, with 12.7 cm (5 inches) spacing on vertical bars. The excluder device is positioned at a 46-47 degree angle pointing upwards towards an escape panel in an intermediary section of netting sewn in just forward of the cod end. Additional details related to the design and construction of the MMED may be found in Appendix A *in* DEA and Dotson et al. (2010).

Modified Cobb trawls have a different shape and functionality than the Nordic 264. The Modified Cobb trawl is smaller than the Nordic 264, is towed at slower speeds, at greater depths, and has historically had considerably lower rates of interactions with marine mammals compared to the Nordic 264 trawl which is generally operated closer to the surface. The Modified Cobb trawls do not yet have MMEDs, however, research and design work is currently being performed to develop effective excluders that will not appreciably affect the catch performance of the net and therefore maintain continuity of the fisheries research data set. Successful development and implementation of excluder devices for Modified Cobb trawls is expected to occur sometime within the near future.

The hard-bottom snapper trawl used in periodic Antarctic surveys has no history of interactions with marine mammals; marine mammal sightings during these surveys are rare. There are no MMEDs that have been developed for this type of snapper trawl and no work is being done to develop such devices.

Acoustic pinger devices

Acoustic pingers are underwater sound emitting devices that decrease the probability of entanglement or unintended capture of marine mammals (see Appendix A *in* DEA). Acoustic pingers have been shown to effectively deter several species of small cetaceans from becoming entangled in gillnets (Barlow and Cameron 2003; Carretta and Barlow 2011). While their effectiveness has not been tested in trawlnets, the SWFSC believes pingers represent a mitigation measure worth pursuing given their effectiveness when used with other gear types.

They are deployed during all trawl operations using the Nordic 264 and Modified Cobb trawl nets. Two to four pingers are placed along the footrope and/or headrope to minimize marine mammal interactions.

Pingers are manufactured by STM Products, model DDD-03H. Pingers remain operational at depths between 10 m and 200 m. Tones range from 100 microseconds to seconds in duration, with variable frequency of 5-500 kHz. The pingers generate a maximum sound pressure level of 176 decibels (dB) root mean square (RMS) referenced to 1 micropascal at 1m at 30-80 kHz.

Speed limits and course alterations

Vessel speeds are restricted on research cruises in part to reduce the risk of ship strikes with marine mammals and sea turtles. Transit speeds vary from 6-14 knots, but average 10 knots. The vessel's speed during active sampling is typically 2-4 knots due to sampling design. These much slower speeds help minimize the risks of ship strikes, especially in terms of potential severity associated with a collision.

As noted above, if marine mammals are sighted near the vessel within 30 minutes prior to deployment of the trawl net, the vessel will be moved away from the animals to a new station.

At any time during a survey or in transit, any crew member that sights marine mammals or sea turtles that may intersect with the vessel course immediately communicates their presence to the bridge for appropriate course alteration or speed reduction as possible to avoid incidental collisions, particularly with large whales (e.g., blue whales).

1.3.4.2 Longline Gear

Visual surveillance by officer on watch, Chief Scientist, or other designated scientist, and crew

Longline surveys are conducted aboard smaller vessels and with fewer crew members than trawl surveys but the monitoring procedures for longline gear are similar to those described for trawling gear. Some parameters, including the specific location on the vessel and the elevation above sea level from which the surveillance is conducted may be adapted to suit the size and design of the particular vessel. However, surveillance would typically be performed from the wheelhouse or bridge of the vessel, using binoculars or another appropriate optical device.

Operational procedures

The "move-on" rule is implemented if any protected species are present within sight of the vessel and appear to be at risk of interactions with the longline gear; longline sets are not made if marine mammals or sea turtles have been seen from the vessel within the past 30 minutes and appear to be in danger of interaction with the longline gear, as determined by the professional judgment of the Chief Scientist or officer on watch. The exception is for California sea lions, which are very common in the longline survey areas. Because they are so commonly seen but very infrequently interact with longline gear, small numbers (5 or less) of California sea lions (*Zalophus californianus*) may be visible from the vessel while the longline gear is set if the officer on watch decides that, because of their behavior or travel vector or other factors, they do not appear to be at risk of interaction with the longline gear. If more than 5 California sea lions are present, the "move-on" rule is applied and the vessel is moved until the sea lions are at a safe distance away from the setting operation, as determined by the professional judgment of the officer on watch.

Longline gear is always the first equipment or fishing gear to be deployed when the vessel arrives on station. Longline gear is set immediately upon arrival at each station provided the conditions requiring the move-on rule have not been met.

Hooks vary in size depending on the target species. For deep-set longline surveys targeting swordfish, 16/0 or 18/0 offset circle hooks (stainless steel) are used. The thresher shark survey targets pups; and because use of larger circle hooks results in very low catch rates of shark pups, 13/0 offset circle hooks are used during that survey. For mako and blue sharks, 9/0 J hooks continue to be used. This has been done because: (1) sea turtles have not been taken during this survey; and (2) during testing of circle hooks, target catch rates were substantially lower using circle hooks compared to J hooks.

Longline sets typically last 2-4 hours, although soak time for deep-set longlines for swordfish can extend to 8 hours. Circle hooks and finfish bait (mackerel or sardine) are used where possible to minimize sea turtle bycatch (the SWFSC has never caught sea turtles on longline gear).

All SWFSC longline surveys other than those deep-sets targeting swordfish would not be allowed to soak longer than 4 hours.

In shallow-set surveys (for both HMS shark and thresher shark surveys), mainlines are set at a depth of 12 ft, which given the length of the gangions (12 or 18 ft) would likely allow a hooked turtle to reach the surface to breathe. During swordfish sets, the mainline is set at a depth of 120 ft.

If marine mammals or sea turtles are detected while longline gear is in the water, the officer on watch exercises similar judgments and discretion to avoid incidental take of these species with longline gear as described for trawl gear. The species, number, and behavior of the protected species are considered along with the status of the ship and gear, weather and sea conditions, and crew safety factors. The officer on watch uses professional judgment and discretion to minimize risk of potentially adverse interactions with protected species during all aspects of longline survey activities.

If marine mammals or sea turtles are detected during setting operations and are considered to be at risk, immediate retrieval or halting the setting operations may be warranted. If setting operations have been halted due to the presence of these species, setting does not resume until no marine mammals or sea turtles have been observed for at least 30 minutes.

If marine mammals or sea turtles are detected while longline gear is in the water and are considered to be at risk, haul-back is postponed until the officer on watch determines that it is safe to proceed. Adverse interactions with marine mammals, such as hooking and entanglement, are typically only observed during retrieval of the longline gear when hooks are close to the surface. From limited observations it appears that marine mammals are attracted to fish caught on longline gear (rather than the bait) and on rare occasions are caught when they bite off too much of a hooked fish. Based on these observations, the SWFSC considers the haul back period to be the time when marine mammals are most likely to be caught in longline gear so extra caution is taken during this phase of sampling.

Birds may be attracted to the baited longline hooks, particularly while the longline gear is being deployed from the vessel. Birds may get caught on the hooks, or entangled in the gangions while trying to feed on the bait. Birds may also interact with longline gear as the gear is retrieved. As part of the proposed action, if a short-tailed albatross[6] is observed within 1 nm of a planned longline sampling station, longline sampling gear will not be set.

1.3.4.3 Plankton Nets, Small-mesh Towed Nets, Oceanographic Sampling Devices, Video Cameras, and ROV Deployments

[6] Listed as endangered under the jurisdiction of U.S. Fish and Wildlife in 2000 (65 FR 46643).

The SWFSC deploys a wide variety of gear to sample the marine environment during all of their research cruises, such as plankton nets, oceanographic sampling devices, video cameras, and ROVs. These types of gear are not considered to pose any risk to protected species because of their small size, slow deployment speeds, and/or structural details of the gear and are therefore not subject to specific mitigation measures. However, the officer on watch and crew monitor for any unusual circumstances that may arise at a sampling site and use their professional judgment and discretion to avoid any potential risks to protected species during deployment of all research equipment.

1.3.4.4 Handling and Disposition of Incidentally Captured or Entangled Marine Mammals and ESA-listed Species

The proposed LOA describes the handling procedures for any marine mammals that may be incidentally captured or entangled by the SWFSC (80 FR 8166). The SWFSC has adopted similar protocols that have already been prepared for use for marine mammal and sea turtle bycatch in commercial fisheries, which by nature is very similar to bycatch circumstances in SWFSC research surveys. In general, following a "common sense" approach to handling captured or entangled marine mammals or sea turtles will present the best chance of minimizing injury to the animal and of decreasing risks to scientists and vessel crew. Handling or disentangling marine life carries inherent safety risks, and using best professional judgment and ensuring human safety is paramount. SWFSC staff will be provided with a guide to "Identification, Handling and Release of Protected Species" (see Appendix B.1 of the SWFSC's LOA application) for more specific guidance on protected species handling and will be required to follow the protocols described therein. SWFSC staff will be instructed on: how to identify different species; handle and bring marine mammals and sea turtles aboard a vessel; assess the level of consciousness; remove fishing gear; and return animals to water. The safe handling, sampling, and release, of all protected species during all survey will be treated as a priority, consistent with common sense for human safety. Reporting of all protected species takes to WCR and OPR will occur consistent with the Terms and Conditions of this opinion as well as the requirements of the LOA.

1.3.4.4.1 ESA-listed Marine Mammals

During the course of SWFSC research activities, no ESA-listed marine mammals are expected to be incidentally captured or entangled; therefore no additional potential impacts from handling or sampling of ESA-listed marine mammals is anticipated. In the unexpected event of capturing or entangling a live ESA-listed marine mammal, we expect the SWFSC will follow the basic protocols for safe removal of gear, handling, and release with an emphasis on quick return to the water. If a diagnostic tissue for genetics, such as sloughing skin, is readily available during the handling and release process in a way that does not extend the duration of the event or adds any additional injury, then that tissue can be secured as appropriate. There should be no extended or invasive efforts to collect any data beyond the release. Under MMPA section 109(h), the SWFSC may elect to salvage any dead marine mammal or marine mammal parts and bring those back to the SWFSC for further evaluation. However, ESA-listed marine mammal carcasses or parts shall not be collected without additional further authorization under the ESA.

1.3.4.4.2 Sea Turtles

It is possible that several species of sea turtles could be incidentally captured or entangled during SWFSC research activities. As described in the "Identification, Handling and Release of Protected Species" (Appendix B.1 of the SWFSC's LOA application) the SWFSC will take appropriate measures to handle and release these individuals while minimizing injury to sea turtles and damage to their gear, consistent with the procedures set out in 50 CFR § 223.206(d)(1). If practicable, SWFSC crew will measure, photograph, and apply flipper and passive integrated transponder (PIT) tags to any live sea turtle, and salvage any carcass or parts or collect any other scientifically relevant data from dead sea turtles, per authorization in 50 CFR § 222.310 (endangered) and § 223.206 (threatened) regarding the handling of ESA-listed sea turtles by designated NMFS agents. In addition, SWFSC crew may also collect skin tissue samples for genetic studies. Tissue biopsies would be taken using the antiseptic protocol described by Dutton and Balazs (1995). The biopsy site would be scrubbed with an isopropyl alcohol swab before and after sampling. The tissue biopsy would be obtained using a 4-mm sterile biopsy punch from the trailing edge of a rear flipper when possible, with the resulting plug less than the diameter of the punch. Following the biopsy, an additional antiseptic wipe would be used with modest pressure to stop any bleeding. A new sterile biopsy punch would be used on each animal. It is also possible that the SWFSC may elect to take a biopsy from a turtle that cannot be brought on board a research vessel, including any leatherback turtles that may be captured/entangled. For a turtle that is not boated, they would use 1 cm diameter stainless steel corer attached to a long pole and either target a core from the flipper, shoulder, or pelvic region, although, high vascular areas high on the shoulder or in the armpit will be avoided. A preferred method for leatherback sea turtles involves superficially scraping the carapace with the corer. Biopsy corer and equipment will be sterilized with alcohol or betadine prior to and after all biopsy efforts.

1.3.4.4.3 Eulachon

During trawl surveys, the SWFSC will collect, freeze, and transport dead incidentally captured eulachon back to shore, for transmittal to the NWFSC for further study. However, the SWFSC may elect to limit collection of dead eulachon at certain times, based on the relative extent of eulachon catch that occurs and other sampling priorities of the day. In general, the SWFSC commits to retaining no more than 1 kg of eulachon during any research cruise (~25 individuals), and will strive to collect at least 5 individuals, if practicable, during any one day where dead eulachon are recorded in survey tows. Live eulachon will be processed as a priority, and are expected to be quickly counted, weighed, and returned immediately to the water as soon as practicable.

1.3.4.4.4 Sharks

During longline surveys, the SWFSC may elect to retain and freeze an incidentally captured whole dead scalloped hammerhead shark carcass for transportation back to the SWFSC for further study. The SWFSC may also elect to collect any specific biological sample for life history studies. Any scalloped hammerhead that may be captured or entangled in longline survey gear will be handled in the same manner as all other sharks that are encountered during HMS surveys. A scalloped hammerhead would be immediately released from the gear, measured, a biopsy sample from the dorsal fin or other tissue would be collected (skin flap or biopsy punch), a conventional spaghetti tag would be implanted into the top of a shark just under the dorsal fin, and the shark would be released.

1.3.4.4.5 Salmonids

During trawl surveys (except the juvenile salmon survey, which has its own protocols – see below), the SWFSC may elect to retain and freeze all whole juvenile salmon incidentally captured, as well as take any fin clips or other tissues from those juveniles, as deemed appropriate, consistent with procedures described below for the juvenile salmon survey. The SWFSC may also elect to retain any whole or part (e.g., fin clip) of dead sub-adult salmon that are incidentally captured. We expect that live sub-adults would be handled as priority and are expected to be quickly counted, weighed, and returned immediately to the water as soon as practicable. The procedures for collection and processing of biological samples from incidentally captured salmon would be identical to what is described under the proposed directed research permit in section 1.3.3.

1.3.5 Interrelated and Independent Actions

"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). For the purposes of this consultation, the actions of ongoing SWFSC research activities conducted in the marine environment and the issuance of authorizations and permits associated with achieving compliance with the MMPA and ESA regarding those activities are considered interrelated and interdependent. In addition, any funding or grants issued to the SWFSC support these activities, including other NMFS and

NOAA offices, are considered interrelated with this proposed action. There are no other interdependent or interrelated activities associated with the proposed action.

1.4 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 this proposed action, the action area includes a vast amount of marine waters along the U.S. west coast, throughout the eastern tropical Pacific Ocean, and in the Southern Ocean off Antarctica, as described by (Figures 2-4). Research activities typically occur from ship-based platforms that may transit anywhere through these areas, and we assume that research activities could take place anywhere within these areas for the purposes of analyzing potential impacts to ESA-listed species and designated critical habitats in this opinion.

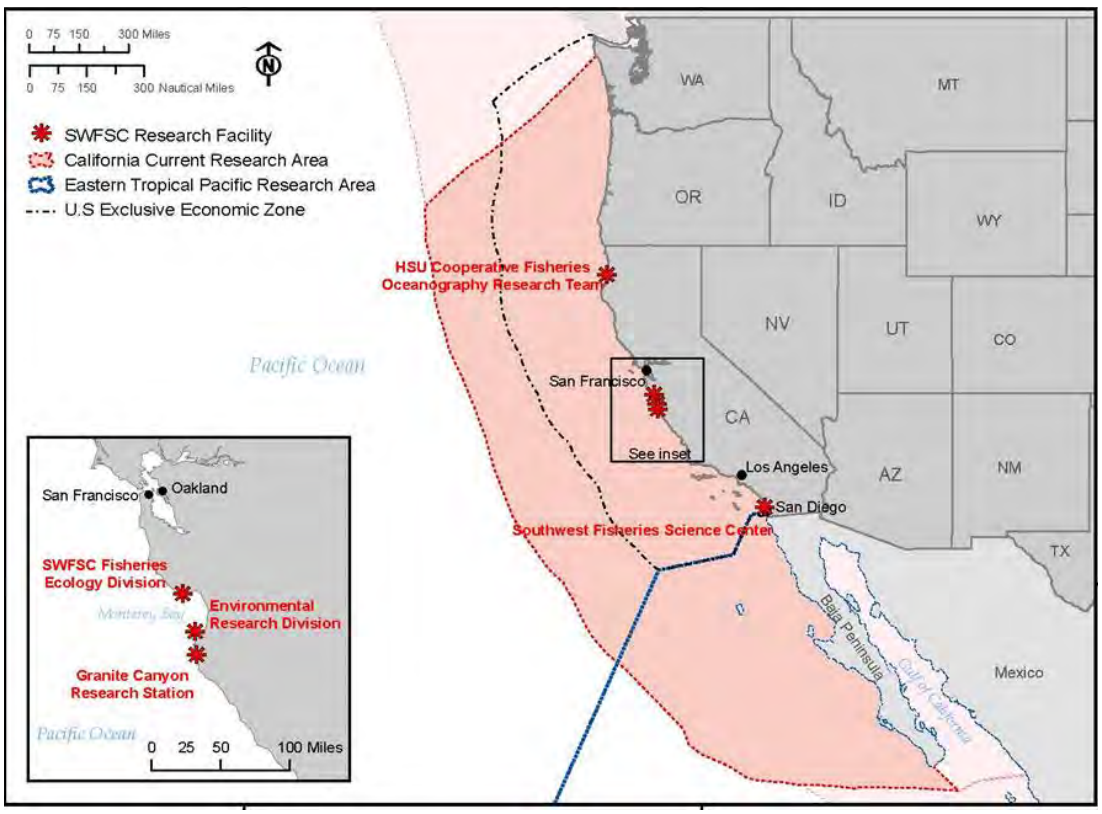

Figure 2. California Current Ecosystem (CCE) research area and research facilities.

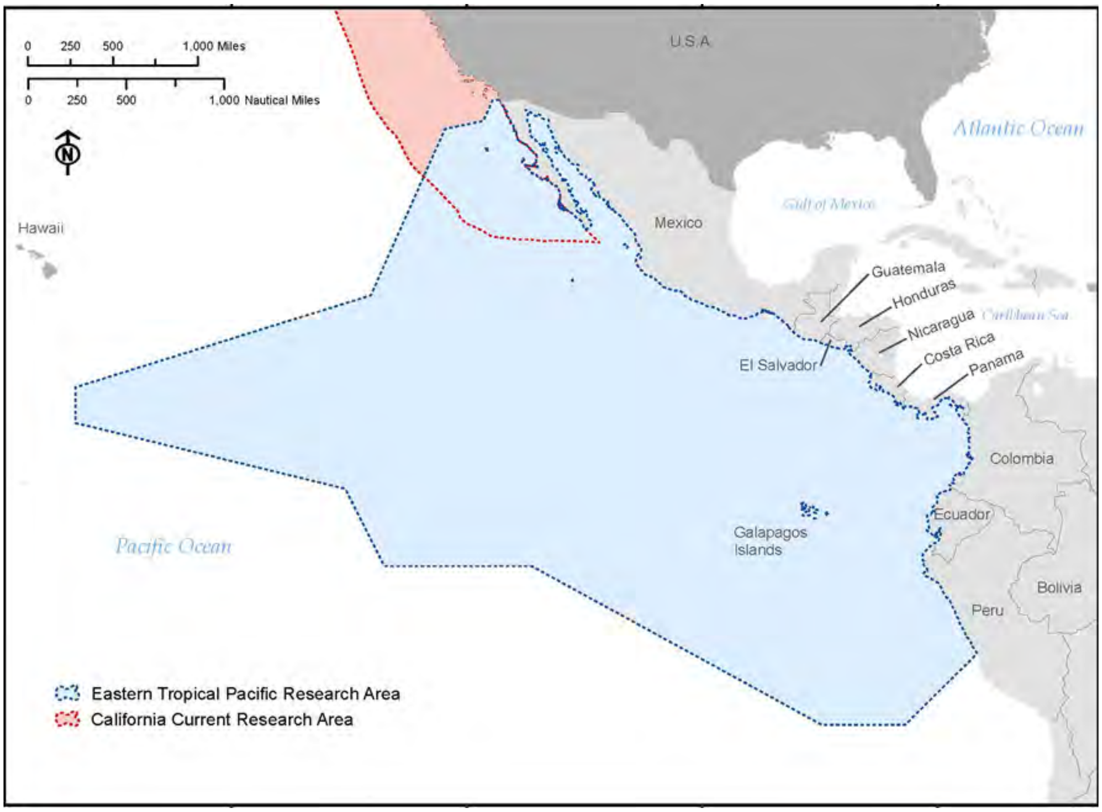

Figure 3. Eastern Tropical Pacific (ETP) research area.

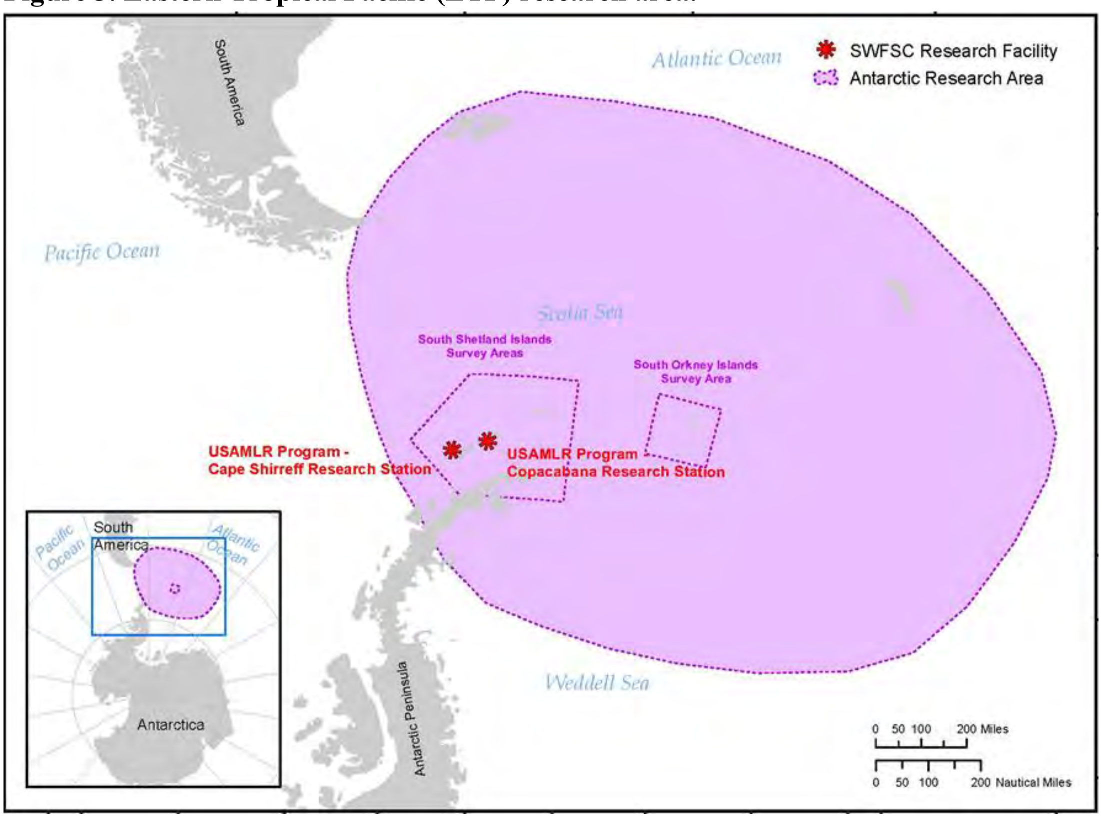

Figure 4. Antarctic research area and research facilities.

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

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

2.1 ESA-listed Species Likely to be Adversely Affected

In this opinion, we have considered the likelihood of adverse effects to ESA-listed species and designated critical habitat as an incidental result of the SWFSC conducting research throughout the CCE, ETP, and Antarctic research areas. The following species were determined likely to be adversely affected as a result of incidental capture or entanglement with SWFSC survey gear: leatherback sea turtle (*Dermochelys coriacea*); loggerhead sea turtle (*Caretta caretta*; North Pacific Ocean Distinct Population Segment, or DPS); olive ridley sea turtle (*Lepidochelys olivacea*); green sea turtle (*Chelonia mydas)*; Pacific eulachon (*Thaleichthys pacificus*; Southern DPS); scalloped hammerhead shark (*Sphyrna lewini*; Eastern Pacific DPS); Chinook (*Oncorhynchus tshawytscha*; Sacramento River winter Evolutionary Significant Unit, or ESU; Central Valley spring ESU; California coastal ESU; Snake River fall ESU; Snake River spring/summer ESU; Lower Columbia River ESU; Upper Willamette River ESU; Upper Columbia River spring ESU; and Puget Sound ESU); chum (*Oncorhynchus keta*; Hood Canal summer run ESU; and Columbia River ESU); coho (*Oncorhynchus kistuch*; Central California coastal ESU; S. Oregon/N. California coastal ESU; Oregon Coast ESU; and Lower Columbia River ESU); sockeye (*Oncorhynchus nerka*; Snake River ESU; and Ozette Lake ESU); and steelhead (*Oncorhynchus mykiss*; Southern California DPS; South-Central California DPS; Central California Coast DPS; California Central Valley DPS; Northern California DPS; Upper Columbia River DPS; Snake River Basin DPS; Lower Columbia River DPS; Upper Willamette River DPS; Middle Columbia River DPS; and Puget Sound DPS. No other adverse effects arising from the research actions were identified for any of these species (with the exception of the direct take discussed below). The potential effects of SWFSC research activities on the species listed above are analyzed in the Effects of the Action section 2.6, although additional reference information describing the nature of potential exposure to some stressors can be found in the "Not Likely to Adversely Affect" Determinations section 2.2.

In addition to incidental capture in SWFSC research gear, salmonids are directly targeted for capture in SWFSC survey trawls along the U.S. west coast. This action is being authorized under section 10 of the ESA as directed scientific research. However, the list of ESA-listed salmon affected and the nature of the impacts associated with incidental or directed take of salmon in SWFSC trawl surveys are so similar that we combine incidental and directed impacts on salmonids from SWFSC survey trawls into one effects analysis in this opinion.

2.2 ESA-listed Species Not Likely to be Adversely Affected

The proposed action is not likely to adversely affect the blue whale (*Balaenoptera musculus*), fin whale (*Balaenoptera physalus*), humpback whale (*Megaptera novaeangliae*), sei whale (*Balaenoptera borealis*), sperm whale (*Physeter macrocephalus*), killer whale (*Orcinus orca;* Southern Resident DPS), gray whale (*Eschrichtius robustus*; Western North Pacific DPS), North Pacific right whale (*Eubalaena japonica*), Guadalupe fur seal (*Arctocephalus townsendi*), vaquita (*Phocoena sinus*), southern right whale (*Eubalaena australis*), hawksbill sea turtle (*Eretmochelys imbricate*), green sturgeon (*Acipenser* medirostris), canary rockfish (*Sebastes pinniger*; Puget Sound/Georgia Basin DPS), totoaba (*Totoaba macdonaldi*), white abalone (*Haliotis sorenseni*), black abalone (*Haliotis cracherodii*), and coral spp. The proposed action is also not likely to adversely affect the designated critical habitats of Steller sea lion (*Eumetopias jubatus*[7]), green sturgeon, or leatherback sea turtles. These analyses are found in the "Not Likely to Adversely Affect" Determinations section (2.2.1). Critical habitat for other species, such as ESA-listed salmonids, has not been designated in marine waters that overlap with the action area of this proposed action, and are not considered further in this opinion.

2.2.1 "Not Likely to Adversely Affect" Determinations

Under the ESA, "effects of the action" means the direct and indirect effects of an action on the listed species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action (50 CFR 402.02). The applicable standard to find that a proposed action is not likely to adversely affect listed species or critical habitat is that all of the effects of the action are expected to be discountable, insignificant, or completely beneficial. Beneficial effects are contemporaneous positive effects without any adverse effects to the species or critical habitat. Insignificant effects relate to the size of the impact and should never reach the scale where take occurs. Discountable effects are those extremely unlikely to occur.

We do not anticipate the proposed action will adversely affect blue whales, fin whales, humpback whales, sei whales, sperm whales, Southern Resident killer whales, Western North

[7] The eastern DPS of Steller sea lion was delisted on November 4, 2013 (78 FR 66140); however their critical habitat still remains designated.

Pacific gray whales, Guadalupe fur seals, North Pacific right whales, Southern right whales, vaquita, green sturgeon (southern DPS), yelloweye rockfish (Puget Sound/Georgia Basin DPS), boccacio (Puget Sound/Georgia Basin DPS), canary rockfish (Puget Sound/Georgia Basin DPS), totoaba, white abalone, or black abalone. NMFS also does not anticipate that the proposed action is likely to adversely affect any designated critical habitats for ESA-listed species, including Steller sea lions, green sturgeon, and leatherback sea turtles.

In our effects analysis, we identified four potential stressors as a result of SWFSC survey activities: direct capture or interactions with survey gear; vessel collisions; potential disturbance or injury from acoustic sources; and removals of prey. In this section, we will analyze each species or species group as applicable relative to all four of these potential stressors. In terms of potential effects on designated critical habitats, potential impacts from SWFSC research activities are centered on removals of prey during research conducted within those designated habitats. For the species identified in section 2.1 as likely to be adversely affected by the actions, we detail the effects analysis in section 2.6.

2.2.1.1 Marine Mammals

One important limitation of the analysis of potential impacts to ESA-listed marine mammals conducted by the SWFSC in the DEA, especially related to the MMPA Level B harassment exposure analysis, is that the density estimates underlying take calculations presumed a uniform distribution of animals throughout the ecosystems, while in reality for more species they are considerably patchy, and are dynamic throughout the course of a year. The use of vertical stratification and volumetric density (described in Appendix C of DEA) is an improvement over simple geographical density estimates, although a homogenous distribution (in three dimensions) is still used. In considering the likely exposure of ESA-listed marine mammals to SWFSC research activities, especially the use of active acoustic sources, there are several additional important details related to some ESA-listed species that influence the exposure analysis for those species that we outline below before consideration of each potential stressor.

Vaquita

The vaquita's distribution is restricted to the upper portion of the northern Gulf of California, mostly within the Colorado River delta. They are commonly seen between San Felipe Bay and Rocas Consag in the western upper portion of their range (Jefferson et al. 2008). The SWFSC research in the ETP does not typically extend into far northern portion of the Gulf of California, unless specific directed research on vaquitas is being conducted. Since their distribution does not overlap with the SWFSC research activity being considered in this opinion, the SWFSC did not estimate any MMPA Level B harassment of them and did not request any incidental take authorization for them under the MMPA. As a result, we conclude that effects to vaquitas, acoustic or otherwise, are unlikely to occur.

North Pacific right whale

The migratory patterns of the North Pacific right whale are largely unknown, although it is thought the whales spend the summer on high-latitude feeding grounds and migrate to more temperate waters during the winter. In U.S. waters, North Pacific right whales occurred historically off the U.S. west coast (Scarff 1986; Clapham et al. 2004). However, despite a number of systematic ship and aircraft-based surveys for marine mammals off the U.S. west coast, only seven documented sightings of right whales were made from 1990 through 2000 (Waite et al. 2003). Among these was the sighting of a single right whale in waters off the coast of Washington (Green et al. 1992; Rowlett et al. 1994). Research and monitoring studies conducted from October 2008 through August 2012 by the Navy-funded SOCAL program yielded no right whale sightings. Clapham et al. (2006) observed that although the historic distribution of North Pacific right whales is significantly reduced, the waters of the western Gulf of Alaska and the Bering Sea remain critical habitat for this depleted species throughout most of the year as this area is where almost all recent detections or observations of North Pacific Right whales occur. Research conducted by the SWFSC in the California Current Ecosystem extends only to about the U.S. Canadian border. While it is possible that North Pacific right whales could be present in the proposed action area, it is unlikely that the SWFSC will encounter this species given what has been observed recently, and the fact that the majority of SWFSC research occurs during the spring, summer, and fall when these whales are most likely to be in the waters of Alaska and the Bering Sea. Consequently, the SWFSC did not estimate any MMPA Level B harassment of them and did not request any incidental take authorization for them under the MMPA. As a result, we conclude that effects to North Pacific right whales, acoustic or otherwise, are extremely unlikely to occur.

Eastern DPS Steller sea lion

Steller sea lion – The Eastern DPS of Steller sea lions was delisted in November, 2013 (78 FR 66139). Individuals from this population are expected to be exposed to SWFSC research activities in the California Current Ecosystem. The Western DPS, which includes Steller sea lions that reside in the central and western Gulf of Alaska, Aleutian Islands, as well as those that inhabit the coastal waters and breed in Asia (e.g., Japan and Russia,) remain listed as endangered. Any Steller sea lions that will be exposed to SWFSC research activities will be from the eastern stock. Therefore, they will not be considered any further in this opinion. However, designated critical habitat for Steller sea lions currently remains in place in the California Current Ecosystem, and potential impacts from SWFSC research activities to this designated critical habitat are considered in this opinion (see section 2.2.5.1).

Western North Pacific gray whales

There are two recognized gray whale stocks in the North Pacific, the eastern North Pacific (ENP) which is not listed under the ESA, and the western North Pacific (WNP) which is listed as endangered under the ESA. Historically, the WNP gray whales were considered geographically isolated from the ENP stock; however, recent information is suggesting more overlap exists between these two stocks with WNP gray whales migrating along the U.S. west coast along with ENP gray whales. Two WNP gray whales have been satellite-tracked from Russian foraging areas east along the Aleutian Islands, through the Gulf of Alaska, and south past the coasts of Washington and Oregon to the southern tip of Baja California in one case (Mate et al. 2011) and in the other case, where the satellite tag remained on the animal longer, back to Sakhalin Island (IWC 2012). Comparisons of ENP and WNP gray whale photo-identification catalogs have thus far identified 22-24 WNP gray whales occurring on the eastern side of the basin (IWC 2012; Weller et al. 2011; Burdin et al. 2011). During one field season off Vancouver Island, WNP gray whales were found to constitute 6 of the 74 (8.1%) photo-identifications (Weller et al. 2012). In addition, two genetic matches of WNP gray whales off Santa Barbara, California have been made (Lang et al. 2011). Thus, a portion of the WNP gray whale population is assumed to have migrated, at least in some years, to the eastern North Pacific during the winter breeding season (Burdin et al. 2012; Urban et al. 2012).

The current minimum population estimate for ENP gray whales is 19,126 (Carretta et al. 2014). The most recent estimate of WNP gray whale abundance is 137 individuals (IWC 2012). At any given time during the migration, WNP gray whales could be part of the approximately 20,000 gray whales migrating through the California Current Ecosystem. However, the probability that any gray whale interacting with SWFSC research would be a WNP gray whale is extremely small - less than 1% even if the entire population of WNP gray whales were part of the annual gray whale migration. Consequently, the likelihood that any gray whale that interacts with SWFSC research would be a WNP gray whale is extremely low. In addition, gray whale migration is typically limited to relatively near shore areas along the North American west coast during the winter and spring months (November-May). The SWFSC estimates of gray whale exposure to active acoustics were based on a single gray whale density estimate applied across the entire project area with no consideration of proposed project timing. In actuality, very little of the SWFSC research occurs within near shore coastal waters where gray whales migrate through, and much of it occurs outside of the primary annual gray whale migration period (Appendix B in DEA). Although it has not been quantified, we conclude that the exposure of gray whales to active acoustic sources is likely less than what was estimated in the DEA. However, since we cannot discount the potential overlap between SWFSC research and WNP gray whales, we will consider them further in this analysis.

Southern Resident killer whales

In the North Pacific Ocean, three types of killer whales are recognized: "resident", "transient", and "offshore" (Bigg et al. 1990; Ford et al. 2000). The Southern Resident killer whale DPS (SRKW) was listed as endangered under the ESA in 2005 (70 FR 69903; November 18, 2005). The population consists of three pods, referred to as J, K, and L pods. The current population estimate is 79 whales as of July 2014[8]. In November 2006, NMFS designated critical habitat for SRKWs, based primarily on their known distribution during summer and fall. Critical habitat for the Southern Resident killer whale DPS includes approximately 2,560 square miles of inland waters of the Salish Sea in three specific areas: 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. All three pods reside for part of the year in the inland waterways of Washington State and British Columbia (Strait of Georgia, Strait of Juan de Fuca, and Puget Sound), where J, K, and L pods typically arrive in May or June and depart in October or November. Historically there has been little information available about their range and distribution during the winter and early spring, although new information is coming to light. SRKWs were formerly thought to range southward along the coast to about Grays Harbor (Bigg et al. 1990) or the mouth of the Columbia River (Ford et al. 2000), in addition to the coastal and inland waters surrounding Vancouver Island. However, over the last decade, observations, acoustic detections, and recent tagging/tracking of SRKWs off Oregon and California has extended the southern limit of their known range during the winter, where they have been observed primarily in January, February, and March (NMFS NWFSC data). In January, 2013, satellite tracking and observations indicated that members of K pod traveled as far south as Point Reyes, CA, before heading north, completing a round trip from WA/OR coastal waters in about 2 weeks (NWFSC data; http://www.nwfsc.noaa.gov/research/divisions/cbd/marine_mammal/satellite_tagging.cfm). This satellite track has provided the first detailed look of any SRKW movement during the winter.

The estimates of exposure to active acoustic sources during SWFSC research for killer whales were based on density estimates for killer whales of all ecotypes. As mentioned before, most SWFSC research activity along the California Current Ecosystem does not occur during the winter and spring when SRKWs may be found in coastal waters outside of the inland WA and British Columbia. Furthermore, the overlap of SWFSC research that does occur during the winter months in coastal areas north of San Francisco is relatively low. Given the relative distribution of the SWFSC and the various ecotypes of killer whales, encounters will most likely represent killer whales that belong to non-ESA-listed populations such as "offshore" or "transient". Based on these factors, we conclude that the exposure of SRKWs to active acoustic sources is likely far less than what was estimated generally for killer whales by the SWFSC. However, the SWFSC does incidentally and directly capture important prey species for SRKWs

[8] Annual census: http://www.whaleresearch.com/research.html

during research activities, such as Chinook salmon. Since we cannot discount potential interaction between SWFSC research and SRKWs, we will consider them further in this analysis.

2.2.1.1.1 Incidental Capture or Entanglement

SWFSC research surveys have documented captures/entanglements of marine mammals in survey trawls and longline survey gear. From 2008-2012, the SWFSC captured or entangled a total of 58 marine mammals during the trawl research activities that are considered in this opinion; mostly Pacific white-sided dolphins and California sea lions during the CPS surveys (see Appendix C Table 6.1 *in* DEA for the SWFSC marine mammal bycatch history). They also capture/entangled 5 California sea lions during HMS and Thresher Shark pelagic longline surveys. However, no ESA-listed marine mammal species have ever been reported captured/entangled during any SWFSC research activity. As a result, the SWFSC did not request any Level A injury/mortality takes under the MMPA for any ESA-listed marine mammals in their LOA application.

For most of the ESA-listed marine mammal species, the risk of incidental capture or entanglement is very low in trawl gear given the slow speed and relatively small size of survey trawls fished at/near the surface. While the bycatch of large whales in commercial trawl fishing gear is not unprecedented, it is not a common event in any U.S. west coast fishery (NMFS observer data), nor would it ever be expected to occur in a SWFSC survey trawl. However, smaller ESA-listed marine mammals, such as Guadalupe fur seals, could be at more risk of capture if they encountered SWFSC survey trawls, as evidenced by the historical capture of other pinnipeds and dolphins. Use of dedicated marine mammal observers prior to and during survey trawl operations should help research vessels identify the presence of ESA-listed marine mammals during operations, and vessels can take necessary evasive action. Use of marine mammal excluder devices should also help any smaller ESA-listed marine mammal escape relatively unharmed if they do enter a trawl net.

The risk of ESA-listed marine mammals becoming captured/entangled in longline survey gear also exists. Risks of interactions between longline gear and ESA-listed marine mammals include hooking or entanglement with the gear, especially for pelagic longlines. These interactions could result from direct predation of bait or depredation on fish that are already captured by the longline, or by unknowingly swimming into the gear and becoming entangled. Bottom longlines do present some risk of entanglement due to vertical lines running from the surface to the bottom, but gangions and hooks are relatively low in profile on the bottom and likely less vulnerable to hooking or predation by marine mammals than the profile of hooks suspended in the water column in pelagic longline gear. Entanglement of ESA-listed marine mammals, including some species of whales, is known to be an issue with commercial fishing gear on the U.S. west coast (Saez et al. 2013), although usually associated with fixed pot/trap and gillnet gear. Smaller species of marine mammals, such as pinnipeds and dolphins, maybe more vulnerable to capture in longline fishing gear based on past takes by the SWFSC and other generally available commercial fishing bycatch data (NMFS observer data). Compared to commercial longline fishing gear operations, SWFSC research gear is typically shorter in length, uses less hooks, and soaks for less time. This may contribute to the lack of ESA-listed marine mammal bycatch that has occurred historically during SWFSC research activities. Unlike with sea turtles, where the use of longline fishing gear in the ETP is expected to increase the exposure and risks of sea turtle bycatch generally, there is no clear expectation that longline effort in the ETP will be any more or less likely to interact with ESA-listed marine mammals. The CCE is an area of relative high density use for most all of the ESA-listed marine mammal species that may be affected by SWFSC research, so other than increasing the overall amount of total longline effort, additional effort in the ETP is not expected to be associated with any significant increase in interaction rates for these species. Use of dedicated marine mammal observers prior to and during longline survey operations is expected to help research vessels identify the presence of ESA-listed marine mammals, and act accordingly to minimize incidental capture and entanglement risks.

The prediction of future events occurring that have never occurred before, given that no incidental captures or entanglements with ESA-listed marine mammals has ever been documented, is challenging because these risks cannot be completely eliminated. At this time, we conclude that the lack of historical incidental capture or entanglements between survey gear and ESA-listed marine mammals species, even when risks of such interactions have been and continue to remain possible, is a reflection that the mitigation measures that have been used in the past and are expected to be used in the future are effective, either individually or in total, at minimizing the likelihood of these events happening. Any future take events could change this assessment, but until that time, given the historical performance of SWFSC research activities, we conclude that the likelihood of incidental capture or entanglement of ESA-listed marine mammals is discountable

2.2.1.1.2 Vessel Collisions

Collisions of ships and marine mammals can cause major wounds, which may lead to the death of the animal. An animal at the surface could be struck directly by a vessel, a surfacing animal could hit the bottom of a vessel, or an animal just below the surface could be cut by a vessel's propeller. The severity of injuries typically depends on the size and speed of the vessel (Knowlton and Kraus 2001; Laist et al. 2001; Vanderlaan and Taggart 2007).

No marine mammals are likely to be injured or killed by collisions with SWFSC research vessels. The probability of vessel and marine mammal interactions occurring during SWFSC research operations is negligible due to the vessel's slow operational speed, which is typically 4 knots or less. Outside of operations, each vessel's cruising speed would be approximately 10 knots in transit, which is below the speed at which studies have generally noted reported increases in marine mammal injury or death from collisions (~ 14 knots; Laist et al. 2001). During cruises, the SWFSC maintains constant watch and will slow down or take evasive maneuvers to avoid collisions with marine mammals or other species. The officer on watch, Chief Scientist (or other designated member of the Scientific Party), and crew standing watch on the bridge visually scan for marine mammals, sea turtles, and other ESA-listed species (protected species) during all daytime operations. Bridge binoculars (7X) are used as necessary to survey the area as far as environmental conditions (lighting, sea state, precipitation, fog, etc.) will allow (section 1.3.4). At any time during a survey or in transit, any crew member that sights any marine mammals that may intersect with the vessel course immediately communicates their presence to the bridge for appropriate course alteration or speed reduction as possible to avoid incidental collisions, particularly with large whales (e.g., blue whales).

There is still a potential for vessels to strike marine mammals while traveling at slow speeds or during periods of reduced visibility, such as at night. For example, a NOAA contracted survey vessel traveling at low speed while conducting multi-beam mapping surveys off the central California coast struck and killed a female blue whale in October 2009. Considering this slow speed and the continual bridge watches/observation for marine mammals during all ship operations, the SWFSC believes that the vessels will be able to change course if any marine mammal is sighted in the line of vessel movement and avoid a strike. In the case of SWFSC vessels, we anticipate that vessel collisions with marine mammals are rare, unpredictable events for which there are no additional reasonable preventive measures. Even under the remote chance that a strike occurs by a SWFSC research vessel, it is less likely to result in mortality if operating at relatively slow speeds of 10 knots or less (Laist et al. 2001). As a result, we conclude the risk of adverse effects to ESA-listed marine mammals as a result of collisions with SWFSC research vessels is discountable.

2.2.1.1.3 Exposure to Noise

Exposure to loud noise is one of the potential stressors to marine species as noise and acoustic influences may seriously disrupt communication, navigational ability, and social patterns. In particular, marine mammals rely substantially upon sound to communicate, navigate, locate prey, and sense their environment. Given the known sensitivities of marine mammals to sound, Southall et al. (2007) provided a comprehensive review of marine mammal acoustic sensitivities including designating functional hearing groups. Assignment to these groups was based on behavioral psychophysics (the relationship between stimuli and responses to stimuli), evoked audiometry potential, auditory morphology, and, for pinnipeds, whether they were hearing through air or water. Because no direct measurements of hearing exist for baleen whales, hearing sensitivity was estimated from behavioral responses (or lack thereof) to sounds, commonly used vocalization frequencies, body size, ambient noise levels at common vocalization frequencies, and cochlear measurements. Table 4 presents the functional hearing groups and representative species or taxonomic groups for each; most ESA-listed marine mammals found in the proposed project areas are in the first two groups, low frequency cetaceans (baleen whales) and mid frequency cetaceans (odontocetes).

Table 4. Summary of the five functional hearing groups of marine mammals.

Functional Hearing Group	Estimated Auditory Bandwidth	Species or Taxonomic Groups
Low Frequency Cetaceans (Mysticetes–Baleen whales)	7 Hertz (Hz) to 22 kilohertz (kHz) (best hearing is generally below 10 kHz, sensitivity to higher frequencies associated with humpback whales)	All baleen whales
Mid- Frequency Cetaceans (Odontocetes—Toothed whales)	150 Hz to 160 kHz (best hearing is from approximately 10-120 kHz)	Includes species in the following genera: Steno, Tursiops, Stenella, Delphinus, Lagenodelphis, Lagenorhynchus, Lissodelphis, Grampus, Peponocephala, Feresa, Pseudorca, Orcinus, Globicephala, Physeter, Hyperoodon, Ziphius, Berardius, Mesoplodon
High-frequency Cetaceans (Odontocetes)	200 Hz to 180 kHz (best hearing is from approximately 10-150 kHz)	Includes species in the following genera: Phocoena, Phocoenoides, Kogia, Cephalorhynchus
Pinnipeds in water	75 Hz to 75 kHz (best hearing is from approximately 1-30 kHz)	All seals, fur seals, sea lions
Pinnipeds in air	75 Hz to 30 kHz (best hearing is from approximately 1-16 kHz)	All seals, fur seals, sea lions

2.2.1.1.3.1 Active Acoustics Footprint and the MMPA LOA Application

The DEA used to support an application for incidental take authorizations under the MMPA took a dual approach in assessing the impacts of high-frequency active acoustic sources used in fisheries research in three different geographical areas where it operates these devices (California Current, Eastern Tropical Pacific, and the Antarctic). The first approach was a qualitative assessment of potential impacts across marine mammal species and sound types. This analysis considers a number of relevant biological and practical aspects of how marine mammal species likely receive and may be impacted by these kinds of sources. The second approach was a quantitative estimate of the number of marine mammals that could be exposed to sound levels that might reach harassment thresholds under the MMPA based on estimated densities and the size of the sound fields produced by active acoustic sources. This assessment (described in greater detail in Appendix C of the DEA) considered the best available current scientific information on the impacts of noise exposure on marine life and the potential for the types of acoustic sources used in SWFSC surveys to have behavioral and physiological effects.

Table 1 in section 1.3 characterizes the general source parameters for the primary SWFSC vessels operating active acoustic sources (Appendix A of the DEA). This enables a full assessment of all sound sources, including those that are entirely outside the range of marine mammal hearing (> 180 kHz; Table 4 above). Auditing of the active sources also enables a determination of the predominant sources that, when operated, would have sound footprints exceeding those from any other simultaneously used sources. Among those sources operating within the audible band of marine mammal hearing, five predominant sources are identified as having the largest potential impact zones during operations, based on their relatively lower output frequency, higher output power, and their operational pattern of use. These sources are effectively those used directly in acoustic propagation modeling to estimate the zones within which received sound levels in excess of the current thresholds for Level B marine mammal harassment under the MMPA[9] (> 160 dB re 1 µPa RMS (root mean square) for impulsive sound sources[10]) would occur. During this evaluation process, the SWFSC concluded that injury (Level A harassment) was unlikely given the relatively brief acoustic exposures to potentially injurious sound levels (> 180 dB RMS for cetaceans; >190 dB RMS for pinnipeds) that would be expected, if any at all (see section 4.2.4 in DEA Appendix C for a full explanation). As a result, the SWFSC applied only for incidental Level B harassment take authorization under the MMPA resulting from active acoustic sources, and no incidental Level A injury take authorizations. This MMPA LOA application is for marine mammals protected by the MMPA and is not limited to marine mammals also protected by the ESA.

In the MMPA LOA application, the SWFSC calculated the ensonified areas along with density estimates and information regarding likely depth distributions to produce an estimate of the number of incidents that marine mammal species may be exposed to Level B harassment in each survey area (methodology described in section 7.2 *in* DEA Appendix C). Table 5 describes the

[9] NMFS has been using the guidelines of 160 dB as the threshold for harassment under the MMPA for impulsive sounds, and 120 dB for continuous sounds.
[10] The sounds produced by active acoustic sources are very short duration (typically less than 10 milliseconds), so even though they are often produced at a regular rate (every few seconds), they are still intermittent, have high rise times, and are operated from moving platforms. Consequently, they are considered impulsive.

estimated levels of Level B harassment under the MMPA for marine mammals also protected under the ESA.[11]

Table 5. Estimates of annual Level B acoustic harassment under the MMPA by survey region.

	# incidents exposed to Level B acoustic harassments		
Species	California Current	ETP	Antarctic
Killer whale*	13	0	0
Sperm whale	65	5	4
Humpback whale	15	1	49
Blue whale	25	2	0
Fin whale	33	0	114
Sei whale	2	0	0
Gray whale*	346	0	0
Guadalupe fur seal	134	0	0
Southern right whale	0	0	1

* Indicates global species and not number of acoustic harassments associated with the ESA-listed components of these species.

As part of mitigation measures being implemented to reduce marine mammal bycatch in research survey trawls, the SWFSC is deploying pingers with variable frequency (5-500 kHz) and duration (100 microseconds to seconds). The pingers generate a maximum sound pressure level of 176 decibels (dB) root mean square (RMS) referenced to 1 micropascal at 1m at 30-80 kHz. By definition, the intention of these pingers is to influence the behavior of marine mammals, including ESA-listed species, to detect and otherwise avoid capture in survey gear. The exact mechanisms of how pingers have contributed to successful deployment and reduction of some marine mammal bycatch in other commercial fishing settings, or if these pingers will contribute to reduced bycatch in survey trawl gear is unclear. Under MMPA 109(h), NMFS is allowed to intentionally harass marine mammals for their own welfare, which is avoidance of bycatch in this case. As a result, the SWFSC does not require any additional exemptions under the MMPA to employ the use of pingers in survey nets. Under the ESA, the action of preempting bycatch events is considered beneficial, as long as no other contemporaneous adverse effects are occurring as a result. At this point, we assume pingers are beneficial in helping to reduce the chances of bycatch for ESA-listed marine mammals, and we have not identified any adverse effect likely to occur as a result of them. The sounds produced by these pingers are at least partially audible to ESA-listed marine mammals in the higher functional hearing groups, but are still well under the levels of sound being produced by other active acoustic equipment used. As

[11] Includes species of marine mammals with ESA-listed stocks or populations even if not distinguished in the MMPA LOA application.

a result, we do not expect these pingers to produce any injurious effects to any ESA-listed species.

2.2.1.1.3.2 ESA Exposure to Active Acoustics

The SWFSC has estimated the potential extent of exposure to active acoustic sources for marine mammals throughout the range of their research activities that considers many technical details regarding sound propagation, as described in the DEA. However, for the sake of being conservative and to avoid confusion and challenges in interpreting possible or likely hearing thresholds for most any given species of marine mammals, the DEA analysis considered all sound produced by these predominant active sources to be audible by all marine mammals. The estimate also relies upon generic use of the MMPA guideline that exposure to received sound levels in excess of 160 dB equates to a meaningful impact under the MMPA.

Among the ESA-listed marine mammals, most of the active acoustic sources may largely be inaudible to baleen whales and pinnipeds, based on the relative high frequencies of those sources, whereas they more likely may be detected by odontocete cetaceans (e.g., sperm whales). The EK60 echo sounder, which is most commonly the dominant source of active acoustic sound coming from SWFSC research vessels, operates at many different frequencies, but predominantly at 38, 70, 120, and 200 kHz. Based on the information regarding functional hearing ranges of marine mammals in Table 4 above, the lower frequency of this echo sounder (38 kHZ) is likely within the hearing range of mid/high-frequency cetaceans (sperm whales and Southern Resident killer whales); within the hearing range but outside the range of best hearing for pinnipeds (Guadalupe fur seals); and, completely outside the hearing capabilities of baleen whales (blue whales, fin whales, humpback whales, sei whales, WNP gray whales, and Southern right whales). The SX90 sonar also operates in a similar range of hearing (20-30 kHz), but is within the upper extent of the hearing range humpback whales at 20 kHz. The middle frequencies of the EK60 and ME70 echo sounders (70-120 kHz) are largely inaudible to pinnipeds, but are still in upper range of mid/high-frequency cetacean hearing. The high-end frequencies of the EK60 (200+ kHz) are likely not audible by any ESA-listed marine mammals. Information that describes the relative amount of time various frequencies are used has not been provided other than in terms of “predominant,” and the SWFSC relied upon the potential use of the low end frequencies of all active acoustic sources to support estimations of Level B acoustic harassment under the MMPA per the generalized guideline of 160 dB. Even without any specific knowledge of precisely how much each frequency may be used, especially the EK60 echo sounder used predominantly throughout all 3 ecosystems under study by the SWFSC, we conclude that baleen whales, with the exception of humpback whales, likely do not detect any of these active acoustic sources, that pinnipeds and humpback whales may detect them occasionally, and that mid/high-frequency cetaceans can detect them to some degree most of the time.

There is recent information that suggests frequencies of sound produced by high frequency active acoustic devices like the ones used by SWFSC research vessels may not be limited to just the operational frequency. Measurements of the spectral properties of sound pulses transmitted by three commercially available 200 kHz echo sounders under typical operation conditions indicated that the sounders were generating sound within the hearing range of some marine mammals; e.g., killer whales, false killer whales, beluga whales, Atlantic bottlenose dolphins, harbor porpoises, and others (Deng et al. 2014). While on the order of 50 dB down in amplitude from the sounders' center frequencies, the level of sound within the hearing range of some marine mammals was found to be above the thresholds for hearing of many marine mammals but well below the levels that might cause physical injury (Deng et al. 2014). In addition, Hastie at al. (2014) recently found that although peak sonar frequencies may be above marine mammal hearing ranges, high levels of sound can be produced within their hearing ranges that elicit behavioral responses for seals; at least within the range of a confined 40 meter pool. These recent studies do support the idea that active acoustics may be more audible to marine life than relying solely upon the operational frequencies, but that ranges of audible sound are likely restricted to relatively short distances from active acoustic sound sources based on the significant reduction in sound amplitude compared to dB levels at center operational frequencies.

Active Acoustics Zone of Influence

When considering impacts to marine mammals from exposure to sound, NMFS generally relies upon sound level thresholds to predict the level of sound exposure at which we might expect either behavioral changes or physical injury to an animal to occur. In this opinion, we use the 160 dB sound level threshold to define the range of exposure to sound levels that could be expected to cause individuals that can detect these sounds to change their behavior in some respect (potential behavioral responses that constitute harassment under the MMPA), or potentially induce temporary or permanent hearing damage (herein referred to as the "zone of influence"). Active acoustic sources are generally aimed downward, and the extent of received sound levels in excess of 160 dB may extend to 1 km in depth below a vessel but only to about 100 meters out to the side of vessels, depending on the frequencies and source sound levels used (see Appendix C *in* DEA for description of sound field propagation). There are operating modes of some active acoustics on some SWFSC research vessels that have capabilities to orient more horizontally, and we assume that the sound levels in excess of 160 dB resulting from SWFSC acoustics could cover an area several hundred meters across the surface of the ocean away from the vessel, as well as the associated water column beneath.

Extent of Exposure During Research Operations

SWFSC research activities generally involve surveys where vessels travel from station to station to deploy survey equipment for data collection or in fairly continuous survey transects for data collection. Many data collections do involve deployment of gear such as trawl or bongo sampling nets for short periods of time, typically 30 minutes or less, usually conducted at fairly slow speeds of 2-4 knots. There are some data collections where vessels stop to deploy sampling equipment such as CTDs or small boats. There are also times where vessels remain stationary (or near-to-stationary) processing samples, tending to sampling gear in the water, or otherwise waiting for initiation of some research activity to commence. Time periods where vessels remain stationary may only last for less than 30 minutes (e.g., collection of CTD sample), although they may also extend many hours (e.g., vessels at rest while longline gear is soaking). There is no information available that can be used to accurately enumerate specific details regarding the extent of how common these events are and how long these events last for any surveys or across the entire spectrum of research. Therefore, for the purposes of this Opinion, we will assume that events where vessels remain stationary occur sometimes throughout SWFSC research operations, probably more during some surveys than others based on the specific operations required, and that these conditions may last for several hours or more, but that they are not expected to continue for more than 24 hours or for multiple days in a row in the exact same location. Based on the information provided, there do not appear to be SWFSC research activities that require such extended stationary periods. There are no specific mitigation measures currently employed to reduce the potential impacts of the use of active acoustics by SWFSC, other than the general measures in place for SWFSC to avoid collisions and otherwise close encounters with marine mammals during research activities (particularly whales), which are expected to reduce the likelihood that animals will come within the immediate vicinity of the vessels and exposure to the near-source sound levels of the active acoustic sources, unless at the discretion of the animal itself.

The majority of the time SWFSC research vessels are moving, either at slow speeds less than 4 knots, or traveling between survey stations or to specific locations at average speeds of about 10 knots. This means that SWFSC research vessels are predominantly transmitting sound in transit, while they pass by any marine life that may be within hearing range of these frequencies (and able to actually hear them). The exposure of any marine mammals to active acoustic sources under these circumstances is going to be temporary, unless those marine mammals elect to follow SWFSC research vessels, or vessels intentionally follow individual marine mammals. The specific duration of exposure will vary according to the hearing capabilities of specific marine mammal individuals, the nature of the sound source involved (frequency, source level, etc.) and the speed of the vessels during activities. However, we generally conclude that exposures where animals would remain within the "zone of influence" of the active acoustic sources (within a few hundred meters) would be for only very short durations on the order of minutes for vessels in motion even at relatively slow sampling speeds, as opposed to individuals forced to continual exposure to active acoustics at close proximity over multiple hours or days.

For example, a vessel traveling at 2 knots is covering a distance of about 300 meters in the water over a 5 minute period. During the 30 minutes that SWFSC vessels may be engaged in sampling at fairly slow speeds, vessels are expected to cover almost 1 km. A vessel traveling at 10 knots covers about 300 meters in about 1 minute, and over 4.5 km during 15 minutes. Therefore, we assume that exposures to active acoustic sources for any individual marine mammals, especially within near proximity as vessels are in transit, are short term in duration. In addition, we expect that marine mammals will avoid SWFSC research vessels when they are in close proximity, even during periods of time when vessels remain stationary; to the extent they find the active acoustics or other properties of SWFSC vessel activities disturbing (see below in section 2.2.1.1.3.3). This should further reduce the duration and extent of exposure to sound levels for ESA-listed marine mammals.

SWFSC surveys generally involve covering relatively large study areas that require fairly continuous movements across large areas. Even finer scale surveys which may occur within relative small survey areas, or activities where SWFSC vessels remain stationary for a period of time, are not expected to be confined to the exact same area during the course of more than an entire day, or over multiple days, where it would be appropriate to consider them stationary within a single "zone of influence" of potentially disturbing sound levels for an extended period of time. As result, SWFSC research does not involve activities that are repeated in the exact same area over several days or weeks. Consequently, any acoustic disturbance of an area for any individuals that may be found in an area by a SWFSC research vessel is temporary and not expected to be repetitive. In order for longer term or more sustained exposure to active acoustic sounds for any individual marine mammals to occur, they would need to be in a migratory or foraging movement pattern closely aligned to the survey patterns of SWFSC research vessels, which is unlikely given the shape and scale of most SWFSC research surveys. In addition, likely behavioral responses including temporary avoidance of SWFSC vessels are expected to preclude sustained and/or repetitive exposures, even during periods of stationary SWFSC activity (see below).

2.2.1.1.3.3 Active Acoustics Response and Risk

Potential Response from Exposure

Based on the characterization of active acoustic sounds sources, we conclude that some of the sources used are likely to be entirely inaudible to all marine mammal species (other than maybe in the immediate vicinity of sound sources) including the ESA-listed species considered in this opinion. We also conclude that some of the lower frequencies may be detectable over moderate distances from sound sources for some ESA-listed species, although this depends strongly on inter-specific differences in hearing capabilities. Based on past studies and observations, we consider that sounds generated by active acoustic sources used during SWFSC research activities could cause the following possible impacts or responses: temporary behavioral disturbance; masking of natural sounds; temporary or permanent hearing impairment; or non-auditory physical or physiological effects (Richardson et al. 1995; Gordon et al. 2004; Nowacek et al. 2007; Southall et al. 2007).

Marine mammals may behaviorally react to sound when exposed to anthropogenic noise. Disturbance includes a variety of effects, including subtle to conspicuous changes in behavior, movement, and displacement. Controlled experiments involving exposure to loud impulse sound sources (typically low frequency) with captive marine mammals showed pronounced behavioral reactions, including avoidance of loud sound sources. Observed responses of wild marine mammals to loud pulsed sound sources (typically seismic airguns or acoustic harassment devices, or impact pile-driving) have been varied but often consist of avoidance behavior or other behavioral changes suggesting discomfort (see Nowacek et al. 2007 and Southall et al. 2007 for reviews). The exposure to active acoustic sources could result in temporary, short-term changes in an animal's typical behavior and/or avoidance of the affected action area. While low frequency cetaceans (e.g., blue whales) have been observed to respond behaviorally to low- and mid-frequency sounds, there is little evidence of behavioral responses in these species to high frequency sound exposure (see e.g., Jacobs and Terhune 2002; Kastelein et al. 2006). Sperm whales have been observed to interrupt their activities by frequently stopping echolocation and leaving the area in the presence of underwater pulses made by echosounders and military submarine sonar near where the sperm whales are located (Watkins and Schevill 1975; Watkins et al. 1985).

The term masking refers to the inability of a subject to recognize the occurrence of an acoustic stimulus as a result of the interference of another acoustic stimulus (Clark et al. 2009). Introduced underwater sound may, through masking, reduce the effective communication distance of a marine mammal species if the frequency of the source is close to that used as a signal by the marine mammal, and if the anthropogenic sound is present for a significant fraction of the time (Richardson et al. 1995). Masking can interfere with detection of acoustic signals such as communication calls, echolocation sounds, and environmental sounds important to marine mammals. Therefore, under certain circumstances, marine mammals whose acoustic sensors or environment are being severely masked could also be impaired from maximizing their performance fitness in survival and reproduction.

Marine mammals exposed to high intensity sound repeatedly or for prolonged periods can experience hearing threshold shift, which is the loss of hearing sensitivity at certain frequency ranges (Kastak et al. 1999; Schlundt et al. 2000; Finneran et al. 2002, 2005). Threshold shift can be permanent (PTS), in which case the loss of hearing sensitivity is not recoverable, or temporary (TTS), in which case the animal's hearing threshold would recover over time (Southall et al. 2007). Marine mammals depend on acoustic cues for vital biological functions (e.g., orientation, communication, finding prey, avoiding predators); thus, PTS or TTS may result in reduced fitness in survival and reproduction. However, the impact of TTS depends on the frequency and duration of TTS, as well as the biological context in which it occurs. TTS of limited duration, occurring in a frequency range that does not coincide with that used for recognition of important acoustic cues, would have little to no effect on an animal's fitness. Repeated sound exposures that lead to TTS could cause PTS. PTS, in the unlikely event that it occurred, would constitute injury, but TTS is not considered injury (Southall et al. 2007).

Non-auditory physiological effects or injuries that theoretically could occur in marine mammals exposed to strong underwater sound include stress, neurological effects, bubble formation, resonance, and other types of organ or tissue damage (Cox et al. 2006; Southall et al. 2007). Studies examining such effects are limited, however. In general, very little is known about the potential for strong underwater sounds to cause non-auditory physical effects in marine mammals. Such effects, if they occur at all, would presumably be limited to short distances from the sound source and to activities that extend over a prolonged period.

Response and Risk Analysis

There is relatively little direct information about behavioral responses of marine mammals exposed to loud sound, including odontocetes, but the responses that have been measured in a variety of species to audible suggest that the most likely behavioral responses (if any) would be short-term avoidance behavior of the active acoustic sources sounds (see Nowacek et al. 2007; Southall et al. 2007 for reviews). Due to the expected short term duration of exposure to active acoustic sources, in conjunction with the likely avoidance response of individuals, the risks of adverse effects to ESA-listed marine mammals are discountable.

Temporary or Permanent Hearing Loss, Physical Injury, and Masking

As discussed in more detail (see DEA section 4.2.4 and Appendix C), current scientific information supports the conclusion that direct physiological harm is quite unlikely. Southall et al. (2007) provided a number of extrapolations to assess the potential for permanent hearing damage (permanent threshold shift or PTS) from discrete sound exposures and concluded that very high levels (exceeding 200 dB re: 1µPa received sound pressure levels) would be required; typically quite large TTS is required (shift of ~40 dB) to result in PTS from a single exposure. Lurton and DeRuiter (2011) modeled the potential impacts (PTS and behavioral reaction) of conventional echosounders on species of marine mammals. They estimated PTS onset at typical distances of 10 to 20 meters at most for the kinds of sources in the fisheries surveys considered here. They also emphasized that these effects would very likely only occur in the cone ensonified below the ship and that animal responses to the vessel itself at these extremely close ranges would very likely influence their probability of being exposed to these levels. They conclude that, while echosounders may transmit at high sound pressure levels, the very short duration of their pulses and their high spatial selectivity make them unlikely to cause damage to marine mammal auditory systems.

NMFS also considered the potential for non-auditory physical effects resulting from exposure to active acoustic sources. The available data do not allow identification of a specific exposure level above which non-auditory physical effects can be expected (Southall et al. 2007), or any meaningful quantitative predictions of the numbers (if any) of marine mammals that might be affected in those ways. Marine mammals that show behavioral avoidance of loud sounds are especially unlikely to incur any non-auditory physical effects when they do not allow themselves to be exposed to loud sounds at close proximity for any extended period of time.

The potential for direct physical injury from these types of active acoustic sources is low, but there is a low probability of temporary changes in hearing (masking and even temporary threshold shift) from some of the more intense sources in this category. Recent measurements by Finneran and Schlundt (2010) of TTS in mid-frequency hearing cetaceans from high frequency sound stimuli indicate a higher probability of TTS in marine mammals for sounds within their region of best sensitivity; the TTS onset values estimated by Southall et al. (2007) were calculated with values available at that time and were from lower frequency sources. Thus, there is a potential for TTS from some active sources, particularly for mid/high-frequency cetaceans. However, even given the more recent data, animals would have to be relatively close and remain near sources for many repeated pings to receive overall exposures sufficient to cause TTS onset (DEA; Lucke et al. 2009; Finneran and Schlundt 2010). If behavioral responses typically include the temporary avoidance that might be expected (see below), the potential for auditory effects considered physiological damage (injury) or TTS is extremely low so as to be discountable in relation to realistic operations of these devices.

In order for negative impacts associated with masking to occur, we would expect that important sounds associated with echolocation, communication, or other environmental cues would likely need to occur over a sustained period of time in order to produce a discernable or detectable effect on health or fitness of an individual that would constitute an adverse effect under the ESA.[12] Largely these active acoustic sources do not overlap well with any other sounds that are important to species other than mid/high-frequency cetaceans such as sperm whales and killer whales, although the lower ranges of SWFSC active acoustics are likely detectable by humpback whales and pinnipeds as well. Even for these species that can detect the use of high frequency active acoustics, it does not seem likely that the duration of exposure would last long enough to produce significant adverse effects related to masking of important biological or environmental

[12] In this opinion, we use the concept of "fitness" to describe biological functions and behaviors that ultimately lead to survival and reproduction. Our analyses in this opinion evaluate the effects of the action on the fitness of individuals.

cues. Given that SWFSC research vessels are not expected to remain in the same area for multiple days and weeks, any masking of communication or other sounds will be temporary, and animals would be expected to either continue those communications while avoiding SWFSC vessels and/or resuming them in the area shortly after the departure of those vessels.

In summary, we do not expect the project to result in any cases of temporary or (especially) permanent hearing impairment, any significant non-auditory physical or physiological effects, or significant effects as a result of masking. Most likely, if any ESA-listed marine mammals detect active acoustic sound sources at all, they are likely to show some temporary avoidance of the proposed action area where received levels of sound are high enough that hearing impairment could potentially occur. In those cases, the avoidance responses of the animals themselves would reduce or (most likely) avoid the significant effects that may only occur during extended exposures at close proximity to these sounds. Therefore, we conclude the risks of hearing impairment, non-auditory physical injuries, and adverse effects from masking resulting from exposure to active acoustics are discountable.

Temporary Behavioral Disturbance

If a marine mammal does react briefly to an underwater sound by changing its behavior or moving a small distance, the impacts of the change are unlikely to result in a change to the individual's fitness. However, if a sound source displaces marine mammals from an important feeding or breeding area for a prolonged period, impacts on individuals and populations could be more significant. Although we expect that some behavioral disturbance as a result of the proposed action could occur as individuals may avoid vessels, we expect that this disturbance would be localized to a relatively small area surrounding a research vessel, and would last only a short time because vessels are expected to be moving through and away from areas at the same time marine mammals might be simultaneously avoiding those vessels. Even if vessels are stationary for a period of time, we expect animals to move away from the "zone of influence" to avoid the disturbing sound. The distance required to escape this area is going to be on the order of a few hundred meters, based on the sound profile described in the DEA. Movement of this distance is expected to occur relatively quickly in a matter of minutes, in contrast to disturbance leading to movements of great distances that last for require extended periods of hours or days for animals to complete. Observations of marine mammals and tracking data support that movement at this scale is well within their normal daily activity. If individuals were in transit somewhere along a migration, for instance, which for many ESA-listed marine mammals could mean relatively long distances, the increased distance required to go around the area of potentially disturbing sound is likely to be insignificant and undetectable to the fitness of these animals. Typically within a matter of minutes, and occasionally lasting a period of hours, we expect sound levels surrounding any area that a vessel has occupied or traveled through to return to ambient levels and not be expected to result in continued disturbance of marine mammals extending over period of multiple days or weeks. As a result, we expect that marine mammals would be able to resume any activity that might have been temporarily affected, in the unlikely event that any behaviors were affected to begin with.

Based on the proposed SWFSC research activities and proposed MMPA LOA, incidents of potential exposure to active acoustic sources from SWFSC vessel for ESA-listed species that can likely detect at least some of the active acoustic signals, including sperm whales, killer whales, humpback whales, and Guadalupe fur seals, are most likely to occur in the CCE, and also in the Antarctic for humpback whales. These locations are prime locations for foraging for these species, including areas identified as Biologically Important Areas for humpback whale foraging along the U.S. west coast (Calambokidis et al. 2015). As a result, we conclude that foraging behaviors are most likely to be impacted by the proposed action. Other biologically important behaviors such as breeding are not very likely to be impacted by the proposed action. Sperm whale breeding areas extend from Mexico into the Central Pacific out to Hawaii and up to Alaska, largely out of the confines of CCE and areas where SWFSC research occurs. SRKW breeding typically occurs during spring and summer when SRKWs are expected to be within inland waters. Humpback whales are known to breed in waters along Mexico and the ETP. The anticipated overlap and incidents of exposure for those species with SWFSC in areas of the ETP is very low (Table 5). Guadalupe fur seals breed on Guadalupe Island, which is located in Mexican waters, and exposure to SWFSC active acoustics in the water at or near breeding grounds is not expected to disturb breeding at all.

The net result of any temporary disturbance could be increased energetic expenditure to move and avoid the presence of SWFSC research vessels, or temporary exclusion from an area that might include an important resource such as forage. Although we recognize that an individual could be affected in terms of impact from stress caused by the avoidance or expending of energy to exploit different foraging areas, avoidance of the “zone of influence” leading to single or few movements of a few hundred meters is a relatively minor, energetic expenditure for marine animals that typically spend much of their day moving in search of prey. It is possible that the avoidance behaviors lead to a more directed and expedited movement pattern, but this increased and potentially stressful activity is expected to last no more than a few minutes for an animal to move away and outside the range of the “zone of influence” of disturbing sound. At that point, the energetic expense to escape disturbance, even from a stationary vessel, has been paid, no matter how long the vessel remains in place. Approaches and measures to quantitatively assess the energetic cost of avoidance or other behavior responses in terms of health and fitness of an individual relative to its total energy budget are currently very limited for most marine mammal species, and not available for the ESA-listed marine mammals considered in this opinion, although this is an area of active research. Qualitatively, given the short time period that avoidance behavior is expected in comparison to the normal expenditures that may occur during most any day for an individual, we do not expect an individual to experience a significant depletion of energy reserves. As a result, we expect that any stress or increased energy expenditure to be temporary and have no or a negligible effect on the individual's fitness that exceed the natural variability for animals in the environment. Also, we do not expect this short term disturbance to be significant enough to result in behavioral modifications (e.g., prolonged changes in diving/surfacing patterns, habitat abandonment due to loss of desirable acoustic environment, or more than brief cessation of feeding or social interaction) that would lead to a discernable effect on growth, survival, reproduction, or any aspect of fitness or overall health of individuals.

As part of the analysis of the impact of temporary disturbance, we consider the possible energetic cost of foregone foraging if an animal is disturbed and leaves an area of prey due to avoidance of the "zone of influence" created by SWFSC active acoustics. As described before, the size of the "zone of influence" is an area of only a few hundred meters in diameter of open ocean waters. Although prey resources aren't distributed evenly throughout the ocean, we conclude that the small area of disturbance created by SWFSC research vessels is unlikely to contain a substantially large amount of the total available prey for any individual that would avoid that area compared with the area they can be expected to cover within the course of a day, especially within a highly productive environment where marine mammals are be more likely to be foraging. Our expectation is that individuals will continue moving until they find prey, will resume foraging, likely in adjacent areas unless the extent of available prey is really only confined to the "zone of influence," which is unlikely. Once the vessel moves on, any resources contained within (such that they also remain stationary) will become available again.

Common prey for cetaceans in the action area includes a wide variety of nekton species spanning the water column pelagic, epipelagic, benthopelagic and demersal zones, including krill, squid, and fish. The likelihood for avoidance by potential prey of the "zone of influence" due to temporary exposure to loud sound is largely unknown, but most fish are not expected to be able to detect the high frequency of active acoustic sources (see section 2.6.1.3.2 for discussion of sound and fish). Even if some minor disturbance occurs, a rapid return to normal recruitment, distribution, and behavior is anticipated. Any behavioral avoidance by fish of the disturbed area is expected to be localized to a small area surrounding a vessel moving through and out of an area, leaving significantly large areas of prey and marine mammal foraging habitat in the nearby vicinity which could likely draw large whales away simultaneously from the proposed project activities as well. Given the short duration of sound associated with temporary exposure to active acoustic sources and the relatively small areas being affected at any given time, the proposed action is not likely to have a permanent or significant, adverse effect on any fish habitat, or populations of fish and invertebrate species that are important prey for ESA-listed marine mammals, if they are even able to detect the presence of the SWFSC research activity and active acoustics.

In general, research on the potential biological consequences and relative fitness of marine mammals from behavior changes resulting from disturbance have largely been focused on persistent or chronic sources of disturbance, such as exposure to vessel traffic or installation of more permanent structures, and the impact of sustained changes in behavior that continue over time that could lead to scenarios where energetic requirements are consistently or continuously not met, or important behaviors are significantly altered or abandoned altogether. There is no available evidence linking behavior responses of such limited duration as expected from temporary exposure and avoidance of SWFSC research vessels anticipated here leading to energetic costs or reduced foraging that have a measureable or appreciable impact on growth survival, or reproduction. In a recent biological opinion issued by NMFS regarding the impacts of Navy sonar activity in the Pacific, including areas off of southern California (NMFS 2015), NMFS concluded:

"Even if sound exposure were to be concentrated in a relatively small geographic area over a long period of time (e.g., days or weeks during major training exercises), we would expect that some individual whales would most likely respond by temporarily avoiding areas where exposures to acoustic stressors are at higher levels… However, given these animal's mobility and large ranges, we would expect these individuals to temporarily select alternative foraging sites nearby until the exposure levels in their initially selected foraging area have decreased. Therefore, even temporary displacement from initially selected foraging habitat is not expected to impact the fitness of any individual animals because we would expect similar foraging to be available in close proximity. Because we do not expect any fitness consequences from any individual animals, we do not expect any population level effects from these behavioral responses…"

While the activities and exposure levels expected from different actions aren't directly comparable for many reasons, we find the conclusions above to be consistent with the analysis of expected impacts from temporary exposure for the proposed action considered in this opinion. We believe there is a much higher risk of significant impacts to ESA-listed marine mammals when exposures to disturbance or disruption of behaviors are repeated and sustained, especially if these circumstances occurred within areas where the distribution of animals is confined and opportunities to avoid disturbance and/or locate other available preferred habitat may be restricted. It is possible that an individual could receive multiple exposures to SWFSC active acoustics over time, either by encountering the same vessel again as the boats and whales continue moving around (different than whales or vessels actually following each other around), or a different SWFSC research vessel conducting a different survey at another time and/or place. Based on the temporary nature of any behavioral reaction or impact that each encounter is expected to result in, and that these events will likely be separated in space and time, we conclude that those incidents can be considered isolated where animals have resumed activities and recovered from any previous temporary exposure. Considering the relatively low total number of instances of exposures to potentially disturbing sound levels each year that have been predicted for ESA-listed marine mammals that may be able to detect the active acoustics as a result of the proposed action (e.g., 65 sperm whale exposures in the CCE; Table 5) and the large extent of area that SWFSC covers during the course of a year, we conclude it is extremely unlikely that any individual will accumulate a large number of exposures to SWFSC research vessels over the course of a year, and that exposure will dispersed throughout the population over the range of SWFSC activities.

Alternatively, it is possible that marine mammals may elect to remain in the "zone of influence" despite the sound levels due to sufficient impetus to remain in that area to continue foraging in the presence of a desired prey field. While these animals may be subject to exposure of loud sound for longer durations, including instances when the research vessel may be stationary, we do not expect that they will experience significant energetic costs associated with avoidance or foregone prey, as they will continue to feed. Unless the increased duration of exposure leads to some other effect that could lead to reductions in fitness, this situation is not likely to lead to significant effects. Based on the information available, the risks of PTS and TTS or any other physical effects that would affect an individual's fitness, have been determined to be highly unlikely given that animals would have to remain right next to the boat and not just within the "zone of influence" for a significant period of time

In summary, we conclude it is likely that animals which have been temporarily disturbed and/or displaced by avoiding the active acoustics of SWFSC research will not experience energetic costs that lead to measurable or biologically meaningful impacts that could affect the fitness of individuals with respect to survival, growth, and reproduction. We expect the effects of disturbance and avoidance from this proposed action to be temporary and insignificant. As a result, we conclude that the risks associated with exposure to active acoustics leading to short term disturbance and effects on foraging habitat are insignificant and discountable.

2.2.1.1.3.4 Conclusion of Response/Risk for Active Acoustics

For some ESA-listed baleen whales (blue whales, fin whales, sei whales, WNP gray whales, North Pacific right whales, and Southern right whales), odontocete cetaceans (vaquitas) and pinnipeds (WNP Steller sea lions), we conclude it is unlikely that they will detect most of these active acoustic sources, due primarily to their relative low frequency hearing range and/or lack of overlap with SWFSC research activities. For odontocete cetaceans (sperm whales and Southern Resident killer whales), and to a lesser degree humpback whales and other pinnipeds (Guadalupe fur seals), we conclude that these species could be exposed to and detect at least some of the active acoustic sources used during SWFSC research, although the extent of exposure is likely less than what has been conservatively estimated by the SWFSC for reasons discussed above. However, we conclude that short term exposure to active acoustic sources aboard SWFSC research vessels do not present significant risks for ESA-listed marine mammals. We expect exposures that are actually detectable may lead to a temporary disturbance and avoidance of SWFSC vessels that, if it occurs, will not have any discernable effects to health or fitness as a result of this exposure, for any of these ESA-listed marine mammals listed above. This response would result primarily from temporary exposure to relatively high frequency sounds for short durations as the SWFSC research vessels transit through while actively conducting research or en-route to a new sampling location, or remain stationary for a relative short period of time.

Based on the analyses presented above, we conclude that the impacts expected to result from the proposed use of active sound sources by the SWFSC are insignificant, and the risks of injury or disturbance that could lead to adverse effects on the health, behavioral ecology, and social dynamics of individuals of any ESA-listed marine mammal species in ways or to a degree that would reduce their fitness are discountable. Because our analysis indicates that the expected behavioral responses of these animals are not expected to disrupt the foraging, migrating or other behaviors of these animals to such an extent that we would expect reduced growth, reproduction or survival, these expected responses do not appear to result in "take" under the ESA. Consequently, no incidental ESA take of ESA-listed marine mammals as a result of exposure to active acoustic sources used during SWFSC research activity is anticipated.

2.2.1.1.3.5 Vessel Noise

In addition to active acoustic sources, the vessels used for research also produce relatively loud sounds at a much lower frequency. The specific sound profiles of the research vessels used are not readily available. McKenna et al. (2012) described large commercial vessel traffic sound profiles where bulk container and tanker ships produce broadband sounds at or greater than 180 dB re µPa@1m; with highest source level <100 Hz. The research vessels used by the SWFSC vary in length; many of the larger ones are approximately 200 ft in length, which is smaller than large commercial vessels that can exceed 500 ft in length. As a result, we assume that SWFSC research vessels produce low frequency sounds that are loud, but at somewhat lower levels than very large container ships. Clark et al. (2009) examined the concepts of marine mammal communication masking by noise, including sound produced by vessel traffic, and found significant potential for masking effects. There is some evidence that whales can, but sometimes do not, compensate for such changes in their ambient noise environment. For example, killer whales increase the amplitudes of their calls with increasing noise in the 1–40 kHz frequency band (Holt et al. 2009). However, as discussed above, the transitory nature of SWFSC research cruises that typically cover vast areas of ocean and do not remain in the same places for many days and weeks should preclude any sustained lasting impacts from sound produced by SWFSC research vessels to any individuals that would lead to significant or sustained changes in behavior that would be expected to produce decreased fitness or survival that could warrant consideration as take under the ESA. While some SWFSC research may occur in some parts of the CCE year round (e.g., CalCOFI), the sheer size of the proposed project area covered by research activities and the relative frequency and footprint of the SWFSC vessels coming through any same area at most a few times a year leads us to conclude that the potential for impacts accumulating in any one area during the year in a significant or detectable manner is discountable. Accumulation of anthropogenic noise, and specifically vessel noise, is a known problem for marine life including many of the ESA-listed marine mammal species considered in this opinion. However, it is currently not possible to assess the contribution that a relative small number of research cruise trips spread throughout a vast area of the ocean over the course of a year may be contributing to overall magnitude of this problem in a meaningful way. Based on the transitory nature of SWFSC research and the relatively limited presence of SWFSC vessels throughout the action area during the year, we conclude the effects of vessels noise on ESA-listed marine mammals are insignificant.

2.2.1.1.4 Prey Reductions

SWFSC research surveys, primarily use of trawl gear, results in the capture of many species of fish and invertebrates that are sources of prey for ESA-listed species. Table 6 below describes the average annual catch of some potential important prey for ESA-listed species, and relative totals for all SWFSC research activities in comparison to any allowable catch levels in U.S. west coast fisheries. Virtually all of these catches are associated with trawl activities. Included in the table are common prey species for many ESA-listed marine mammal species, including: mackerel, sardine, krill, and squid.

Table 6. Average annual catch of potential forage species for ESA-listed species from all surveys from 2007-2011 (DEA). Allowable biological catch (ABC) in commercial fisheries, along with the proportion of ABC that corresponds to SWFSC totals is also described.

Fish	Average annual total catch (kg)	ABC commercial catch (metric tons)	SWFSC percentage of ABC
Jack mackerel	392	31,000	<0.0001%
Jacksmelt	330	N/A	N/A
Northern anchovy	1,201	34,750	<0.0001%
Pacific hake (whiting)	1,045	2 million	<0.0001%
Pacific mackerel	7,534	42,375	0.0002
Pacific sardine	1,564	84,681	0.0002
Shortbelly rockfish	412	23,500	<0.0001%
Yellowtail rockfish	117	4,320	<0.0001%
Invertebrates			
Market Squid	470	N/A	N/A

Humboldt squid	80	N/A	N/A
Euphausiid (krill)	991	N/A	N/A
Sea nettle jellyfish	18,473	N/A	N/A
Moon jellyfish	2,623	N/A	N/A
Fried-egg jellyfish	33	N/A	N/A
Unidentified salp	24	N/A	N/A

As described further in the analysis in section 2.6.1.4, the magnitude of prey reduction associated with SWFSC research, assuming all captures actually lead to mortality and prey removal, is insignificant compared to the overall amount of forage that is expected to be available for ESA-listed species in the CCE where almost all prey removals are expected to occur as a result of this proposed action. Some survey trawls where krill are captured are conducted in the ARA, and krill is key component of the food web for numerous marine mammals such as ESA-listed whales. Acoustic data are used to measure abundance and distribution of krill but very small amounts of krill and zooplankton are also captured in small-mesh nets (IKMT) for biometric data. Biomass estimates are only available in the few places where research occurs (South Shetland Islands and Elephant Island). Estimates of krill biomass in each of three monitored areas have averaged between 0.5 and 2.5 million mts in the past few years (Van Cise 2009). The amount of krill (approximately 1 mt a year; Table 6) and other zooplankton collected during research is a negligible fraction of overall biomass and would not affect the abundance or availability of prey to any marine mammals.

In addition to the small magnitude of prey reductions that are expected to result from SWFSC research, the temporal and spatial distributions are also important to consider. Surveys generally are spread out systematically over large areas such that prey removals are not concentrated during any place or time in a manner that is expected to affect foraging for any ESA-listed marine mammals in a discernable manner. As a result, we anticipate that the proposed action is not expected to have anything other than very minor and transitory impacts on prey used by the ESA-listed marine mammal species in the action area, and the risks of local depletions that could have an impact on the overall health and fitness of ESA-listed marine mammals are insignificant (see below for more on Southern Resident killer whales and salmon).

2.2.1.1.4.1 Southern Resident Killer Whales

Southern Resident killer whales consume a variety of fish species, but are known to rely heavily upon salmon for prey, especially Chinook salmon (Ford and Ellis 2006; Hanson et al. 2010a). Statistical associations between broad indices of summer/fall Chinook abundance and both Northern and Southern Resident killer whale survival, fecundity, and rates of population increase on an annual time scale have been identified (Ward et al. 2013), and are the subject of ongoing investigation by NMFS, the Canadian Department of Fisheries and Oceans (DFO), and others.

In 2011 and 2012, an independent scientific panel (Panel) held a series of workshops to evaluate the available information regarding the relationship between Chinook abundance and SRKW population dynamics. The Panel found good evidence that Chinook salmon are a very important part of the SRKW diet and good evidence that some SRKW have been observed in poor condition and poor condition is associated with higher mortality rates. They further found that the available data do provide some support for a cause and effect relationship between salmon abundance and SRKW survival and reproductions. They identified "reasonably strong" evidence that vital rates of SRKW are, to some degree, ultimately affected by broad-scale changes in their primary Chinook salmon prey, although they cautioned against over-reliance on any particular correlative study (see Hilborn et al. 2012 for complete discussion of the Panel workshops). Because the SWFSC incidentally captures Chinook salmon during their research trawls in the CCE, we consider the possible impact of those captures on the available prey base of SRKWs, and the likelihood of any adverse effect to the fitness of any individuals as a result of this activity.

The SRKW DPS consists of three large social groups, or pods, referred to as J, K, and L pods. The current population estimate is 79 whales as of December, 2014: 25 in J pod, 19 in K pod, and 35 in L pod (Center for Whale Research 2014[13]). All three pods reside for part of the year in the inland waterways of Washington State and British Columbia (Strait of Georgia, Strait of Juan de Fuca, and Puget Sound), where J, K, and L pods typically arrive in May or June and depart in October or November. Historically, there is little information available about their range and distribution during the winter and early spring. SRKWs were formerly thought to range southward along the coast to about Grays Harbor (Bigg et al. 1990) or the mouth of the Columbia River (Ford et al. 2000), in addition to the coastal and inland waters surrounding Vancouver Island. However, recent sightings, documentation, and satellite tracking of SRKWs off Oregon and California have extended the southern limit of their known range during the winter, where they have been observed primarily in January, February, and March (NWFSC unpublished data[14]).

Southern resident killer whales feed primarily on salmonids, with a strong preference for Chinook salmon (78 percent of identified prey) in Puget Sound and inland waters during the summer and fall, likely because they are the largest salmon species and contain the highest lipid content (NMFS 2008c). Although there is limited information available on diet and prey selection while foraging in coastal waters during the winter, the available information suggests that salmon, and Chinook salmon in particular, are an important source of prey there as well (NMFS and USFWS 2012). Direct observations of two predation events occurred when SRKWs were in coastal waters, and prey was identified to species and stock using genetic analysis of

[13] http://www.whaleresearch.com/#!orca-population/cto2
[14] Recent results from satellite tracking by NWFSC can be found at http://www.nwfsc.noaa.gov/research/divisions/cb/ecosystem/marinemammal/satellite_tagging/index.cfm

prey remains; both were identified as Columbia River Chinook stocks (Hanson et al. 2010b). Chemical analyses also support the importance of salmon in the year round diet of SRKW (Krahn et al. 2004, 2007, and 2009). Based on available information, it is reasonable to infer that their preference for Chinook salmon, including age-2 and age-3 fish (NMFS and USFWS 2012) remains strong when Chinook salmon are available; however, SRKWs are opportunistic feeders and may switch to other prey species such as chum salmon when those prey are available in higher densities in inland waters during the late fall (Hanson et al. 2010c).

As a result of SWFSC research activities, including both the directed take of salmon during the juvenile salmon survey, and incidental captured during other fish trawl surveys, we anticipate the following total of juvenile and sub-adult salmon that may be captured, and killed (mortality):

Table 7. Total number of salmon expected to be captured, and killed or released alive during all SWFSC trawl surveys per year.

Chinook	Directed Take		Incidental Take		Total Take	
	Juvenile	Sub-adult	Juvenile	Sub-adult	Juvenile	Sub-adult
Mortality	141	36	48	5	189	41
Live Release	0	50	0	0	0	50
coho						
Mortality	144	12	26	26	170	38
Live Release	0	45	0	0	0	45
steelhead						
Mortality	34	31	4	4	38	35
Live Release	0	3	0	0	0	3
sockeye						
Mortality	0	0	4	4	4	4
chum						
Mortality	0	0	5	5	5	5

For Chinook, we expect a total of up to 189 juveniles and 41 sub-adults to be killed per year during SWFSC research trawl surveys (Table 7). Based on the information available, it is unlikely that small juvenile salmon are the primary source of prey for SRKWs, given relative small size of juvenile Chinook and the apparent preference of SRKWs for larger fish. As a result, removal of juvenile Chinook by SWFSC research activity is not expected to result in significant direct competition with SRKW foraging. In addition, much of SWFSC trawl research occurs in the CCE during the spring, summer, and fall, while SRKWs are typically only present in the marine waters of the CCE during the winter, further reducing the potential for direct competition. However, SWFSC salmon removals do have an impact the future marine populations of Chinook and ultimately how many Chinook will be available for SRKWs. While juvenile Chinook may not be primary prey, sub-adult Chinook in marine waters likely are. Welch et al. (2011) estimated that survival of juvenile salmonids in the early marine environment in the Pacific is typically much less than 50%. For the purposes of cohort reconstructions supporting ocean salmon fishery management on the U.S. west coast, NMFS assumes that age-2 annual survival (essentially the transition stage between juvenile and sub-adult) is estimated at 50%, and subsequent annual survival rates for sub-adults is 80% (O'Farrell et al. 2012). In reality, survival rates are likely influenced by a wide range of factors that are highly variable in space and time. For the purposes of this opinion, we will assume that 50% of juveniles that may be killed each year during SWFSC research would have survived until reaching the sub-adult stage (189 x 0.5 = 95 sub-adults), and that the total impact of SWFSC research on reductions of Chinook for SRKWs is equal to the of all sub-adults that may be directly killed during SWFSC research each year plus the estimated loss of future sub-adults as juveniles that may killed during SWFSC research each year (41 + 95 = 136 sub-adults).

Noren (2011) estimated the energetic needs and subsequent prey requirements of SRKWs based on the nutritional value of Chinook (average value for adults from the Fraser River: 16,386 kcal/fish) assuming a single-species diet (for simplicity). When subsisting only on Chinook, the daily consumption rate for the entire SRKW population greater than 1 year of age (81 individuals in 2008) ranges from 792 to 951 fish/day (289,131–347,000 fish/year). The total number of adult Chinook salmon estimated to be present annually in the ocean in the coastal portion of the range of SRKWs is at least 3 million (NMFS and USFWS 2012). Using the maximum estimate of 136 sub-adult Chinook killed during SWFSC research each year, the resulting loss of potential Chinook prey for SRKWs equates to 0.005% the total number of adult Chinook salmon present in the marine coastal range of SRKWs each year, on average. This represents a very small fraction of what would otherwise be available to SRKWs in marine coastal waters. Even if we assumed all lost sub-adult Chinook resulting from the proposed action would have consumed by SRKWs, 136 Chinook would not support more than a dozen SRKWs for a day given their consumption rates described above. Currently, it is not possible to effectively evaluate if the relative impact of this proposed action is significant enough to make an impact on the density of Chinook prey in the ocean that is detectable by SRKWs. As we explained above, surveys are generally spread out systematically over large areas such that removals of Chinook salmon are not expected to be concentrated during any place or time in a manner that is expected to significantly affect foraging for SRKWs, even for a day. It seems unlikely that the small magnitude of juvenile and sub-adult Chinook that may be lost from the overall Chinook population in the ocean as a result of SWFSC research, spread out in space and time, is likely to be detectable by SRKWs given their wide-ranging distribution in coastal waters. In addition, Chinook removals are likely to spread out among the various ESA-listed ESUs and non-listed populations that will not have significant long term impacts to those populations. To the extent that any Chinook populations are believed to be especially common sources of prey for SRKWs, such as Chinook that return to the Salish Sea and Puget Sound area during the summer and fall, we do not expect SWFSC research to inherently impact those stocks more than others during research activities spread out across the CCE.

While Chinook have been identified as a preferred prey source for SRKWs, it is also known that other salmon are also possible prey sources. In Table 7 above, we described the total take of other salmon species, including coho, steelhead, chum, and sockeye, across all SWFSC research trawl research activities considered in this opinion. Similar to the Chinook analysis described above, even considering the possibility that the entire grand total of sub-adult and juvenile salmon that may be killed each year would represent potential prey lost for SRKWs, the totals (406 juveniles and 123 sub-adults) represent insignificant totals compared to the amount of salmon that are in expected to be available to SRKWs each year, especially considering that these salmon removals are expected to be spread out across the CCE during the year, mostly at a time when SRKWs are not present in the CCE.

As a result of this analysis, we conclude that the risks of adverse effects to SRKWs via the reduction of prey caused by directed and incidental salmon capture are insignificant.

NMFS designated critical habitat for the Southern Resident killer whale population includes approximately 2,560 square miles of inland waters in three specific areas: 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 are outside of the proposed action area, therefore we will not consider any potential impacts to this critical habitat further in this opinion.

2.2.1.1.5 Conclusion for Marine Mammals

Based on all of the above, we conclude that blue whales, fin whales, humpback whales, sei whales, sperm whales, Southern Resident DPS killer whales, Western North Pacific DPS gray whales, North Pacific right whales, Guadalupe fur seals, vaquitas, southern right whales may be affected, but are not likely to be adversely affected, by SWFSC research activities considered in this opinion.

2.2.2 Hawksbill Sea Turtle

Once abundant, hawksbills are now rare in the eastern Pacific (Cliffton et al. 1982; Gaos et al. 2010; Seminoff et al. 2003). Within the eastern Pacific, approximately 300 females are estimated to nest each year along the coast from Mexico south to Peru (Gaos et al. 2010). Bycatch in commercial fisheries is acknowledged as a threat to hawksbill turtles, more commonly associated with nearshore artisanal fisheries in the eastern Pacific (NMFS and USFWS 2013b). Hawksbill bycatch in U.S. longline fisheries that range into the ETP has not been known to occur, and the available data from international purse seine fisheries in the ETP suggest hawksbill bycatch is very rare (IATTC data).

In 2013, a hawksbill turtle stranding was recorded in Southern California near San Diego (NMFS stranding data). This was the first account of a hawksbill in the stranding record on the U.S. west coast and it isn't clear what this stranding may be representing in terms of expected distributions for this species. A subsequent necropsy conducted by the SWFSC concluded the turtle was emaciated, consistent with a determination this individual was not feeding well outside of its normal habitat. Hawksbills are more commonly found in the ETP, but they commonly occur in nearshore coastal waters outside of areas where SWFSC surveys that use fish sampling gears such as trawls and longlines in the CCE or ETP are expected to occur.

Considering the relatively low population numbers that exist and that the limited longline effort that has been proposed for the ETP is unlikely to occur in nearshore coastal waters, we conclude that the risk of incidental capture/entanglement is discountable. Since there is relatively little chance of interactions between SWFSC research activity and hawksbill sea turtles, NMFS also concludes that the risk of adverse effects via any of the potential stresses considered and discounted for other sea turtles in section 2.6.1 are discountable for hawksbill sea turtles as well.

2.2.3 Marine Fish (green sturgeon, Puget Sound/Georgia Basin DPS canary rockfish, and totoaba)

For reasons discussed in section 2.6.1, the risk of adverse effects from vessel collisions, noise, and prey reductions for ESA-listed marine fish are insignificant and/or discountable. Therefore, we will only consider the potential for incidental capture and/or entanglement of the following ESA-listed marine fish here in this section.

2.2.3.1 Green Sturgeon

The green sturgeon is an anadromous, long-lived, and bottom-oriented (demersal) fish species in the family Acipenseridae. Green sturgeon range from the Bering Sea, Alaska, to Ensenada, Mexico, and use a diversity of habitat types at different life stages. Based on genetic analyses and spawning site fidelity (Adams et al. 2002; Israel et al.2004), NMFS determined that green sturgeon are composed of at least two distinct population segments (DPSs): a northern DPS consisting of populations originating from coastal watersheds northward of and including the Eel River ("Northern DPS green sturgeon"); and a southern DPS consisting of populations originating from coastal watersheds south of the Eel River ("Southern DPS green sturgeon"). Southern DPS green sturgeon were listed as threatened under the ESA in 2006 (71 FR 17757). NMFS determined that ESA listing for Northern DPS green sturgeon was not warranted, but maintained the species on the NMFS Species of Concern list. After migrating out of their natal rivers, sub-adult green sturgeon move between coastal waters and various estuaries along the U.S. West Coast between San Francisco Bay, CA, and Grays Harbor, WA (Lindley et al. 2008; Lindley et al. 2011).

Relatively little is known about the extent to which green sturgeon use habitats in the coastal ocean and in estuaries, or the purpose of their episodic aggregations there at certain times (Lindley et al. 2008; Lindley et al. 2011). While in the ocean, archival tagging indicates that green sturgeon occur between 0 and 200 m depths, but spend most of their time between 20–80 m in water (Nelson et al. 2010; Huff et al. 2011). They are generally demersal but make occasional forays to surface waters, perhaps to assist their migration (Kelly et al. 2007).

To date, no green sturgeon have been incidentally captured or entangled during SWFSC research surveys. SWFSC survey trawls are conducted at or near the surface while green sturgeon spend most all of their time at or near the bottom. Pelagic longline surveys also target fish in the water column, and mostly are conducted in waters south of central California, and likely do not overlap at all with green sturgeon in coastal waters. Bottom longline surveys are conducted in more northern waters, but are typically conducted in waters much deeper than where green sturgeon are expected to be found, with sablefish longlines typically set at ~400 meters compared to sturgeon expected to be found in waters 80 meters deep or less. Consequently, it is unlikely that green sturgeon would encounter or be captured or entangled in SWFSC survey gear. As a result, we concludes that the risk of adverse effects to green sturgeon via any of the potential stresses considered in section 2.6.1, including incidental capture or entanglement, are discountable.

2.2.3.2 Puget Sound/Georgia Basin DPS Canary Rockfish

Canary rockfish are found from the western Gulf of Alaska to northern Baja California, but are most abundant from British Columbia to central California (Miller and Lea 1972; Hart 1973; Cailliet et al. 2000; Love et al. 2002). Adults are most common from 80 to 200 m but have been found as deep as 439 m. Juveniles are found in intertidal surface waters, and occasionally as deep as 838 m. The larvae and pelagic juveniles of canary rockfish are found in the upper 100 m of the water column (Love et al. 2002). Largely due to ecological and environmental factors considered by Stout et al. (2001) that serve to limit the potential for migration of rockfish in/out of Puget Sound, and genetic differences that have been observed for rockfish between inner (Puget Sound or Strait of Georgia) and outer (California Current) populations, a NMFS BRT determined that all species/populations of rockfish that inhabit the Georgia Basin or Puget Sound are likely to meet the “discreteness” and “significance” criteria of the DPS policy (Drake et al. 2010). In 2010, NMFS listed the Puget Sound/ Georgia Basin DPS of canary rockfish as threatened (75 FR 22276).

Canary rockfish have been documented as captured in SWFSC research survey trawls. An average of 156 kg of canary rockfish are caught each year in SWFSC research survey trawls, usually during the juvenile rockfish surveys (DEA). However, canary rockfish that occur and are encountered by any proposed project outside of the Puget Sound/ Georgia Basin DPS boundary are not considered to be part of the ESA-listed population. All SWFSC research, including survey trawls, occurs in Pacific Ocean waters outside of the Puget Sound/Georgia Basin DPS. As a result, none of the canary rockfish that may be captured by SWFSC research gear are considered to be part of the ESA-listed population. Since no research effort occurs within the ESA-listed boundary of canary rockfish, we do not expect that any adverse effects to ESA-listed canary rockfish will occur.

2.2.3.3 Totoaba

Totoaba is a large fish that occurs exclusively within the Gulf of California. Schools of adult totoaba migrate northward in the winter along the east coast of the Gulf of California to the Colorado River delta and remain there for weeks before spawning in the spring. Adults then migrate back south along the west coast for the rest of the year. Juveniles remain in the upper Gulf of California for two years before beginning this migration pattern. They inhabit mainly the upper half of the Gulf and the first 75 feet (23 m) of the water column.

As mentioned above, SWFSC research in the ETP does not typically extend into far northern portion of the Gulf of California where totoaba are most commonly found. In addition, SWFSC research that might occur in the ETP, and the Gulf of California specifically, does not include any sampling gear such as trawls or longlines that might encounter and capture or entangle totoaba. Any future longline survey effort in the ETP is unlikely to occur in the upper Gulf of California for many reasons, including sensitivities to protected species and international boundaries. As a result, we concludes that the risk of adverse effects to totoaba via any of the potential stresses considered in section 2.6.1, including incidental capture or entanglement, are discountable.

2.2.4 Invertebrates (white abalone, black abalone, and coral).

Two ESA-listed species of invertebrates may be found in the proposed action areas of the CCE, including white abalone and black abalone. Both of these invertebrate species are benthic, except for early larval stages. White abalone are found in open low and high relief rock or boulder habitat that is interspersed with sand channels, usually at depths of 80-100 feet (25-30 m), making them the deepest occurring abalone species in California. They currently are known to occur and at some of the offshore islands and banks of the Southern California Bight and along the coast of Baja California. White abalone were listed as endangered in 2001 (66 FR 29046). Black abalone are found in shallow subtidal and intertidal areas along rocky habitats stretching from central California south into Baja California, including some of the offshore Channel Islands in the Southern California Bight. Black abalone were listed as endangered in 2009 (74 FR 1937), and critical habitat was designated in 2011 (76 FR 66806).

As benthic invertebrate species, abalone are not expected to be affected by SWFSC research through incidental capture or entanglement, vessel collisions, or disturbance from loud sounds. Most SWFSC research activities take place well beyond the relatively shallow waters where abalone occur. Trawl and pelagic longline survey gear pose no risk to abalone living on the seafloor bottom, and the bottom longlines are set at depths well deeper than any ESA-listed abalone is known to occur. Activities such as ROV survey operations occur with use of cameras which are not expected to harm or impact abalone. Abalone feed primarily on kelp and algae, which is not subject to any impacts from SWFSC research. As a result, we conclude that the risks of adverse effects to white or black abalone via any of the potential stresses considered in section 2.6.1 are discountable. Black abalone critical habitat includes certain rocky intertidal and shallow habitats along the California coasts, but no SWFSC research activity considered in this opinion occurs in such shallow water habitats, and no impact to black abalone critical habitat is expected from this proposed action.

In a recent listing decision, NMFS listed 20 species of corals as threatened, including five in the Caribbean and 15 in the Indo-Pacific (79 FR 53852). These species are known to occur in the western or central portions of the Pacific, but not in the ETP. None of these species are known to occur within the proposed action area and would be expected to be affected by SWFSC research activities.

2.2.5 Effects to Designated Critical Habitats

The SWFSC may affect the designated critical habitat of several ESA-listed species, including western DPS Steller sea lions, green sturgeon, and leatherback sea turtles. The potential effects to these designated critical habitats result from removal of prey during SWFSC trawl surveys conducted in the CCE.

2.2.5.1 Steller Sea Lion Critical Habitat

On November 4, 2013, NOAA Fisheries published a final rule removing the eastern DPS of Steller sea lions from the List of Endangered and Threatened Wildlife under the ESA (78 FR 66140). The final delisting rule advised that for ESA section 7 consultations for Federal actions that may affect currently designated Steller sea lion critical habitat, we will address effects to such habitat in terms of effects to those physical and biological features essential to the conservation of the western DPS of Steller sea lions that remains listed under the ESA.

Proposed SWFSC research activities extend through coastal waters of the CCE into areas adjacent to rookery areas designated as critical habitat for Steller sea lions in Oregon and California. Based on genetic and tagging data, individuals of the listed western DPS of Steller sea lions are not known to visit the areas designated as critical habitat in Oregon or California (Bickham et al. 1996; Raum-Suryan et al. 2002). Additionally, there is no evidence that would suggest that the western DPS would need to expand into these areas in Oregon or California for recovery. Therefore, we do not anticipate that the proposed SWFSC research activities will affect physical or biological features essential to the conservation of the western Steller sea lion DPS because the proposed action's effects are limited to areas outside the current or anticipated range of the western DPS.

2.2.5.2 Green Sturgeon Critical Habitat

Critical habitat has been designated for the Southern DPS of green sturgeon (Federal Register: 74 FR 52300, October 9, 2009). In the coastal ocean, this designation covers waters shallower than 60 fathoms (approximately 110 m) from Monterey Bay, CA to the Canadian border, including the Strait of Juan de Fuca. Natal rivers and numerous estuaries along the West Coast (e.g., San Francisco Bay, lower Columbia River estuary, Willapa Bay, and Grays Harbor) were also designated as critical habitat for the species. For marine waters, primary constituent elements identified for coastal marine areas include: migratory corridor, water quality, and food resources.

Some SWFSC research activity, particularly survey trawls for CPS, rockfish, and salmon, does occur within coastal marine waters of green sturgeon critical habitat throughout the year (Appendix B *in* DEA). The only potential impact of SWFSC research activities to green sturgeon critical habitat is removal of prey during these trawl surveys. Specific data on green sturgeon prey species in coastal marine waters is lacking, but likely includes benthic invertebrates and fish species similar to those fed upon by green sturgeon in bays and estuaries, including crangonid and callianasid shrimp, Dungeness crab, molluscs, and amphipods, and small fish, such as sand lances (*Ammodytes* spp.) and anchovies (Engraulidae) (Moyle 2002; Dumbauld et al. 2008).

Table 6 describes the total catch the more prominent fish and invertebrate species that might be potential forage for ESA-listed species. While some small fish species that may be potential prey for green sturgeon, such as anchovies, are regularly caught (>1000kg per year across all surveys), most of the invertebrate species captured in SWFSC survey trawls are more pelagic and surface oriented species that are generally not associated with the benthic environment and diet that has been described for green sturgeon and considered likely to be their prey in the marine environment. It is not clear exactly how much SWFSC research and overall prey removal occurs within the designated critical habitat for green sturgeon, but any removals of potential prey such as anchovies are likely to be limited to very small localized totals that are scattered across a relatively large survey area. The overall density of prey items in any area should not be affected in a significant way that would be detectable by individual sturgeon. Green sturgeon are known to be generalist feeders and may feed opportunistically on a wide variety of benthic species encountered. SWFSC survey trawls occur at or near the surface, and it is unlikely that the resources there that removed by SWFSC survey trawls represent constituents of the primary foraging options for green sturgeon. Thus, the removal of fish and invertebrate species by SWFSC survey trawls is not expected to significantly reduce the quality or quantity of prey resources for green sturgeon within designated critical habitat. Consequently, green sturgeon critical habitat is not likely to be adversely affected by the proposed action.

2.2.5.3 Leatherback Critical Habitat

NMFS revised the current critical habitat for leatherback sea turtles by designating additional areas within the Pacific Ocean on January 26, 2012. This designation includes approximately 16,910 square miles along the California coast from Point Arena to Point Arguello east of the 3,000 meter depth contour; and 25,004 square miles from Cape Flattery, Washington to Cape Blanco, Oregon east of the 2,000 meter depth contour. The designated areas comprise approximately 41,914 square miles of marine habitat and include waters from the ocean surface down to a maximum depth of 262 feet. NMFS identified the feature essential to conservation as: the occurrence of prey species, primarily scyphomedusae of the order Semaeostomeae (e.g., *Chrysaora*, *Aurelia*, *Phacellophora*, and *Cyanea*), of sufficient condition, distribution, diversity, abundance and density necessary to support individual as well as population growth, reproduction, and development of leatherbacks.

Although jellyfish blooms are seasonally and regionally predictable, their fine-scale local distribution is patchy and dependent upon oceanographic conditions. Little information exists on their populations in open coastal systems, including the California Current upwelling system. Based on available research in coastal waters, jellyfish are most abundant in coastal waters of California, Oregon, and Washington during late summer to early fall months (Shenker 1984; Suchman and Brodeur 2005; Graham 2009), which overlaps with the time when turtles are most frequently sighted near central California (Starbird et al. 1993; Benson et al. 2007b) and in coastal waters off Oregon and Washington (Bowlby 1994). During this time period, many SWFSC research activities are occurring within the designated critical habitat for leatherbacks, especially survey trawls for CPS, rockfish, and salmon (Appendix B *in* DEA).

Table 6 describes the average total catch of jellyfish species in SWFSC research survey trawls each year, including: sea nettles (*Chrysaora*); moon jellyfish (*Aurelia*); and fried-egg jellyfish (*Phacellophora*). The average annual catch of *Chrysaora* in the course of all SWFSC research surveys over the past five years is about 18,473 kg, and the estimated total average annual catch of *Aurelia* is 2,623 kg. Catches of jellyfish from the Juvenile Salmon Surveys far exceed those from other SWFSC surveys. Approximately 97% of the total *Chrysaora* catch that occurs annually in SWFSC survey trawls comes during juvenile salmon surveys, 99 percent of which are caught from within designated critical habitat for leatherback sea turtles. These surveys occur in the summer and fall, during the times of year when leatherbacks are most likely to be present in their designated critical habitat. These juvenile salmon surveys also catch approximately 96% of the total SWFSC research *Aurelia* catch each year, of which 62 percent are caught from within designated critical habitat for leatherback sea turtles (section 3.2.4 in DEA).

Although the total biomass of jellyfish species in SWFSC research areas is difficult to estimate, a mean areal density of 251,522 ± 57,504 jellyfish per square nautical mile (jellies/nm^2) has been calculated in the central California foraging area of leatherback turtles based on acoustic backscatter survey data (Graham 2009). While this estimate refers to more species than just sea nettles or moon jellies, these species are significant contributors to the total jellyfish population in the CCE within designated critical habitat for leatherbacks along the U.S. west coast, which is a significant component to why this area appears to be preferred foraging habitat for leatherbacks in the summer and fall. Sea nettle can achieve very large sizes of up to 30 inches in diameters (bell size), weighing many kilograms. Moon jellies are smaller, but still get as large as 15 inches in diameter. There is no standard conversion of jellyfish biomass to number of individuals for these species to make specific quantitative relationships between. But we can use the density provided by Graham (2009) to estimate how many jellyfish might be found in the entire area designated as critical habitat for leatherbacks. Conservatively applying the low end of the Graham (2009) jellyfish estimate in central California (251,522 - 57,504 = 194,018 jellies/nm^2) to the total square mileage of leatherback critical habitat (approximately 42,000 m^2), we estimate at least 3 billion jellyfish are in leatherback critical habitat. It is unknown if the density of jellyfish is similar through the entire leatherback critical habitat area, especially outside of Central California, and what proportion sea nettles and moon jellies constitute throughout. But we conclude that there are likely hundreds of million, if not billions, of these individuals scattered throughout this area. The capture and removal of 20,000 kg during a single year most likely represents a very small fraction of the total jellyfish population available to leatherbacks. The average weight of these jellyfish species are not clear, but even if the average sea nettle and moon jellyfish only 0.1 kg (likely underestimate), the SWFSC is capturing on the order of 0.001 percent of the available jellyfish likely to be important food for leatherbacks in their survey trawls within designated critical habitat (200,000 jellyfish out of 2 billion).

When captured, jellyfish are typically returned to the water fairly immediately. The mortality rates of jellyfish captured in trawl nets is unknown. In tows where catch volumes are high, it is possible that jellyfish can be damaged significantly, possibly to a point where immediate or delayed mortality can occur. But given their relative simple morphology as a gelatinous invertebrate, it should also be expected that many jellyfish do survive capture and release from survey trawls. In addition, jellyfish captures in SWFSC survey trawl gear are spread out over an area as the surveys move from station to station, and not concentrated all in one place over a period of time. As part of the operational procedure for survey trawls, SWFSC research cruises aim to avoid areas of high jellyfish and salp densities during towing to avoid compromising sampling town or even damaging survey nets. As a result, SWFSC vessels will generally move on from survey stations where jellyfish density appears high. This should help prevent any significant removals of jellyfish from the immediate vicinity of any adjacent foraging leatherbacks.

Considering the relative small amount of available jellyfish prey that is expected to be removed, which may only be temporarily until jellyfish are returned to the water, and that jellyfish removal is expected to be spread out over space and time to a degree, and that the SWFSC will make efforts to avoid high density areas of jellyfish, the capture of jellyfish by SWFSC survey trawls is not expected to significantly reduce the quality or quantity of prey resources for leatherbacks within designated critical habitat. Consequently, leatherback critical habitat is not likely to be adversely affected by the proposed action.

2.3 Analytical Approach

This opinion includes both jeopardy analyses and consideration of adverse modifications to designated critical habitat. The jeopardy analysis relies upon the regulatory definition of “to jeopardize the continued existence[15] 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.

The adverse modification analysis considers the impacts of the Federal action on the conservation value of designated critical habitat. This opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 CFR 402.02. Instead, we have relied upon the statutory provisions of the ESA to complete the following analysis with respect to critical habitat.[16]

[15]“’Jeopardize the continued existence of’ means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species” (50 CFR § 402.02).
[16] Memorandum from William T. Hogarth to Regional Administrators, Office of Protected Resources, NMFS (Application of the “Destruction or Adverse Modification” Standard Under Section 7(a)(2) of the Endangered Species Act) (November 7, 2005).

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 range-wide status of the species and critical habitat likely to be adversely affected by the proposed action.
Describe the environmental baseline in the action area.
Analyze the effects of the proposed action on both species and their habitat using an "exposure-response-risk" approach.
Describe any cumulative effects in the action area.
Integrate and synthesize the above factors to assess the risk that the proposed action poses to species and critical habitat.
Reach jeopardy and adverse modification conclusions.
If necessary, define a reasonable and prudent alternative to the proposed action.

2.4 Range-wide Status of the Species and Critical Habitat

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

One factor affecting the range-wide status of ESA-listed species and aquatic habitat at large is climate change. Climate change has received considerable attention in recent years, with growing concerns about global warming and the recognition of natural climatic oscillations on varying time scales, such as long term shifts like the Pacific Decadal Oscillation or short term shifts, like El Niño or La Niña. Evidence suggests that the productivity in the North Pacific (Mackas et al. 1989; Quinn and Niebauer 1995) and other oceans could be affected by changes in the environment. Important ecological functions such as migration, feeding, and breeding locations may be influenced by factors such as ocean currents and water temperature. Any changes in these factors could render currently used habitat areas unsuitable and new use of previously unutilized or previously not existing habitats may be a necessity for displaced individuals. Changes to climate and oceanographic processes may also lead to decreased productivity in different patterns of prey distribution and availability. Such changes could affect individuals that are dependent on those affected prey.

Based upon available information, it is likely that sea turtles are being affected by climate change. Sea turtle species are likely to be affected by rising temperatures that may affect nesting success and skew sex ratios, as some rookeries are already showing a strong female bias as warmer temperatures in the nest chamber leads to more female hatchlings (Kaska et al. 2006; Chan and Liew 1995). Rising sea surface temperatures and sea levels may affect available nesting beach areas as well as ocean productivity. Sea turtles are known to travel within specific isotherms and these could be affected by climate change and cause changes in their bioenergetics, thermoregulation, and foraging success during the oceanic phase of their migration and prey availability (Robinson et al. 2008; Saba et al. 2012). However, the existing data and current scientific methods and analysis are not able to predict the future effects of climate change on this species or allow us to predict or quantify this threat to the species (Hawkes et al. 2009).

Climate change is likely to play an increasingly important role in determining the abundance of ESA-listed salmonid species, and the conservation value of designated critical habitats, along the U.S. west coast. These changes will not be spatially homogeneous across the landscape. Areas with elevations high enough to maintain temperatures well below freezing for most of the winter and early-spring will be less affected. Low-elevation areas are likely to be more affected. During the last century, average regional air temperatures increased by 1.5°F, and increased up to 4°F in some areas. Warming is likely to continue during the next century as average temperatures increase another 3 to 10°F. Overall, about one-third of the current cold-water fish habitat in the Pacific Northwest is likely to exceed key water temperature thresholds by the end of this century (USGCRP 2009). Precipitation trends during the next century are less certain than for temperature but increased precipitation is likely to occur during October through March and decrease during summer months, and more of the winter precipitation is likely to fall as rain rather than snow (ISAB 2007; USGCRP 2009). Where snow occurs, a warmer climate will cause earlier runoff so stream flows in late spring, summer, and fall will be lower and water temperatures will be warmer (ISAB 2007; USGCRP 2009).

Higher winter stream flows due to predicted increases in precipitation increase the risk that winter floods in sensitive watersheds will damage spawning redds and wash away incubating eggs. Earlier peak stream flows will also flush some young salmon and steelhead from rivers to estuaries before they are physically mature, increasing stress and the risk of predation. Lower stream flows and warmer water temperatures during summer will degrade summer rearing conditions, in part by increasing the prevalence and virulence of fish diseases and parasites (USGCRP 2009). Other adverse effects are likely to include altered migration patterns, accelerated embryo development, premature emergence of fry, variation in quality and quantity of tributary rearing habitat, and increased competition and predation risk from warm-water, non-native species (ISAB 2007).

The earth's oceans are also warming, with considerable interannual and inter-decadal variability superimposed on the longer-term trend (Bindoff et al. 2007). Historically, warm periods in the coastal Pacific Ocean have coincided with relatively low abundances of salmon and steelhead, while cooler ocean periods have coincided with relatively high abundances (Scheuerell and Williams 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 described in ISAB (2007), climate change effects that have, and will continue to, influence the habitat and species in the action area include increased ocean temperature, increased stratification of the water column, and intensity and timing changes of coastal upwelling. These continuing changes will alter primary and secondary productivity, marine community structures, and in turn, salmonid growth, productivity, survival, and migrations. A mismatch between earlier smolt/juvenile migrations (due to earlier peak spring freshwater flows and decreased incubation period) and altered upwelling may reduce marine survival rates for salmon and eulachon. Under the A1B emissions scenario presented in ISAB (2007), median increases in ocean temperature for the North Pacific and adjacent Arctic basins are projected to increase by 2^{o} C by the 2080s. With this warming, models predict a reduction in summertime thermal habitat ranges in the Pacific Ocean from 29% (chum) to 86% (Chinook) (Abdul-Aziz et al. 2011). Other marine fish, such as scalloped hammerheads, may be influenced by changing ocean conditions resulting from climate change, but these possible influences are generally poorly understood at this time.

We consider the ongoing implications of climate change as part of the status of ESA-listed species, although the time horizon for the proposed project is relatively short (5 years) and it isn't likely that climate or other associated environmental conditions will make dramatic changes over a such a short time period. Instead, where necessary or appropriate, we consider whether impacts to species resulting from proposed actions could potentially influence the resiliency or adaptability of those species to deal with climate change that we believe is likely over the foreseeable future.

2.4.1 Sea Turtles

2.4.1.1 Leatherback Turtles

The leatherback turtle is listed as endangered under the ESA throughout its global range. Increases in the number of nesting females have been noted at some sites in the Atlantic, but there have been substantial declines or collapse of some populations throughout the Pacific, such as in Malaysia and Mexico. In the Pacific, leatherback nesting aggregations are found in the eastern and western Pacific. In the eastern Pacific, major nesting sites are located in Mexico, Costa Rica, and Nicaragua. Nesting in the western Pacific occurs at numerous beaches in Indonesia, the Solomon Islands, Papua New Guinea, and Vanuatu, with a few nesters reported in Malaysia and only occasional reports of nesting in Thailand and Australia (Eckert et al. 2012).

Leatherback turtles lead a completely pelagic existence, foraging widely in temperate and tropical waters except during the nesting season, when gravid females return to tropical beaches to lay eggs. Leatherbacks are highly migratory, exploiting convergence zones and upwelling areas for foraging in the open ocean, along continental margins, and in archipelagic waters (Morreale et al. 1994; Eckert 1998, 1999; Benson et al. 2007a, 2011). Recent satellite telemetry studies have documented transoceanic migrations between nesting beaches and foraging areas in the Atlantic and Pacific Ocean basins (Ferraroli et al. 2004; Hays et al. 2004; James et al. 2005; Eckert 2006; Eckert et al. 2006; Benson et al. 2007a; Benson et al. 2011). In the Pacific, leatherbacks nesting in Central America and Mexico migrate thousands of miles into tropical and temperate waters of the South Pacific (Eckert and Sarti 1997; Shillinger et al. 2008). After nesting, females from the Western Pacific nesting beaches make long-distance migrations into the a variety of foraging areas including the central and eastern North Pacific, westward to the Sulawasi and Sulu and South China Seas, or northward to the Sea of Japan (Benson et al. 2007a; Benson et al. 2011).

Population Status and Trends: Leatherbacks are found throughout the world and populations and trends vary in different regions and nesting beaches. In 1980, the leatherback population was estimated at approximately 115,000 (adult females) globally (Pritchard 1982). By 1995, one estimate claimed this global population of adult females had declined to 34,500 (Spotila et al. 1996). A current global population estimate is not available at this time, but details on what is known of populations are provided below.

In the Pacific leatherback populations are declining at all major Pacific basin nesting beaches, particularly in the last two decades (Spotila et al. 1996; Spotila et al. 2000; NMFS and USFWS 2007a). In the eastern Pacific, nesting counts indicate that the population has continued to decline since the mid 1990's leading some researchers to conclude that this leatherback is on the verge of extirpation (Spotila et al. 1996; Spotila et al. 2000). Steep declines have been documented in Mexico and Costa Rica, the two major nesting sites for eastern Pacific leatherbacks. Recent estimates of the number of nesting females/year in Mexico and for Costa Rica is approximately 200 animals or less for each county per year (NMFS and USFWS 2013a) Estimates presented at international conferences show the numbers declining even more in all of the major nesting sites in the eastern Pacific.

The western Pacific leatherback metapopulation that nests in Indonesia, Papua New Guinea, Solomon Islands, and Vanuatu harbors the last remaining nesting aggregation of significant size in the Pacific with approximately 2700–4500 breeding females (Dutton et al. 2007; Hitipeuw et al. 2007). The current overall estimate for Papua Barat (Indonesia), Papua New Guinea, and Solomon Islands is 5,000 to 10,000 nests per year (Nel 2012). Although there is generally insufficient long term data to calculate population trends, in all of these areas, the number of nesting females is substantially lower than historical records (Nel 2012). This metapopulation is made up of small nesting aggregations scattered throughout the region, with a dense focal point on the northwest coast of Papua Barat, Indonesia; this region is also known as the Bird's Head

Peninsula where approximately 75 percent of regional nesting occurs (Hitipieuw et al. 2007). Genetic results to date have found that nesting aggregations that comprise the western Pacific population all belong to a single stock (Dutton et al. 2007). The Bird's Head region consists of four main beaches, three that make up the Jamursba-Medi (JM) beach complex, and a fourth which is Wermon beach (Dutton et al. 2007).

The most recently available information on nesting numbers in northwest Papua reflects a disturbing decline. Tapilatu et al. (2013) estimated that the annual number of nests at Jamursba-Medi has declined 78.2 percent over the past 27 years (5.5% annual rate of decline), from 14,522 in 1984 to 1,532 in 2011. The beach at Wermon has been consistently monitored since 2002 and has declined 62.8 percent from 2,944 nests in 2002 to 1,292 nests in 2011 (11.6% annual rate of decline). Collectively, Tapilatu et al. (2013) estimated that since 1984, these primary western Pacific beaches have experienced a long-term decline in nesting of 5.9 percent per year. With a mean clutch frequency of 5.5 ±1.6, approximately 489 females nested in 2011.

Migratory routes of leatherback turtles originating from eastern and western Pacific nesting beaches are not entirely known for the entire Pacific population; however, satellite tracking of post-nesting females and foraging males and females, as well as genetic analyses of leatherback turtles caught in U.S. Pacific fisheries or stranded on the West Coast of the U.S. indicate that the leatherbacks found off the U.S. West Coast are from the western Pacific nesting populations, specifically boreal summer nesters. Given the relative size of the nesting populations, it is likely that the animals will be from the Jamursba-Medi nesting beaches, although some may come from the comparatively small number of summer nesters at Wermon in Papua Barat, Indonesia. As mentioned earlier, one female has been tracked traveling from foraging areas on the U.S. West Coast to the Solomon Islands. The Papua Barat, Jamursba-Medi nesting population generally exhibits site fidelity to the central California foraging area (Benson *et al*. 2011; Seminoff *et al*. 2012).

<u>Threats:</u> The primary threats identified for leatherbacks are fishery bycatch and impacts at nesting beaches, including nesting habitat, direct harvest and predation. Leatherback are vulnerable to bycatch in a variety fisheries, including longline, drift gillnet, set gillnet, bottom trawling, dredge, and pot/trap fisheries that are operated on the high seas or in coastal areas throughout the species' range. On the high seas, bycatch in longline fisheries is considered a major threat to leatherbacks (Lewison et al. 2004). At or adjacent to nesting sites, population declines are primarily the result of a wide variety of human activities, including legal harvests and illegal poaching of adults, immature animals, and eggs; incidental capture in coastal fisheries; and loss and degradation of nesting and foraging habitat as a result of coastal development, including predation by domestic dogs and feral pigs foraging on nesting beaches associated with human settlement and commercial development of coastal areas. In addition to anthropogenic factors, natural threats to nesting beaches and marine habitats such as coastal erosion, seasonal storms, predators, temperature variations, and phenomena such as El Niño also affect the survival and recovery of leatherback populations (Eckert et al. 2012). Marine debris is

also a source of mortality to all species of sea turtles because small debris can be ingested and larger debris can entangle animals, leading to death.

2.4.1.2 Loggerhead turtle, North Pacific DPS

Loggerheads are circumglobal, inhabiting continental shelves, bays, estuaries, and lagoons in temperate, subtropical, and tropical waters. Major nesting grounds are generally located in temperate and subtropical regions, with scattered nesting in the tropics. On September 22, 2011, the U.S. Fish and Wildlife Service (USFWS) and NMFS published a final rule listing nine distinct population segments (DPS) of loggerhead sea turtles (76 FR 58868). The North Pacific Ocean DPS of loggerheads, which is the population of loggerheads likely to be exposed to the proposed actions, was listed as endangered.

Juvenile loggerheads originating from nesting beaches in the western Pacific Ocean appear to use oceanic developmental habitats and move with the predominant ocean gyres for several years before returning to their neritic foraging habitats (Pitman 1990; Bowen et al. 1995; Musick and Limpus 1997). Adults may also periodically move between neritic and oceanic zones (Harrison and Bjorndal 2006). In the western Pacific, the only major nesting beaches are in the southern part of Japan (Dodd 1988). In Japan, loggerheads nest on beaches across 13 degrees of latitude (24°N to 37°N), from the mainland island of Honshu south to the Yaeyama Islands, which appear to be the southernmost extent of loggerhead nesting in the western North Pacific. Satellite tracking of juvenile loggerheads indicates the Kuroshio Extension Bifurcation Region in the central Pacific to be an important pelagic foraging area for juvenile loggerheads (Polovina et al. 2006; Kobayashi et al. 2008; Howell et al. 2008). Other important juvenile turtle foraging areas have been identified off the coast of Baja California Sur, Mexico (Peckham and Nichols 2006; Peckham et al. 2007; Conant et al. 2009). After spending years foraging in the central and eastern Pacific, loggerheads return to their natal beaches for reproduction (Resendiz et al.1998; Nichols et al. 2000) and remain in the western Pacific for the remainder of their life cycle (Iwamoto et al. 1985; Kamezaki et al. 1997; Conant et al. 2009; Hatase et al. 2002).

Loggerheads that have been documented off the U.S. west coast are primarily found south of Point Conception, California in the Southern California Bight. South of Point Eugenia on the Pacific coast of Baja California, pelagic red crabs have been found in great numbers, attracting top predators such as tunas, whales and sea turtles, particularly loggerheads (Pitman 1990; Wingfield et al. 2011). Pitman (1990) found loggerhead distribution off Baja to be strongly associated with the red crab, which often occurred in such numbers as to “turn the ocean red.” Considerable efforts have been spent studying the movements and relationships of juvenile loggerheads in the central Pacific and off Baja and the west coast of the U.S. to understand migrations and/or developmental patterns across the North Pacific (see Nichols et al. 2000; Polovina et al. 2003; Polovina et al. 2004; Polovina et al. 2006; Kobayashi et al. 2008; Howell et al. 2010; Peckham et al. 2011; Allen et al. 2013), but the ecology of juvenile loggerheads in the eastern Pacific is still not well understood.

Population Status and Trends: The North Pacific loggerhead DPS nests primarily in Japan (Kamezaki et al. 2003), although low level nesting may occur outside of Japan in areas surrounding the South China Sea (Chan et al. 2007; Conant et al. 2009). Nesting beach monitoring in Japan began in the 1950s on some beaches, and grew to encompass all known nesting beaches starting in 1990 (Kamezaki et al. 2003). Along the Japanese coast, nine major nesting beaches (greater than 100 nests per season) and six "submajor" beaches (10–100 nests per season) exist, including Yakushima Island where 40 percent of nesting occurs (Kamezaki et al. 2003). Census data from 12 of these 15 beaches provide composite information on longer-term trends in the Japanese nesting assemblage. As a result, Kamezaki et al. (2003) concluded a substantial decline (50–90%) in the size of the annual loggerhead nesting population in Japan since the 1950s. As discussed in the 2011 final ESA listing determination, current nesting in Japan represents a fraction of historical nesting levels (Conant et al. 2009; 76 FR 58868). Nesting declined steeply from an initial peak of approximately 6,638 nests in 1990–1991, to a low of 2,064 nests in 1997. During the past decade, nesting increased gradually to 5,167 nests in 2005 (Conant et al. 2009), declined and then rose again to a record high of 11,082 nests in 2008, and then 7,495 and 10,121 nests in 2009 and 2010, respectively (STAJ 2008, 2009, 2010). At the November 2011 Sea Turtle Association of Japan annual sea turtle symposium, the 2011 nesting numbers were reported to be slightly lower at 9,011 (NMFS 2012a - Asuka Ishizaki, pers. comm. November 2011). The total number of adult females in the population was estimated at 7,138 for the period 2008-2010 by Van Houtan (2011).

Threats: A detailed account of threats of loggerhead sea turtles around the world is provided in recent status reviews (NMFS and USFWS 2007b; Conant et al. 2009). The most significant threats facing loggerheads in the North Pacific include coastal development and bycatch in commercial fisheries. Destruction and alteration of loggerhead nesting habitats are occurring throughout the species' range, especially coastal development, beach armoring, beachfront lighting, and vehicular/ pedestrian traffic. Coastal development includes roads, buildings, seawalls, etc., all of which reduce suitability of nesting beaches for nesting by reducing beach size and restricting beach migration in response to environmental variability. In Japan, many nesting beaches are lined with concrete armoring to reduce or prevent beach erosion, causing turtles to nest below the high tide line where most eggs are washed away unless they are moved to higher ground (Matsuzawa 2006). Coastal development also increases artificial lighting, which may disorient emerging hatchlings, causing them to crawl inland towards the lights instead of seaward. Overall, the Services have concluded that coastal development and coastal armoring on nesting beaches in Japan are significant threats to the persistence of this DPS (76 FR 58868; September 22, 2011).

For both juvenile and adult individuals in the ocean, bycatch in commercial fisheries, both coastal and pelagic fisheries (including longline, drift gillnet, set-net, bottom trawling, dredge, and pound net) throughout the species' range is a major threat (Conant et al. 2009). Specifically in the Pacific, bycatch continues to be reported in gillnet and longline fisheries operating in ‘hotspot” areas where loggerheads are known to congregate (Peckham et al. 2007). Interactions and mortality with coastal and artisanal fisheries in Mexico and the Asian region likely represent the most serious threats to North Pacific loggerheads (Peckham et al. 2007; Ishihara et al. 2009; Conant et al. 2009). Additional fishery interactions in domestic and international pelagic fisheries in the North Pacific are also known to exist (Lewison et al. 2004; NMFS 2012a). As mentioned in the leatherback threats section, marine debris, including debris resulting from the 2011 earthquake and tsunami that took place off Japan, threatens the North Pacific DPS of loggerheads through ingestion and entanglement.

2.4.1.3 Olive ridley turtle

A 5-year status review of olive ridley sea turtles was completed in 2014.[17] Although the olive ridley turtle is regarded as the most abundant sea turtle in the world, olive ridley nesting populations on the Pacific coast of Mexico are listed as endangered under the ESA; all other populations are listed as threatened. Olive ridley turtles occur throughout the world, primarily in tropical and sub-tropical waters. Nesting aggregations in the Pacific Ocean are found in the Marianas Islands, Australia, Indonesia, Malaysia, and Japan (western Pacific), and Mexico, Costa Rica, Guatemala, and South America (eastern Pacific). Like leatherback turtles, most olive ridley turtles lead a primarily pelagic existence (Plotkin et al. 1993), migrating throughout the Pacific, from their nesting grounds in Mexico and Central America to the deep waters of the Pacific that are used as foraging areas (Plotkin et al. 1994). While olive ridleys generally have a tropical to subtropical range, with a distribution from Baja California, Mexico to Chile (Silva-Batiz et al. 1996), individuals do occasionally venture north, some as far as the Gulf of Alaska (Hodge and Wing 2000). Olive ridleys live within two distinct oceanic regions including the subtropical gyre and oceanic currents in the Pacific. The gyre contains warm surface waters and a deep thermocline preferred by olive ridleys. The currents bordering the subtropical gyre, the Kuroshio Extension Current, North Equatorial Current and the Equatorial Counter Current, all provide for advantages in movement with zonal currents and location of prey species (Polovina et al. 2004). A more complete review of current information can be found in the 5-year status review document published in 2014 by the US Fish and Wildlife Service and NMFS (NMFS and USFWS 2014).

Population Status and Trends: Olive ridleys are the most abundant sea turtle, but population structure and genetics are poorly understood for this species. It is estimated that there are over 1 million females nesting annually (NMFS and USFWS 2014). Unlike other sea turtle species, most female olive ridleys nest annually. According to the Marine Turtle Specialist Group of the IUCN, there has been a 50 percent decline in olive ridleys worldwide since the 1960s, although there have recently been substantial increases at some nesting sites (NMFS and USFWS 2007c). A major nesting population exists in the eastern Pacific on the west coast of Mexico and Central

[17] http://www.nmfs.noaa.gov/pr/pdfs/species/oliveridleyturtle_5yearreview2014.pdf

America. Both of these populations use the north Pacific as foraging grounds (Polovina et al. 2004).

Because the proposed action is most likely to occur closer to eastern Pacific nesting and foraging sites, we assume that this population would be more likely to be affected by the proposed action. The eastern Pacific population is thought to be increasing, while there is inadequate information to suggest trends for other populations. Eastern Pacific olive ridleys nest primarily in large *arribadas* on the west coasts of Mexico and Costa Rica. Since reduction or cessation of egg and turtle harvest in both countries in the early 1990s, annual nest totals have increased substantially. On the Mexican coast alone, in 2004-2006, the annual total was estimated at 1,021,500 – 1,206,000 nests annually (NMFS and USFWS 2007c). Eguchi et al. (2007) analyzed sightings of olive ridleys at sea, leading to an estimate of 1,150,000 – 1,620,000 turtles in the eastern tropical Pacific in 1998-2006. In contrast, there are no known *arribadas* of any size in the western Pacific, and apparently only a few hundred nests scattered across Indonesia, Thailand and Australia (Limpus and Miller 2008).

Threats: Threats to olive ridleys are described in the most recent five year status review (NMFS and USFWS 2014). Direct harvest and fishery bycatch are considered the two biggest threats. There has been historical and current direct harvest of olive ridleys. In the 1950's through the 1970's, it is estimated that millions of olive ridleys were killed for meat and leather and millions of eggs were collected at nesting beaches in Mexico, Costa Rica, and other locations in Central and South America. Harvest has been reduced in the 1980's and 1990's, although eggs are still harvested in parts of Costa Rica and there is an illegal harvest of eggs in parts of Central America and India (NMFS and UWFWS 2014).

Olive ridleys have been observed caught in a variety of fishing gear including longline, drift gillnet, set gillnet, bottom trawl, dredge and trap net. Fisheries operating in coastal waters near *arribadas* can kill tens of thousands of adults. This is evident on the east coast of India where thousands of carcasses wash ashore after drowning in coastal trawl and drift gillnets fishing near the huge *arribada (*NMFS and USFWS 2007c*)*. Based upon available information, it is likely that olive ridley sea turtles are being affected by climate change. Similar to other sea turtle species, olive ridleys are likely to be affected by rising temperatures that may affect nesting success and skew sex ratios and rising sea surface temperatures that may affect available nesting beach areas as well as ocean productivity. As mentioned in the leatherback threats section, marine debris, including debris resulting from the 2011 earthquake and tsunami that took place off Japan, threatens olive ridleys through ingestion and entanglement.

2.4.1.4 Green turtle

Green turtles are found throughout the world, occurring primarily in tropical, and to a lesser extent, subtropical waters. The species occurs in five major regions: the Pacific Ocean, Atlantic Ocean, Indian Ocean, Caribbean Sea, and Mediterranean Sea. The eastern Pacific population

includes turtles that nest on the coast of Mexico, which have been historically listed under the ESA as endangered[18]. The western Atlantic population includes turtles that nest in Florida, which have been historically listed under the ESA as endangered.[19] All other green turtles (including those in the eastern Pacific population that nest outside of Mexico, and those in the western Atlantic population that nest outside of Florida) are listed as threatened.[20] In recent years, NMFS and USFWS established a biological review team to evaluate the status of the populations of green turtles to determine if nesting populations should be divided in to distinct population segments (similar to the agency's action on loggerhead sea turtles) and whether the listing status of some of the populations should be changed. The 2015 biological status report (Seminoff et al. 2015) can be found at:
http://www.nmfs.noaa.gov/pr/species/Status%20Reviews/green_turtle_sr_2015.pdf

Molecular genetic techniques have helped researchers gain insight into the distribution and ecology of migrating and nesting green turtles. Throughout the Pacific, nesting assemblages group into two distinct regional areas: 1) western Pacific and South Pacific islands, and 2) eastern Pacific and central Pacific, including the rookery at French Frigate Shoals, Hawaii. In the eastern Pacific, greens forage coastally from southern California in the north to Mejillones, Chile in the South. Based on mitochondrial DNA analyses, green turtles found on foraging grounds along Chile's coast originate from the Galapagos nesting beaches, while those greens foraging in the Gulf of California originate primarily from the Michoacan nesting stock. Green turtles foraging in southern California and along the Pacific coast of Baja California originate primarily from rookeries of the Islas Revillagigedos (Dutton 2003).

Population Status and Trends: NMFS and USFWS (2007d) provided population estimates and trend status for 46 green turtle nesting beaches around the world. Of these, twelve sites had increasing populations (based upon an increase in the number of nests over 20 or more years ago), four sites had decreasing populations, and ten sites were considered stable. For twenty sites there are insufficient data to make a trend determination or the most recently available information is too old (15 years or older). A complete review of the most current information on green sea turtles is available in the 2015 Status Review (Seminoff et al. 2015).

Green turtles that may be found within the action area likely nest in the eastern or central Pacific. Green turtles in the eastern Pacific were historically considered one of the most depleted populations of green turtles in the world. The primary green turtle nesting grounds in the eastern Pacific are located in Michoacán, Mexico, and the Galapagos Islands, Ecuador (NMFS and USFWS 1998). Here, green turtles were widespread and abundant prior to commercial exploitation and uncontrolled subsistence harvest of nesters and eggs. Sporadic nesting occurs

[18] On March 23, 2015, NMFS proposed to revise the listing of green sea turtles worldwide to 11 DPSs, including listing the East Pacific DPS as threatened (80 FR 15271).
[19] Included in North Atlantic DPS proposed for listing as threatened on March 23, 2015 (80 FR 15271)
[20] 3 DPS are proposed for listing as endangered - Central South Pacific DPS, Central West Pacific DPS, and Mediterranean DPS.

on the Pacific coast of Costa Rica. Analysis using mitochondrial DNA sequences from three key nesting green turtle populations in the eastern Pacific indicates that they may be considered distinct management units: Michoacán, Mexico; Galapagos Islands, Ecuador, and Islas Revillagigedos, Mexico (Dutton 2003). The central Pacific component nests exclusively in the Hawaiian Archipelago, with over 90 percent of nesting at French Frigate Shoals (FFS) in the Northwestern Hawaiian Islands.

Information has been suggesting steady increasing in nesting at the primary nesting sites in Michoacan, Mexico, and in the Galapagos Islands since the 1990s (Delgado and Nichols 2005; Senko et al. 2011). Colola beach is the most important green turtle nesting area in the eastern Pacific; it accounts for 75 percent of total nesting in Michoacan and has the longest time series of monitoring data since 1981. Nesting trends at Colola have continued to increase since 2000 with the overall eastern Pacific green turtle population also increasing at other nesting beaches in the Galapagos and Costa Rica (Wallace et al. 2010; NMFS and USFWS 2007d). Based on recent nesting beach monitoring efforts, the current adult female nester population for Colola, Michoacán is over 11,000 females, making this the largest nesting aggregation in the East Pacific DPS comprising nearly 60 percent of the estimated total adult female population (Seminoff et al. 2015).

Two foraging populations of green turtles are found in U.S. waters adjacent to the proposed action area. South San Diego Bay serves as important habitat for a resident population of up to about 60 juvenile and adult green turtles in this area (Eguchi et al. 2010). There is also an aggregation of green sea turtles that appear to be persistent in the San Gabriel River and surrounding coastal areas in the vicinity of Long Beach, California (Lawson et al. 2011). This group of turtles has only recently been identified and very little is known about their abundance, behavior patterns, or relationship with the population in San Diego Bay.

Threats: A thorough discussion of threats to green turtles worldwide can be found in the most recent status review (Seminoff et al. 2015). Major threats include: coastal development and loss of nesting and foraging habitat; incidental capture by fisheries; and the harvest of eggs, sub-adults and adults. Climate change is also emerging as a critical issue. Destruction, alteration, and/or degradation of nesting and near shore foraging habitat is occurring throughout the range of green turtles. These problems are particularly acute in areas with substantial or growing coastal development, beach armoring, beachfront lighting, and recreational use of beaches. In addition to damage to the nesting beaches, pollution and impacts to foraging habitat becomes a concern. Pollution run-off can degrade sea grass beds that are the primary forage of green turtles. The majority of turtles in coastal areas spend their time at depths less than 5 m below the surface (Schofield et al. 2007; Hazel et al. 2009), and hence are vulnerable to being struck by vessels and collisions with boat traffic are known to cause significant numbers of mortality every year (NMFS and USFWS 2007d; Seminoff et al. 2015). Marine debris is also a source of concern for green sea turtles due to the same reasons described earlier for other sea turtle species.

The bycatch of green sea turtles, especially in coastal fisheries, is a serious problem because in the Pacific, many of the small-scale artisanal gillnet, setnet, and longline coastal fisheries are not well regulated. These are the fisheries that are active in areas with the highest densities of green turtles (NMFS and USFWS 2007d). The meat and eggs of green turtles has long been favored throughout much of the world that has interacted with this species. As late as the mid-1970s, upwards of 80,000 eggs were harvested every night during nesting season in Michoacán (Clifton et al. 1982). Even though Mexico has implemented bans on the harvest of all turtle species in its waters and on the beaches, poaching of eggs, females on the beach, and animals in coastal water continues to happen. In some places throughout Mexico and the whole of the eastern Pacific, consumption of green sea turtles remain a part of the cultural fabric and tradition (NMFS and USFWS 2007d).

Like other sea turtle species, increasing temperatures have the potential to skew sex ratios of hatchling and many rookeries are already showing a strong female bias as warmer temperatures in the nest chamber leads to more female hatchlings (Kaska et al. 2006; Chan and Liew 1995). Increased temperatures also lead to higher levels of embryonic mortality (Matsuzawa et al. 2002). An increase in typhoon frequency and severity, a predicted consequence of climate change (Webster el al. 2005), can cause erosion which leads to high nest failure (VanHouten and Bass 2007). Green sea turtles feeding may also be affected by climate change. Seagrasses are a major food source for green sea turtles and may be affected by changing water temperature and salinity (Short and Neckles 1999; Duarte 2002). Climate change could cause shifts in ocean productivity (Hayes et al. 2005), which may affect foraging behavior and reproductive capacity for green sea turtles (Solow et al. 2002) similar to what has been observed during El Niño events in the western Pacific (Chaloupka 2001).

2.4.2 Marine Fish

2.4.2.1 Pacific eulachon, southern DPS

The southern distinct population segment of eulachon occurs in four areas: Puget Sound, the Willamette and Lower Columbia, Oregon Coast, and Southern Oregon/Northern California Coasts. The ESA-listed population of eulachon includes all naturally-spawned populations that occur in rivers south of the Nass River in British Columbia to the Mad River in California. Core populations for this species include the Fraser River, Columbia River and (historically) the Klamath River. Eulachon leave saltwater to spawn in their natal streams late winter through early summer, and typically spawn at night in the lower reaches of larger rivers fed by snowmelt. After hatching, larvae are carried downstream and widely dispersed by estuarine and ocean currents. Eulachon movements in the ocean are poorly known although the amount of eulachon bycatch in the pink shrimp fishery seems to indicate that the distribution of these organisms overlap in the ocean.

Few direct estimates of eulachon abundance exist. Escapement counts and spawning stock biomass estimates are only available for a small number of systems. Catch statistics from commercial and tribal fisheries are available for some systems in which no direct estimates of abundance are available. However, inferring population status or even trends from yearly catch statistic changes requires making certain assumptions that are difficult to corroborate (e.g., assuming that harvest effort and efficiency are similar from year to year, assuming a consistent relationship among the harvested and total stock portion, and certain statistical assumptions, such as random sampling). Unfortunately, these assumptions cannot be verified, few fishery-independent sources of eulachon abundance data exist, and in the United States, eulachon monitoring programs just started in 2011. However, the combination of catch records and anecdotal information indicates that there were large eulachon runs in the past and that eulachon populations have severely declined. As a result, eulachon numbers are at, or near, historically low levels throughout the range of the southern DPS. In 2011, estimates from the two largest remaining eulachon spawning areas, the lower Columbia River and Fraser River, suggested over 19 million eulachon returned to spawn in those two systems (NMFS 2012b).

In the early 1990s, there was an abrupt decline in the abundance of eulachon returning to the Columbia River with no evidence of returning to their former population levels since then (Drake et al. 2008). Persistent low returns and landings of eulachon in the Columbia River from 1993 to 2000 prompted the states of Oregon and Washington to adopt a Joint State Eulachon Management Plan in 2001 that provides for restricted harvest management when parental run strength, juvenile production, and ocean productivity forecast a poor return (WDFW and ODFW 2001). Despite a brief period of improved returns in 2001–2003, the returns and associated commercial landings have again declined to the very low levels observed in the mid-1990s (Joint Columbia River Management Staff 2009), and since 2005, the fishery has operated at the most conservative level allowed in the management plan (Joint Columbia River Management Staff 2009). Large commercial and recreational fisheries have occurred in the Sandy River in the past. The most recent commercial harvest in the Sandy River was in 2003. No commercial harvest has been recorded for the Grays River from 1990 to the present, but larval sampling has confirmed successful spawning in recent years (USDC 2011).

<u>Limiting Factors</u> include (Gustafson et al. 2010; Gustafson et al. 2011; NOAA Fisheries 2011):

Changes in ocean conditions due to climate change, particularly in the southern portion of its range where ocean warming trends may be the most pronounced and may alter prey, spawning, and rearing success.
Climate-induced change to freshwater habitats, dams and water diversions (particularly in the Columbia and Klamath Rivers where hydropower generation and flood control are major activities)
Bycatch of eulachon in commercial fisheries
Adverse effects related to dams and water diversions
Artificial fish passage barriers

Increased water temperatures, insufficient streamflow
Altered sediment balances
Water pollution
Over-harvest
Predation

2.4.2.2 Scalloped hammerhead shark, eastern DPS

The scalloped hammerhead shark can be found in coastal warm temperate and tropical seas worldwide. The scalloped hammerhead shark occurs over continental and insular shelves, as well as adjacent deep waters, but is seldom found in waters cooler than 22° C (Compagno 1984). It ranges from the intertidal and surface to depths of up to 450–512 m (Klimley 1993), with occasional dives to even deeper waters (Jorgensen et al. 2009). It has also been documented entering enclosed bays and estuaries (Compagno 1984). These sharks have been observed making migrations along continental margins as well as between oceanic islands in tropical waters (Kohler and Turner 2001, Duncan and Holland 2006, Bessudo et al. 2011, Diemer et al. 2011). These long distance migrations have occurred over continental shelves and seamounts, and have not been seen over deep pelagic waters (NMFS 2014a). Distribution in the eastern Pacific extends from the coast of Southern California, including the Gulf of California, to Ecuador and possibly Peru, to the offshore waters around Hawaii and Tahiti (Miller et al. 2014).

Population Status and Trends: The 2014 Status Review Report (Miller et al. 2014) identified 6 DPS of the worldwilde scalloped hammerhead population (Figure 5). Four were listed under the ESA, including the Eastern Pacific DPS which is listed as endangered, largely due to existing threats associated with commercial fisheries catch and bycatch throughout the DPS (NMFS 2014a). The Central Pacific DPS was not listed under the ESA, due primarily to the relative lack of threats facing this DPS and the presence of productive pupping grounds in Hawaii (NMFS 2014a). Abundance data from the eastern Pacific are limited, but available information suggests that the Eastern Pacific DPS is declining (NMFS 2014a). Although precise population estimates are not available in the eastern Pacific, estimates based on assumptions related to genetic and demographic parameters have been made for populations in Baja and Pacific Panama, which suggest combined totals in these two populations is at least in the 10's of millions (Duncan et al. 2006; Miller et al 2014).

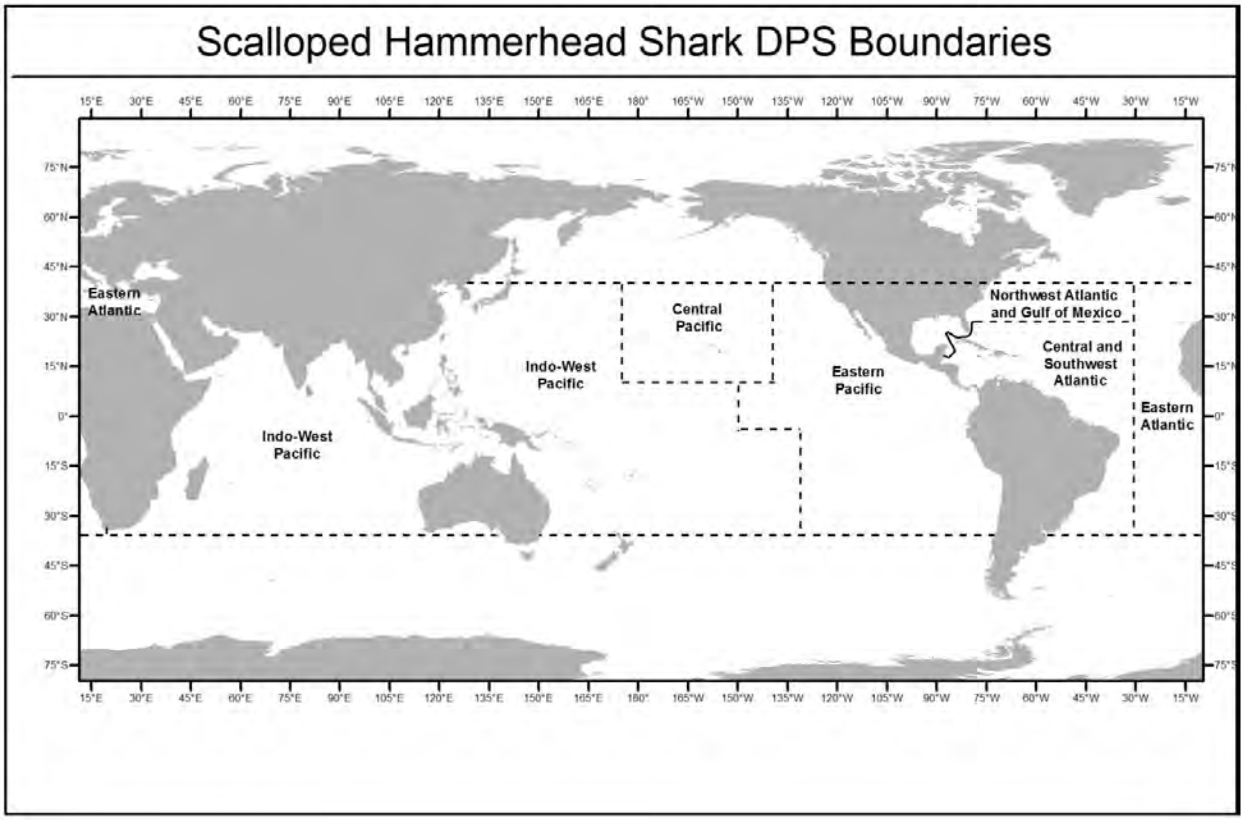

Figure 5. Illustration of scalloped hammerhead DPS delineations (NMFS 2014a).

Limiting Factors or Threats: Overutilization by industrial/commercial fisheries, artisanal fisheries, and illegal fishing of the scalloped hammerhead shark are the most serious threats to the persistence of this DPS. Scalloped hammerhead sharks are both targeted and taken as bycatch in many global fisheries. They are targeted by semi-industrial, artisanal and recreational fisheries and caught as bycatch in pelagic longline fisheries, and purse seine fisheries. There is a lack of information on the fisheries prior to the early 1970s, with only occasional mentions in historical records. Significant catches of scalloped hammerheads have and continue to go unrecorded in many countries outside the U.S. In addition, scalloped hammerheads are likely under-reported in catch records as many records do not account for discards (e.g., where the fins are kept but the carcass is discarded) or reflect dressed weights instead of live weights. Also, many catch records do not differentiate between the hammerhead species, or shark species in general, and thus species-specific population trends for scalloped hammerheads are not readily available.

2.4.3 Salmonids

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

"Spatial structure" refers both to the spatial distributions of individuals in the population and the processes that generate that distribution. A population's spatial structure depends fundamentally on habitat quality and spatial configuration and the dynamics and dispersal characteristics of individuals in the population. "Diversity" refers to the distribution of traits within and among populations. These range in scale from DNA sequence variation at single genes to complex life history traits (McElhany et al. 2000). "Abundance" generally refers to the number of naturally-produced adults (i.e., the progeny of naturally-spawning parents) in the natural environment (e.g., on spawning grounds). "Productivity," as applied to viability factors, refers to the entire life cycle; i.e., the number of naturally-spawning adults produced per parent. When progeny replace or exceed the number of parents, a population is stable or increasing. When progeny fail to replace the number of parents, the population is declining. McElhany et al. (2000) use the terms "population growth rate" and "productivity" interchangeably when referring to production over the entire life cycle. They also refer to "trend in abundance," which is the manifestation of long-term population growth rate.

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

2.4.3.1 Chinook

Chinook salmon are anadromous fish spending some time in both fresh- and saltwater. The older juvenile and adult life stages occur in the ocean, until the adults ascend freshwater streams to spawn. Eggs (laid in gravel nests called redds), alevins (gravel dwelling hatchlings), fry (juveniles newly emerged from stream gravels), and young juveniles all rear in freshwater until they become large enough to migrate to the ocean to finish rearing and maturing into adults. Chinook salmon are the largest member of the *Oncorhynchus* genus, with adults weighing more than 120 pounds having been reported from North American waters (Scott and Crossman 1973; Page and Burr 1991). Chinook salmon exhibit two main life history strategies: ocean-type fish and river-type fish (Healey 1991; Myers et al. 1998). Ocean-type fish typically are fall or winter-run fish that enter freshwater at an advanced stage of maturity, move rapidly to their spawning areas on the mainstem or lower tributaries of rivers, and spawn within a few weeks of freshwater entry. Their offspring emigrate to estuarine or marine environments shortly after emergence from the redd (Healey 1991). River-type fish are typically spring or summer-run fish that have a protracted adult freshwater residency, sometimes spawning several months after entering freshwater. Progeny of river-type fish frequently spend one or more years in freshwater before emigrating.

2.4.3.1.1 Sacramento River winter-run Chinook

Spatial Structure and Diversity: The Sacramento River winter-run (SWR) Chinook salmon ESU has been completely displaced from its historical spawning habitat by the construction of Shasta and Keswick dams. Approximately, 300 miles of tributary spawning habitat in the upper Sacramento River is now inaccessible to the ESU. Most components of the SWR Chinook salmon life history (e.g., spawning, incubation, freshwater rearing) have been compromised by the habitat blockage in the upper Sacramento River. The only remaining spawning habitat in the upper Sacramento River is between Keswick Dam and Red Bluff Diversion Dam (RBDD). This habitat is artificially maintained by cool water releases from Shasta and Keswick Dams, and the spatial distribution of spawners in the upper Sacramento River is largely governed by the water year type and the ability of the Central Valley Project to manage water temperatures in this area.

Abundance and Productivity: A captive broodstock artificial propagation program for SWR Chinook salmon has operated since the early 1990s as part of recovery actions for this ESU. As many as 150,000 juvenile salmon have been released in a single year by this program, but in most cases the number of fish released was in the tens of thousands (Good et al. 2005). NMFS reviewed this hatchery program in 2004 and concluded that as much as 10 percent of the natural spawners may be attributable to the program's support of the population (69 FR 33102). However, the naturally spawning component of this ESU has exhibited marked improvements in abundance and productivity in the 2000s (CDFG 2008). These increases in abundance are encouraging, relative to the years of critically low abundance of the 1980s and early 1990s; however, returns of several West Coast Chinook salmon and coho salmon stocks were lower in the 2000's, and SWR Chinook returns dropped below 1,000 in 2011. Returns have been increasing since that time and numbered approximately 6,000 in 2014 (PFMC 2014). This population remains below established recovery goals and the naturally-spawned component of the ESU is dependent on one extant population in the Sacramento River. There is particular concern about risks to the ESU's genetic diversity (genetic diversity is probably limited because there is only one remaining population) life-history variability, local adaptation, and spatial structure (Good et al. 2005; 70 FR 37160).

Since 2000, the proportion of hatchery-origin, SRW Chinook spawning in the river has ranged up to 10% (Table 8), which is below the low-risk threshold for hatchery influence (Williams et al. 2011). The current average run size for the SRW Chinook salmon ESU is 2,106 fish (2,023 natural-origin, 83 hatchery produced) (Table 8).

Table 8. Average abundance estimates for SRW Chinook salmon natural- and hatchery-origin spawners 2001-2011 (Killam 2012; O'Farrell et al. 2012).

Year	Natural-origin Spawners[a]	Hatchery-origin Spawners[b]	% Hatchery Origin	Expected Number of Outmigrants[c]
2001	8,120	104	1.3%	649,600
2002	7,360	104	1.4%	588,800
2003	8,133	85	1.0%	650,640
2004	7,784	85	1.1%	622,720
2005	15,730	109	0.7%	1,258,400
2006	17,197	99	0.6%	1,375,760
2007	2,487	55	2.2%	198,960
2008	2,725	105	3.7%	218,000
2009	4,416	121	2.7%	353,280
2010	1,533	63	3.9%	122,640
2011	738	89	10.8%	59,040
ESU Average[d]	**2,023**	**83**	**3.9%**	**161,840**

[a] Five-year geometric mean of post fishery natural-origin spawners (2007-2011).
[b] Five-year geometric mean of post fishery hatchery-origin spawners (2007-2011). Data from http://www.calfish.org/LinkClick.aspx?fileticket=Kttf%2boZ2ras%3d&tabid=104&mid=524.
[c] Expected number of outmigrants=Total spawners*40% proportion of females*2,000 eggs per female*10% survival rate from egg to outmigrant
[d] Averages are calculated as the geometric mean of the annual totals (2007-2011).

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

Limiting Factors: SRW Chinook salmon were first listed as threatened in 1989 under an emergency rule. In 1994, NMFS reclassified the ESU as an endangered species due to several factors, including: (1) the continued decline and increased variability of run sizes since its listing as a threatened species in 1989; (2) the expectation of weak returns in coming years as the result of two small year classes (1991 and 1993); and (3) continuing threats to the species. NMFS issued a final listing determination on June 28, 2005. Between the time Shasta Dam was built and the SRW Chinook salmon were listed in 1989, major impacts to the population occurred from warm water releases from Shasta Dam, juvenile and adult passage constraints at the RBDD, water exports in the southern Delta, and entrainment at a large number of unscreened or poorly-screened water diversions.

Designated critical habitat for SRW Chinook salmon has been degraded from conditions known to support viable salmonid populations. It does not provide the full extent of conservation values necessary for the recovery of the species. In particular, adequate river flows and water temperatures have been impacted by human actions, substantially altering the historical river characteristics in which the SRW Chinook salmon evolved. Depletion and storage of stream flows behind large dams on the Sacramento River and other tributary streams have drastically altered the natural hydrologic cycles of the Sacramento River and Delta. Alteration of flows results in migration delays, loss of suitable habitat due to dewatering and blockage; stranding of fish from rapid flow fluctuations; entrainment of juveniles into poorly screened or unscreened diversions, and increased water temperatures harmful to salmonids. Other impacts of concern include alteration of stream bank and channel morphology, loss of riparian vegetation, loss of spawning and rearing habitat, fragmentation of habitat, loss of downstream recruitment of spawning gravels, degradation of water quality, and loss of nutrient input.

2.4.3.1.2 Central Valley spring-run Chinook

Spatial Structure and Diversity: Historically, the predominant salmon run in the Central Valley was the spring-run Chinook salmon. Extensive construction of dams throughout the Sacramento-San Joaquin basin has reduced the Central Valley spring-run (CVS) Chinook salmon run to only a small portion of its historical distribution. The Central Valley drainage as a whole is estimated to have supported CVS Chinook salmon runs as large as 600,000 fish between the late 1880s and 1940s (CDFG 1998). The ESU has been reduced to only three naturally-spawning populations that are free of hatchery influence from an estimated 17 historic populations.[21] These three populations (spawning in three tributaries to the Sacramento River - Deer, Mill, and Butte creeks), are in close geographic proximity, increasing the ESU's vulnerability to disease or catastrophic events. CVS Chinook salmon from the Feather River Hatchery (FRH) were included in the ESU because they are believed by NMFS to be the only population in the ESU that displays early run timing. This early run timing is considered by NMFS to represent an important evolutionary legacy of the spring-run populations that once spawned above Oroville Dam (70 FR 37160).

Abundance and Productivity: The FRH's goal is to release five million spring-run Chinook salmon per year. Over the past five years, the Feather River hatchery released an average of 2,178,601 juvenile adipose clipped CVS Chinook salmon (Table 9).

Table 9. Average CVS Chinook salmon smolt release 2009-2013 (Regional Mark Processing Center 2014).

[21] There has also been a small run in Big Chico Creek in recent years (Good et al. 2005).

Artificial propagation program	Run Timing	Clipped Adipose Fin	Intact Adipose Fin
Feather River Hatchery	Spring	2,178,601	-
Total		**2,178,601**	

Sacramento River tributary populations in Mill, Deer, and Butte creeks are likely the best trend indicators for the CVS Chinook salmon ESU as a whole because these streams contain the majority of the abundance, and are currently the only independent populations in the ESU. Generally, these streams have shown a positive escapement trend since 1991, displaying broad fluctuations in adult abundance, ranging from 1,013 in 1993 to 23,788 in 1998 (Table 10). Escapement numbers are dominated by Butte Creek returns, which averaged over 7,000 fish from 1995 to 2005 (peaking in 1998 at over 20,000 fish and 2005 at over 10,000 fish), but then declined in years 2006 through 2011 with an average of just over 3,000 (with the exception of 2008 which was almost 15,000 fish). During this same period, adult returns on Mill and Deer creeks have averaged over 2,000 fish total and just over 1,000 fish total, respectively. From 2001 to 2005, the CVS Chinook salmon ESU experienced a trend of increasing abundance in some natural populations, most dramatically in the Butte Creek population (Good et al. 2005). Although trends were generally positive during this time, annual abundance estimates display a high level of fluctuation, and the overall number of CVS Chinook salmon remained well below estimates of historic abundance.

Table 10. CVS Chinook salmon population estimates from CDFW (2013a) with corresponding cohort replacement rates for years since 1986.

Year	Sacramento River Basin Escapement Run Size[a]	FRFH Population	Tributary Populations	5-Year Moving Average Tributary Population Estimate	Trib CRR[b]	5-Year Moving Average of Trib CRR	5-Year Moving Average of Basin Population Estimate	Basin CRR	5-Year Moving Average of Basin CRR
1986	3,638	1,433	2,205						
1987	1,517	1,213	304						
1988	9,066	6,833	2,233						
1989	7,032	5,078	1,954		0.89			1.93	
1990	3,485	1,893	1,592	1,658	5.24		4,948	2.30	
1991	5,101	4,303	798	1,376	0.36		5,240	0.56	
1992	2,673	1,497	1,176	1,551	0.60		5,471	0.38	
1993	5,685	4,672	1,013	1,307	0.64	1.54	4,795	1.63	1.36
1994	5,325	3,641	1,684	1,253	2.11	1.79	4,454	1.04	1.18
1995	14,812	5,414	9,398	2,814	7.99	2.34	6,719	5.54	1.83
1996	8,705	6,381	2,324	3,119	2.29	2.73	7,440	1.53	2.03
1997	5,065	3,653	1,412	3,166	0.84	2.77	7,918	0.95	2.14
1998	30,534	6,746	23,788	7,721	2.53	3.15	12,888	2.06	2.23
1999	9,838	3,731	6,107	8,606	2.63	3.26	13,791	1.13	2.24

2000	9,201	3,657	5,544	7,835	3.93	2.44	12,669	1.82	1.50
2001	16,869	4,135	12,734	9,917	0.54	2.09	14,301	0.55	1.30
2002	17,224	4,189	13,035	12,242	2.13	2.35	16,733	1.75	1.46
2003	17,691	8,662	9,029	9,290	1.63	2.17	14,165	1.92	1.43
2004	13,612	4,212	9,400	9,948	0.74	1.79	14,919	0.81	1.37
2005	16,096	1,774	14,322	11,704	1.10	1.23	16,298	0.93	1.19
2006	10,948	2,181	8,767	10,911	0.97	1.31	15,114	0.62	1.21
2007	9,726	2,674	7,052	9,714	0.75	1.04	13,615	0.71	1.00
2008	6,368	1,624	4,744	8,857	0.33	0.78	11,350	0.40	0.69
2009	3,801	989	2,812	7,539	0.32	0.69	9,388	0.35	0.60
2010	3,792	1,661	2,131	5,101	0.30	0.54	6,927	0.39	0.49
2011	4,967	1,969	3,067	3,961	0.65	0.47	5,731	0.78	0.53
2012	18,275	3,738	10,810	4,713	3.84	1.09	7,441	0.79	0.54
2013	38,556	4,294	18,499	7,464	8.68	2.76	13,878	2.00	0.86
Median	10,962	3,734	6,508	6,324	2.08	1.83	10,258	1.00	1.29

[a] NMFS is only including the escapement numbers from the Feather River Fish Hatchery (FRFH) and the Sacramento River tributaries in this table. Sacramento River Basin run size is the sum of the escapement numbers from the FRFH and the tributaries.
[b] Abbreviations: CRR = Cohort Replacement Rate, Trib = tributary

From 2005 through 2011, abundance numbers in most of the tributaries declined. Adult returns from 2006 to 2009, indicate that population abundance for the entire Sacramento River basin is declining from the peaks seen in the five years prior to 2006. Declines in abundance from 2005 to 2011, placed the Mill Creek and Deer Creek populations in the high extirpation risk category due to the rates of decline, and in the case of Deer Creek, also the level of escapement (NMFS 2011a). Butte Creek has sufficient abundance to retain its low extirpation risk classification, but the rate of population decline in years 2006 through 2011 is nearly sufficient to classify it as a high extirpation risk based on this criteria. Nonetheless, the watersheds identified as having the highest likelihood of success for achieving viability/low risk of extirpation include, Butte, Deer and Mill creeks (NMFS 2011a). Some other tributaries to the Sacramento River, such as Clear Creek and Battle Creek have seen population gains in the years from 2001 to 2009, but the overall abundance numbers have remained low. Year 2012 appeared to be a good return year for most of the tributaries with some, such as Battle Creek, having the highest return on record (799). Additionally, 2013 escapement numbers combined for Butte, Mill and Deer creeks increased (over 17,000), which resulted in the second highest number of spring-run Chinook salmon returning to the tributaries since 1998. However, 2014 appears to be lower, just over 5,000 fish, which indicates a highly fluctuating and unstable ESU.

While we currently lack data on naturally-produced juvenile CVS Chinook salmon production, it is possible to make rough estimates of juvenile abundance from adult return data. The CDFG (1998) published estimates in which average fecundity of spring-run Chinook salmon is 4,161 eggs per female. By applying the average fecundity of 4,161 eggs per female to the estimated 3,732 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 1,552,885 natural outmigrants annually. In addition, hatchery managers could produce approximately 2,000,000 listed hatchery juvenile CVS Chinook salmon each year (Table 9 above).

Limiting Factors: Several actions have been taken to improve habitat conditions for CVS Chinook salmon, including: habitat restoration efforts in the Central Valley; and changes in freshwater harvest management measures. Although protective measures likely have contributed to recent increases in CVS Chinook salmon abundance, the ESU is still well below levels observed from the 1960s. Threats from climatic variation, high temperatures, predation, and water diversions still persist. Hatchery production can also pose a threat to salmonids. Potential adverse effects from hatchery production include competition for food between naturally-spawned and hatchery fish, run hybridization and genomic homogenization. Despite these potential impacts from hatchery production, NMFS ultimately concluded the FRH stock should be included in the CVS Chinook ESU because it still exhibited a spring-run migration timing and was the best opportunity for restoring a more natural spring-run population in the Feather River. In the most recent status review of this ESU, NMFS concluded that the FRH stock should be considered part of the CVS Chinook ESU (Williams et al. 2011). Because wild CVS Chinook salmon ESU populations are confined to relatively few remaining watersheds and continue to display broad fluctuations in abundance, the BRT concluded that the ESU is likely to become endangered within the foreseeable future. The most recent status review concludes the status of CVS Chinook salmon ESU has probably deteriorated since the 2005 status review (Williams et al. 2011).

2.4.3.1.3 California Coastal Chinook

Spatial Structure and Diversity: The California Coastal (CC) Chinook salmon ESU was historically comprised approximately 38 Chinook salmon populations[22] (Bjorkstedt et al. 2005, Spence et al. 2008). Many of these populations (about 21) were independent or potentially independent, meaning they had a high likelihood of surviving for 100 years absent anthropogenic impacts. The remaining populations were likely more dependent upon immigration from nearby independent populations (Bjorkstedt et al. 2005, Spence et al. 2008).

Abundance and Productivity: Data on CC Chinook abundance, both historical and current, are sparse and of varying quality (Bjorkstedt et al. 2005). Estimates of absolute abundance are not available for populations in this ESU (Myers et al. 1998). In 1965, the California Department of Fish and Game (CDFG)(1965) estimated escapement for this ESU at over 76,000. Most were in the Eel River (55,500), with smaller populations in Redwood Creek (5,000), Mad River (5,000),

[22] Population is defined by Bjorkstedt et al. 2005 and McElhaney et al. 2000 as, in brief summary, a group of fish of the same species that spawns in a particular locality at a particular season and does not interbreed substantially with fish from any other group. Such fish groups may include more than one stream. These authors use this definition as a starting point from which they define four types of populations (not all of which are mentioned here).

Mattole River (5,000), Russian River (500) and several smaller streams in Humboldt County (Myers et al. 1998). Currently available data indicate abundance is far lower, suggesting an inability to sustain production adequate to maintain the ESU populations. Recent growth rates are fluctuating (depending upon the year) coastwide in California; for example, in 2007-2009, dramatic declines in Chinook salmon returns occurred throughout California. More recently, Chinook salmon counts in the Russian River have continually increased since record lows in 2008. The highest count recorded since monitoring began in 2000 was surpassed in November, 2012 (Sonoma County Water Agency 2012).

Although there are limited population-level estimates of abundance for CC Chinook salmon populations, Table 11 summarizes the information that is available for the major watersheds in the ESU. Based on this limited information, the current average run size for CC Chinook ESU is 7,144 adults. While we currently lack data on naturally-produced juvenile CC Chinook salmon production, it is possible to make rough estimates of juvenile abundance from adult return data. Juvenile CC Chinook salmon population abundance estimates come from escapement data, the percentage of females in the population, and fecundity. Average fecundity for female CC Chinook is not available. However, Healey and Heard (1984) indicates that average fecundity for Chinook salmon in the nearby Klamath River is 3,634 eggs for female. By applying an average fecundity of 3,634 eggs per female to the estimated 3,572 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 1,298,065 natural outmigrants annually.

Table 11. Abundance Geometric Means for Adult CC Chinook Salmon Natural-origin Spawners.

Population	Years	Spawners	Expected Number of Outmigrants[ab]
Redwood Creek[c]	2009-2013	1,745	317,067
Mad River[d]	2008 - 2013	76	13,809
Freshwater Creek[e]	2008 - 2013	3	545
Eel River mainstem[f]	2008 - 2013	1,379	250,564
Eel River (Tomki Creek)[d]	2008 - 2013	61	11,084
Eel River (Sproul Creek)[d]	2008 - 2013	187	33,978
Mattole River[g]	2006 - 2009	1,170	212,589
Russian River[h]	2008 - 2013	2,523	458,429
Total		**7,144**	**1,298,065**

[a]Expected number of outmigrants=Total spawners*50% proportion of females*3,634 eggs per female*10% survival rate from egg to outmigrant.

[b]Based upon number of natural-origin spawners.
[c]Metheny and Duffy 2014
[d]PFMC 2013
[e] Ricker et al. 2014
[f]source: http://www.pottervalleywater.org/van_arsdale_fish_counts.html
[g]Mattole Salmon Group 2011
[h]source: http://www.scwa.ca.gov/chinook/

Limiting Factors: Because of their prized status in the sport and commercial fishing industries, CC Chinook salmon have been the subject of many artificial production efforts, including out-of-basin and out-of-ESU stock transfers (Bjorkstedt et al. 2005). It is, therefore, likely that CC Chinook salmon genetic diversity has been significantly adversely affected despite the relatively wide distribution of populations within the ESU. An apparent loss of the spring-run Chinook life history in the Eel River Basin and elsewhere in the ESU also indicates risks to the diversity of the ESU. Data from the 2009 adult CC Chinook salmon return counts and estimates indicated a further decline in returning adults across the range of CC Chinook salmon on the coast of California (Jeffrey Jahn, NMFS, personal communication, 2010). Ocean conditions are suspected as a primary short term cause because of the wide geographic range of declines (Lindley et al. 2009). However, the number of adult CC Chinook salmon returns in the Russian River Watershed increased substantially in 2010/2011 compared to 2008/09 and 2009/10 returns.[23] Increases in adult Chinook salmon returns during 2010/2011 have been observed in the Central Valley populations as well. These numbers must be taken in context of the overall Chinook salmon abundance in the ESU which has recently been reviewed by Williams et al. (2011), who found no evidence of a substantial change in the status of the CC Chinook ESU since the last status review by Good et al. (2005). Based on this information, NMFS chose to maintain the threatened listing of CC Chinook salmon (76 FR 50447).

2.4.3.1.4 Snake River fall Chinook

Spatial Structure and Diversity: Snake River (SR) fall Chinook includes all naturally-spawned populations of fall-run Chinook salmon in the mainstem Snake River below Hells Canyon Dam, and in the Tucannon River, Grande Ronde River, Imnaha River, Salmon River, and Clearwater River, and progeny of four artificial propagation programs. The Interior Columbia Technical Recovery Team (IC-TRT) identified three populations of this species, although only the lower mainstem population exists at present, and it spawns in the lower main stem of the Clearwater, Imnaha, Grande Ronde, Salmon and Tucannon rivers. The extant population of SR fall Chinook salmon is the only remaining population from an historical ESU that also included large mainstem populations upstream of the current location of the Hells Canyon Dam complex (Ford 2011; NMFS 2011b). The population is at moderate risk for diversity and spatial structure.

[23] http://www.scwa.ca.gov/chinook/

Overall, the new information considered does not indicate a change in the biological risk category since the last status review (Ford 2011).

Abundance and Productivity: The recent increases in natural origin abundance are encouraging. However, hatchery origin spawner proportions have increased dramatically in recent years – on average, 78% of the estimated adult spawners have been hatchery origin over the most recent brood cycle. The apparent leveling off of natural returns in spite of the increases in total brood year spawners may indicate that density dependent habitat effects are influencing production or that high hatchery proportions may be influencing natural production rates. The A&P risk rating for the population is "moderate." Given the combination of current A&P and SS/D ratings summarized above, the overall viability rating for Lower SR fall Chinook salmon would be rated as "maintained."[24]

The 1999 NMFS Status Review Update noted increases in the Lower Granite Dam counts in the mid-1990s, and the upward trend in returns—the 2001 count over Lower Granite Dam exceeded 8,700 adult fall Chinook—has largely continued. The largest increase in fall Chinook returns to the Snake River spawning area was from the Lyons Ferry Snake River stock component. Returns there increased from under 200 per year before to 1998 to over 1,200 and 5,300 adults in 2000 and 2001, respectively. The increase includes returns from the on-station release program as well as returns from large supplementation releases above Lower Granite Dam. Moreover, from the year 2003 through the year 2008, the five-year average return to the ESU was 11,321 adult fish (Ford 2011); of these, approximately 78% were of hatchery origin. Overall, from the year 2010 through the year 2014, the five-year average escapement of SR fall Chinook was 14,438 naturally produced adult fish and 30,475 hatchery propagated adult fish (Table 12).

Table 12. Estimated numbers of adult SR fall Chinook salmon (NWFSC 2015).

Year	Hatchery Escapement	Natural Escapement
2010	32,408	7,356
2011	15,516	8,064
2012	19,038	11,325
2013	30,794	20,444
2014	54,621	25,001
Average	30,475	14,438

[24] "Maintained" population status is for populations that do not meet the criteria for a viable population but do support ecological functions and preserve options for ESU/DPS recovery.

Juvenile abundance estimates are published each spring in an annual memorandum estimating percentage of listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River basin. Numbers for 2015 are not available at this time; however the average outmigration for the years 2010-2014 is shown in Table 13.

Table 13. Recent five-year average projected outmigrations for SR fall Chinook salmon (Ferguson 2010; Dey 2011; Zabel 2013; Zabel 2014a; Zabel 2014b).

Origin	Outmigration
Natural	570,821
Listed Hatchery: Adipose Clipped	3,076,642
Listed Hatchery: Intact Adipose	3,915,529

The number of natural fish 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) spawner counts and associated sex ratios and fecundity estimates can vary considerably between years; (2) multiple juvenile age classes (fry, parr, smolt) are present yet comparable data sets may not exist for all of them; and (3) 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.). Listed hatchery fish outmigration numbers are also affected by some of these factors, however releases from hatcheries are generally easier to quantify than is natural production. These caveats are generally applicable to all salmonid ESUs.

Limiting Factors include (NOAA Fisheries 2011):

Degraded freshwater habitat: Floodplain connectivity and function, and channel structure and complexity have been degraded as a result of cumulative impacts of agriculture, forestry, and development.
Harvest-related effects
Loss of access to historic habitat above Hells Canyon and other Snake River dams
Mainstem Columbia River and Snake River hydropower impacts
Hatchery-related effects
Degraded estuarine and nearshore habitat

2.4.3.1.5 Snake River spring/summer Chinook

Spatial Structure and Diversity: This species includes all naturally-spawned populations of spring/summer-run Chinook salmon in the mainstem Snake River and the Tucannon River, Grande Ronde River, Imnaha River, and Salmon River subbasins; and progeny of fifteen artificial propagation programs. The IC-TRT currently believes there are 27 extant and 4 extirpated populations of Snake River (SR) spring/summer-run Chinook salmon, and aggregated these into major population groups (IC-TRT 2007; Ford 2011). Each of these populations faces a "high" risk of extinction (Ford 2011).

Abundance and Productivity: Population level status ratings remain at "high" risk across all MPGs within the ESU, although recent natural spawning abundance estimates have increased, all populations remain below minimum natural origin abundance thresholds. Spawning escapements in the most recent years in each series are generally well below the peak returns but above the extreme low levels in the mid-1990s. Relatively low natural production rates and spawning levels below minimum abundance thresholds remain a major concern across the ESU.

The ability of SR spring/summer-run Chinook salmon populations to be self-sustaining through normal periods of relatively low ocean survival remains uncertain. Factors cited by Good et al. (2005) remain as concerns or key uncertainties for several populations. Overall, the new information considered does not indicate a change in the biological risk category since the last status review (Ford 2011).

The 1997-2001 geometric mean total return for spring/summer Chinook was slightly more than 6,000 fish. This was a marked improvement over the previous ten years when the geometric mean return was 3,076. That increase continued relatively steadily through 2004, when 97,946 adults returned (including jacks), but dropped off precipitously in 2005 when only 39,126 fish (including jacks) returned above Ice Harbor Dam (FPC 2005). The increases from 2001 through 2004 are generally thought to have been a result of good ocean conditions for rearing and good Columbia River flows for outmigration. But even with generally better trends in recent years, no population of SR spring/summer Chinook is known to be meeting its interim recovery goals (Ford 2011). In fact, the most recent return numbers to individual populations show most of the runs to be at less than half the desired levels (Ford 2011). Overall, from the year 2009 through the year 2013, the five-year average escapement of naturally produced SR spring/summer Chinook was 20,422 naturally produced and 60,058 hatchery propagated fish (Table 14).

Table 14. Estimated numbers of adult SR spring/summer Chinook salmon (ODFW/WDFW 2014).

Year	Return to Columbia River		Hatchery Escapement[a]	Natural Escapement[a]
	Hatchery	Natural		
2009	68,937	20,240	48,750	14,313
2010	130,976	34,764	94,984	25,211
2011	92,639	30,567	72,264	23,844
2012	75,656	33,856	55,482	24,828
2013	45,400	21,929	28,811	13,916
Average	82,722	28,271	60,058	20,422

[a] Lower Granite Dam passage plus Tucannon River escapement.

Juvenile abundance estimates are published each spring in an annual memorandum estimating percentage of listed Pacific salmon and steelhead smolts arriving at various locations in the

Columbia River basin. The averages of the five most recent projections for the SR spring/summer Chinook salmon juvenile outmigration are displayed below.

Table 15. Recent five-year average projected outmigrations for SR spring/summer Chinook salmon (Ferguson 2010; Dey 2011; Zabel 2013; Zabel 2014a; Zabel 2014b).

Origin	Outmigration
Natural	1,454,727
Listed Hatchery: Adipose Clipped*	4,381,302
Listed Hatchery: Intact Adipose*	1,158,078

*When the above species was listed, NMFS included certain artificially propagated (hatchery-origin) populations in the listing. Some of those listed fish have had their adipose fins clipped at their respective hatcheries and some have not.

Limiting Factors include (NOAA Fisheries 2011):

Degraded freshwater habitat: Floodplain connectivity and function, channel structure and complexity, riparian areas and large wood supply, stream substrate, elevated water temperature, stream flow, and water quality have been degraded as a result of cumulative impacts of agriculture, forestry, and development
Mainstem Columbia River and Snake River hydropower impacts
Harvest-related effects
Predation

2.4.3.1.6 Lower Columbia River Chinook

Spatial Structure and Diversity: Lower Columbia River (LCR) Chinook includes all naturally-spawned populations of Chinook salmon in the Columbia River and its tributaries from its mouth at the Pacific Ocean upstream to a transitional point between Washington and Oregon east of the Hood River and the White Salmon River; the Willamette River to Willamette Falls, Oregon, exclusive of spring-run Chinook salmon in the Clackamas River; and progeny of seventeen artificial propagation programs.[25] LCR Chinook populations exhibit three different life history types base on return timing and other features: fall-run (a.k.a. "tules"), late-fall-run (a.k.a. "brights"), and spring-run. The Willamete/Lower Columbia Technical Recovery Team (WLC-TRT) identified 32 historical populations of LCR Chinook salmon— seven in the coastal subregion, six in the Columbia Gorge, and 19 in the Cascade Range. Spatial structure has been substantially reduced in several populations. Low abundance, past broodstock transfers and other legacy hatchery effects, and ongoing hatchery straying may have reduced genetic diversity within and among LCR Chinook salmon populations. Hatchery-origin fish spawning naturally may also have reduced population productivity (Lower Columbia Fish Recovery Board 2010;

[25] In 2009, the Elochoman tule fall Chinook salmon program was discontinued and four new fall Chinook salmon programs have been initiated. In 2011, NMFS recommended removing the Elochoman program from the ESU and adding the new programs to the ESU (NMFS 2011b).

ODFW 2010; NMFS 2013a). Out of the 32 populations that make up this ESU, only the two late-fall runs, the North Fork Lewis and Sandy, are considered viable. Most populations (26 out of 32) have a very low probability of persistence over the next 100 years (and some are extirpated or nearly so) (Lower Columbia Fish Recovery Board 2010; ODFW 2010; Ford 2011; NMFS 2013a). Five of the six strata fall significantly short of the WLC-TRT criteria for viability; one stratum, Cascade late-fall, meets the WLC TRT criteria (NMFS 2013a).

Abundance and Productivity: A&P ratings for LCR Chinook salmon populations are currently "low" to "very low" for most populations, except for spring Chinook salmon in the Sandy River, which are "moderate" and late-fall Chinook salmon in North Fork Lewis River and Sandy River, which are "very high" (NMFS 2013a). Low abundance of natural-origin spawners (100 fish or fewer) has increased genetic and demographic risks. Other LCR Chinook salmon populations have higher total abundance, but several of these also have high proportions of hatchery-origin spawners. Particularly for tule fall Chinook salmon populations, poor data quality prevents precise quantification of population abundance and productivity; data quality has been poor because of inadequate spawning surveys and the presence of unmarked hatchery-origin spawners (Ford 2011).

In 1998, NMFS assessed the abundance in smaller tributary streams in the range of the species to be in the hundreds of fish (Myers et al. 1998). Larger tributaries (e.g., Cowlitz River basin) contained natural runs of Chinook salmon ranging in size from 100 to almost 1,000 fish. In 2005, NMFS calculated adult abundance using the geometric mean of natural-origin spawners in the five years previous to 2003 (Good et al. 2005). In 2005, NMFS estimated the LCR Chinook salmon abundance at approximately 14,130 fish (Good et al. 2005). Data that are more recent place the abundance of naturally produced LCR Chinook salmon at approximately 13,594 spawners (Table 16).

Table 16. Abundance estimates for LCR Chinook salmon populations (ODFW 2014a; WDFW 2014).

Stratum (Run)	Population	Years	Total	HOR(1)	NOR(2)
Coastal (Fall)	Youngs Bay	2012-13	6,686	6,516	170
	Grays/Chinook	2008-2012	319	106	213
	Big Creek	2012-13	1,096	1,041	55
	Elochoman/Skamokowa	2008-2012	1,091	628	463
	Clatskanie	2012-13	3,205	2,999	206
	Mill/Abernathy/Germany	2008-2012	817	302	515
	Scappoose		na	na	na
Cascade (Fall)	Lower Cowlitz	2008-2012	617	0	617
	Upper Cowlitz	2008-2012	2,670	2,204	466
	Toutle	2008-2012	na	na	na
	Coweeman	2008-2012	1,080	891	189
	Kalama	2008-2012	5,420	4,198	1,222

	Lewis	2004-2008	1,060	0	1,060
	Washougal	2012-13	321	261	60
	Clackamas	2008-2012	3,050	1,216	1,834
	Sandy	2012-13	714	146	568
Columbia Gorge (Fall)	Lower gorge	2003-2007	146	Unknown	146
	Upper gorge	2008-2012	827	Unknown	345
	Hood		na	na	na
	White Salmon	2008-2012	1,522	Unknown	1,524
Cascade (Late Fall)	Sandy		na	na	na
	North Fork Lewis	2008-2012	843	134	709
Cascade (Spring)	Upper Cowlitz	2005-2009	589	0	589
	Cispus		na	na	na
	Tilton		na	na	na
	Toutle		na	na	na
	Kalama	2006-2011	606	0	606
	North Fork Lewis	2007-2012	199	0	199
	Sandy	2008-2012	4,064	2,226	1,838
Gorge (Spring)	White Salmon		na	na	na
	Hood		na	na	na
Total			36,942	22,868	13,594

(1) Hatchery Origin (HOR) spawners.
(2) Natural Origin (NOR) spawners.

The Oregon and Washington recovery plans rate all but three Chinook populations as low to very low for abundance and productivity (ODFW 2010; LCFRB 2010). The range of abundance recommended for recovery is from 300 (Kalama spring-run) to 7,300 (North Fork Lewis late fall-run). Current abundance estimates from WDFW and ODFW suggest that only five populations are at or have exceeded abundance goals, and for one of these (the White Salmon), we do not know what portion of the spawners are hatchery origin.

NWFSC publishes juvenile abundance estimates each year in the annual memorandum estimating percentages of listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River basin. Numbers for 2015 are not available at this time; however, the average outmigration for the years 2010-2014 is shown in Table 17 (Ferguson 2010; Dey 2012; Zabel 2013, 2014a, 2014b).

Table 17. Average estimated outmigration for ESA-listed LCR Chinook salmon (2010-2014).

Origin	Outmigration
Natural	13,271,270
Listed hatchery intact adipose	1,070,253
Listed hatchery adipose clip	35,337,495

Limiting Factors include (NOAA Fisheries 2011; NMFS 2013a):

Degraded estuarine and near-shore marine habitat resulting from cumulative impacts of land use and flow management by the Columbia River hydropower system Degraded freshwater habitat: Floodplain connectivity and function, channel structure and complexity, riparian areas, stream substrate, stream flow, and water quality have been degraded as a result of cumulative impacts of agriculture, forestry, and development.
Reduced access to spawning and rearing habitat mainly as a result of tributary hydropower projects
Hatchery-related effects
Harvest-related effects on fall Chinook salmon
An altered flow regime and Columbia River plume has altered the temperature regime and estuarine food web, and has reduced ocean productivity
Reduced access to off-channel rearing habitat in the lower Columbia River
Reduced productivity resulting from sediment and nutrient-related changes in the estuary
Juvenile fish strandings that result from ship wakes
Contaminants affecting fish health and reproduction

2.4.3.1.7 Upper Willamette River Chinook

Spatial Structure and Diversity: Upper Willamette River (UWR) Chinook includes all naturally spawned populations of spring-run Chinook salmon in the Clackamas River; in the Willamette River and its tributaries above Willamette Falls, Oregon; and progeny of seven artificial propagation programs. All seven historical populations of UWR Chinook salmon identified by the WLC-TRT occur within the action area and are contained within a single ecological subregion, the western Cascade Range. The McKenzie River population currently characterized as at a "low" risk of extinction and the Clackamas population has a "moderate" risk (Ford 2011). Consideration of data collected since the last status review in 2005 has confirmed the high fraction of hatchery origin fish in all of the populations of this species (even the Clackamas and McKenzie rivers have hatchery fractions above WLC-TRT viability thresholds). All of the UWR Chinook salmon populations have "moderate" or "high" risk ratings for diversity. Clackamas River Chinook salmon have a "low" risk rating for spatial structure (Ford 2011).

Abundance and Productivity: The Clackamas and McKenzie river populations currently have the best risk ratings for A&P, spatial structure, and diversity. Data collected since the Biological Review Team (BRT) status update in 2005 highlighted the substantial risks associated with pre-spawning mortality. Although recovery plans are targeting key limiting factors for future actions, there have been no significant on-the-ground-actions since the last status review to resolve the lack of access to historical habitat above dams nor have there been substantial actions removing hatchery fish from the spawning grounds. Overall, the new information does not indicate a change in the biological risk category since the last status review (Ford 2011).

Recent data on returning adults are summarized in Table 18 (ODFW and WDFW 2007a, 2008a, 2009a, 2010a, 2011a). Abundance of adult UWR spring Chinook has declined since the highs witnessed around the turn of this century. The 5-year average return for UWR spring Chinook salmon is 11,303 naturally produced adults and 40,338 hatchery adults (2007-2011). Average escapement for the years 2007-2011 was a combined total of 39,168 hatchery- and naturally-produced adult Chinook.

Table 18. Adult UWR spring Chinook escapement to the Clackamas River and Willamette Falls fish ladder (ODFW and WDFW 2011a, 2012a, 2013a, 2014a; ODFW 2014).

Year	Total Escapement	Hatchery Escapement	Natural Escapement
2010	78,032	66,543	11,489
2011	51,922	36,506	15,416
2012	43,012	32,334	10,678
2013	35,714	24,332	11,382
2014	37,300	30,959	6,341
Average	49,196	38,135	11,061

The NWFSC publishes juvenile abundance estimates each year in the annual memorandum estimating percentages of ESA-listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River basin. Numbers for 2015 are not available at this time; however the average outmigration for the years 2010-2014 is shown in Table 19 (Ferguson 2010; Dey 2012; Zabel 2013, 2014a, 2014b).

Table 19. Average estimated outmigration for ESA-listed UWR Chinook salmon (2010-2014).

Origin	Outmigration
Natural	1,813,726
Listed hatchery intact adipose	42,420
Listed hatchery adipose clipped	6,006,713

<u>Limiting Factors</u> include (NOAA Fisheries 2011; ODFW and NMFS 2011c):

Significantly reduced access to spawning and rearing habitat because of tributary dams
Degraded freshwater habitat, especially floodplain connectivity and function, channel structure and complexity, and riparian areas and large wood recruitment as a result of cumulative impacts of agriculture, forestry, and development

Degraded water quality and altered temperature as a result of both tributary dams and the cumulative impacts of agriculture, forestry, and urban development
Hatchery-related effects
Anthropogenic introductions of non-native species and out-of-ESU races of salmon or steelhead have increased predation on, and competition with, native UWR Chinook salmon
Ocean harvest rates of approximately 30%

2.4.3.1.8 Upper Columbia River spring Chinook

Spatial Structure and Diversity: Upper Columbia River (UCR) spring Chinook includes all naturally-spawned populations of Chinook salmon in all river reaches accessible to Chinook salmon in Columbia River tributaries upstream of the Rock Island Dam and downstream of Chief Joseph Dam (excluding the Okanogan River), the Columbia River upstream to Chief Joseph Dam, and progeny of six artificial propagation programs. The IC-TRT identified four independent populations of UCR spring-run Chinook salmon in the upriver tributaries of Wenatchee, Entiat, Methow, and Okanogan (extirpated), but no major groups due to the relatively small geographic area affected (Ford 2011; NMFS 2011b).

The composite SS/D risks for all three of the extant populations in this MPG are at "high" risk. The spatial processes component of the SS/D risk is "low" for the Wenatchee River and Methow River populations and "moderate" for the Entiat River (loss of production in lower section increases effective distance to other populations). All three of the extant populations in this MPG are at "high" risk for diversity, driven primarily by chronically high proportions of hatchery-origin spawners in natural spawning areas and lack of genetic diversity among the natural-origin spawners (Ford 2011).

Increases in natural origin abundance relative to the extremely low spawning levels observed in the mid-1990s are encouraging; however, average productivity levels remain extremely low. Overall, the viability of UCR spring Chinook salmon ESU has likely improved somewhat since the last status review, but the ESU is still clearly at "moderate-to-high" risk of extinction (Ford 2011).

Abundance and Productivity: UCR spring Chinook salmon is not currently meeting the viability criteria (adapted from the IC-TRT) in the Upper Columbia Recovery Plan. A&P remains at "high" risk for each of the three extant populations in this MPG/ESU. The 10-year geometric mean abundance of adult natural origin spawners increased for each population relative to the levels for the 1981-2003 series, but the estimates remain below the corresponding IC-TRT thresholds. Estimated productivity (spawner to spawner return rate at low to moderate escapements) was on average lower over the years 1987-2009 than for the previous period. The combinations of current abundance and productivity for each population result in a "high" risk rating.

From the year 2006 through 2010, the five-year average return to the ESU—as measured primarily by spawning surveys--was 3,900 (Salmonid Population Summary (SPS) query, April 2014[26]); of these, approximately 65% were of hatchery origin. Counts at Rock Island Dam in 2008, 2010, and 2011 showed an average estimated 1,668 natural fish retuning to the ESU which, given a 35% natural origin for the overall return, indicated that the total return was on the order of 4,766 fish. These figures demonstrate that there is some degree of variability in the various sources for returning adult numbers. As a result, it is sometimes difficult to take all the various factors into account (survey types, data gaps, various dam counts, hatchery vs. wild components, etc.) and clearly and accurately determine what the returns actually are. Nonetheless, the figures we believe to be the most likely to represent the actual returns come from the U.S. v. Oregon Technical Advisory Committee (TAC) numbers derived from dam counts and complied by the WDFW (WDFW 2013). These numbers are widely used throughout the region for management purposes (particularly in setting harvest quotas), and at this point represent the very best available scientific and technical knowledge to which we have access. The most recent year for which these numbers have been calculated and published is 2014 (via the FCRPS Adaptive Management Implementation Plan). That year, the UCR spring Chinook total return to Rock Island Dam was 3,986 natural adults. The most recent four-year average to that date was 3,170 fish. Given that these fish comprise approximately 35% of the total run, it signifies that the total return for 2014 was 11,388 fish and the most recent four year average was 9,057 adults.

Juvenile abundance estimates are published each spring in an annual memorandum estimating percentage of ESA-listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River basin. The averages of the five most recent projections for the UCR spring Chinook juvenile outmigration are displayed below in Table 20.

Table 20. Recent five-year average projected outmigrations for UCR Chinook (Ferguson 2010; Dey 2012; Zabel 2013; Zabel 2014a, Zabel 2014b).

Origin	Outmigration
Natural	570,965
Listed Hatchery: Adipose Clipped*	504,620
Listed Hatchery: Intact Adipose*	931,815

*When the above species was listed, NMFS included certain artificially propagated (hatchery-origin) populations in the listing. Some of those listed fish have had their adipose fins clipped at their respective hatcheries and some have not.

[26] The data contained in the SPS database are primarily summary data, compiled at the population level. The database also includes a limited number of series representing the aggregate returns to groups of populations (e.g., Lower Granite Dam counts) or counts of spawners within a subsection of a population where expansions to the population level were not feasible.

Limiting Factors include (Upper Columbia Salmon Recovery Board 2007; NOAA Fisheries 2011):

Mainstem Columbia River hydropower–related adverse effects: upstream and downstream fish passage, ecosystem structure and function, flows, and water quality
Degraded freshwater habitat: Floodplain connectivity and function, channel structure and complexity, riparian areas and large woody debris recruitment, stream flow, and water quality have been degraded as a result of cumulative impacts of agriculture, forestry, and development
Degraded estuarine and nearshore marine habitat
Hatchery related effects: including past introductions and persistence of non-native (exotic) fish species continues to affect habitat conditions for listed species
Harvest in Columbia River fisheries

2.4.3.1.9 Puget Sound Chinook

Spatial Structure and Diversity: Puget Sound (PS) Chinook includes all naturally spawned populations of Chinook salmon from rivers and streams flowing into Puget Sound including the Straits of Juan De Fuca from the Elwha River, eastward, including rivers and streams flowing into Hood Canal, South Sound, North Sound and the Strait of Georgia in Washington, and progeny of 26 artificial propagation programs. The PS-TRT identified 22 historical populations, grouped into five major geographic regions, based on consideration of historical distribution, geographic isolation, dispersal rates, genetic data, life history information, population dynamics, and environmental and ecological diversity. The NMFS adopted the Shared Strategy for Puget Sound locally-developed listed species recovery plan for PS Chinook salmon in 2007 (SSPS 2007).

Indices of spatial distribution and diversity have not been developed at the population level. Based on a Shannon Diversity Index at the ESU level, diversity is declining (due primarily to the increased abundance of returns to the Whidbey Basin region) for both distribution among populations and among regions (Ford 2011). Overall, the new information on abundance, productivity, spatial structure and diversity since the 2005 status review does not indicate a change in the biological risk category (Ford 2011).

Abundance and Productivity: No trend was notable for the total ESU escapements; while trends vary from decreasing to increasing among populations. Natural-origin pre-harvest recruit escapements remained fairly constant from 1985-2009. Returns (pre-harvest run size) from the natural spawners were highest in 1985, declined through 1994, remained low through 1999, increased in 2000 and again in 2001, and have declined through 2009, with 2009 having the lowest returns since 1997. Median recruits per spawner for the last 5-year period (brood years 2002-2006) is the lowest over any of the 5-year intervals. Many of the habitat and hatchery actions identified in the PS Chinook salmon recovery plan are likely to take years or decades to be implemented and to produce significant improvements in natural population attributes, and these trends are consistent with these expectations (Ford 2011).

NMFS concluded in 1998 (Myers et al. 1998), 2005 (Good et al. 2005), and 2011 (Ford 2011) that the PS Chinook ESU was likely to become endangered in the foreseeable future. In the first status review, the PS Chinook BRT estimated the total PS Chinook salmon run size in the early 1990s to be approximately 240,000 Chinook, with the vast majority as hatchery-origin. Based on current estimates, 67,000 of those fish were naturally produced Chinook salmon (Unpublished data, Norma Sands, NWFSC, March 5, 2010). ESU escapement increased to 45,214 (2000-2004); but has since declined to 37,409, during the most recent status review (2005-2009), and 30,955 from 2008-2012 (Tables 21 and 22).

Table 21. Abundance–five-year geometric means for adult (age 3+) natural (natural and hatchery origin) and natural origin only spawners for the ESU with ranges and medians given for the populations (Ford 2011).

	Natural Escapement			Natural Origin Escapement		
Year Range	**ESU**	**Population Range**	**Population Median**	**ESU**	**Population Range**	**Population Median**
1985-1989	36,750	48-8,276	770	28,601	30-7,965	725
1990-1994	26,094	101-5,511	395	19,511	20-5,304	381
1995-1999	28,981	104-6,729	479	19,011	18-5,982	380
2000-2004	45,214	202-12,109	999	32,794	71-11,678	430
2005-2009	37,409	81-10,345	909	25,848	44-9,724	482

Table 22. Average abundance estimates for PS Chinook salmon natural- and hatchery-origin spawners 2008-2012 (unpublished data, Mindy Rowse, NWFSC, Jan. 28, 2015).

Population Name	Natural-origin Spawners[a]	Hatchery-origin Spawners[b]	% Hatchery Origin	Minimum Viability Abundance[c]	Expected Number of Outmigrants[d]
N. Fork Nooksack	171	1,066	86.18%	16,000	98,960
S. Fork Nooksack	111	264	70.40%	9,100	30,000
Lower Skagit	1,343	63	4.48%	16,000	112,480
Upper Skagit	6,545	135	2.02%	17,000	534,400
Cascade	316	9	2.77%	1,200	26,000
Lower Sauk	372	0	0.00%	5,600	29,760
Upper Sauk	700	18	2.51%	3,000	57,440
Suiattle	335	2	0.59%	600	26,960
N. Fork Stillaguamish	533	393	42.44%	17,000	74,080
S. Fork Stillaguamish	57	8	12.31%	15,000	5,200
Skykomish	1,534	510	24.95%	17,000	163,520
Snoqualmie	804	231	22.32%	17,000	82,800
Sammamish	165	1,249	88.33%	10,500	113,120
Cedar	776	168	17.80%	11,500	75,520
Duwamish/Green	599	890	59.77%	17,000	119,120

Population Name	Natural-origin Spawners[a]	Hatchery-origin Spawners[b]	% Hatchery Origin	Minimum Viability Abundance[c]	Expected Number of Outmigrants[d]
White	957	674	41.32%	14,200	130,480
Puyallup	482	596	55.29%	17,000	86,240
Nisqually	552	1,404	71.78%	13,000	156,480
Skokomish	253	1,055	80.66%	12,800	104,640
Mid-Hood Canal	58	171	74.67%	11,000	18,320
Dungeness	115	139	54.72%	4,700	20,320
Elwha	171	898	84.00%	15,100	85,520
ESU Average[e]	18,127	11,089	37.96%		2,337,280

[a] Five-year geometric mean of post-fishery natural-origin spawners.
[b] Five-year geometric mean of post-fishery hatchery-origin spawners.
[c] Ford 2011
[d] Expected number of outmigrants=Total spawners*40% proportion of females*2,000 eggs per female*10% survival rate from egg to outmigrant
[e] ESU Average is calculated as the geometric mean of the annual totals and not the sum of the geometric means.

Juvenile PS Chinook abundance estimates come from escapement data, the percentage of females in the population, and fecundity. Fecundity estimates for the ESU range from 2,000 to 5,500 eggs per female, and the proportion of female spawners in most populations is approximately 40% of escapement. By applying a conservative fecundity estimate (2,000 eggs/female) to the expected female escapement (both natural-origin and hatchery-origin spawners – 14,608 females), the ESU is estimated to produce approximately 23.4 million eggs annually. Smolt trap studies have researched egg to migrant juvenile Chinook salmon survival rates in the following Puget Sound tributaries: Skagit River, North Fork Stillaguamish River, South Fork Stillaguamish River, Bear Creek, Cedar River, and Green River (Beamer et al. 2000; Seiler et al. 2002, 2004, 2005; Volkhardt et al. 2005; Griffith et al. 2004). The average survival rate in these studies was 10%, which corresponds with those reported by Healey (1991). With an estimated survival rate of 10%, the ESU should produce roughly 2.34 million natural outmigrants annually.

<u>Limiting Factors</u> include (SSPS 2007; NOAA Fisheries 2011):

Degraded nearshore and estuarine habitat: Residential and commercial development has reduced the amount of functioning nearshore and estuarine habitat available for salmon rearing and migration. The loss of mudflats, eelgrass meadows, and macroalgae further limits salmon foraging and rearing opportunities in nearshore and estuarine areas.
Degraded freshwater habitat: Floodplain connectivity and function, channel structure and complexity, riparian areas and large wood supply, stream substrate, and water quality have been degraded for adult spawning, embryo incubation, and rearing as a result of cumulative impacts of agriculture, forestry, and development.

Anadromous salmonid hatchery programs: Salmon and steelhead released from Puget Sound hatcheries operated for harvest augmentation purposes pose ecological, genetic, and demographic risks to natural-origin Chinook salmon populations.
Salmon harvest management: Total fishery exploitation rates have decreased 14 to 63% from rates in the 1980s, but weak natural-origin Chinook salmon populations in Puget Sound still require enhanced protective measures to reduce the risk of overharvest in Chinook salmon-directed fisheries.

2.4.3.2 Chum

Chum salmon *(Oncorhynchus keta)* is a species with a wide geographic and spawning distribution. Chum salmon range farther north along the shores of the Arctic Ocean than any other salmonids; major spawning populations are found only as far south as Tillamook Bay on the northern Oregon coast. Chum salmon spawn in the lowermost reaches of rivers and streams, typically within 62 miles (100 kilometers) of the ocean, often near springs. Chum salmon migrate, almost immediately after hatching, to estuarine and ocean waters. This means that the survival and growth of juvenile chum salmon depends less on freshwater conditions and more on favorable estuarine and marine conditions.

NMFS has identified four chum salmon ESUs that occur within the the SWFSC research area and of these two are considered threatened under the ESA: Hood Canal Summer-run and Columbia River ESUs. The Puget Sound/Strait of Georgia and Pacific Coast chum salmon ESUs are currently not listed under the ESA.

2.4.3.2.10 Hood Canal summer chum

<u>Spatial Structure and Diversit</u>y: Hood Canal summer (HCS) chum includes all naturally spawned populations of summer-run chum salmon in Hood Canal and its tributaries; populations in Olympic Peninsula rivers between Hood Canal and Dungeness Bay, Washington; and progeny of eight artificial propagation programs. The Strait of Juan de Fuca population spawns in rivers and streams entering the eastern Strait and Admiralty Inlet. The HCS chum population includes all spawning aggregations within the Hood Canal area (Hood Canal Coordinating Council 2005; NMFS 2007a). The Puget Sound Technical Recovery Team (PS-TRT) identified two independent populations of HCS chum salmon (NMFS 2007b), which include 16 historical stocks or spawning aggregations (including eight that are extant), based on consideration of historical distribution, geographic isolation, dispersal rates, genetic data, life history information, population dynamics, and environmental and ecological diversity. The historical populations included at least those 16 spawning aggregation units and likely some additional undocumented and less-persistent aggregations (NMFS 2007b). Programs are underway to reintroduce summer-run chum salmon to several of the watersheds where stocks were lost.

Diversity is increasing from the low values seen in the 1990s, due both to the reintroduction of spawning aggregates and the more uniform relative abundance between populations; this is a good sign for viability in terms of spatial structure and diversity. Spawning survey data shows that the spawning distribution within most streams has been extended farther upstream as abundance has increased (WDFW and Point No Point Treaty Tribes 2007). Estimates of population viability from three time periods (brood years 1971-2006, 1985-2006, and 1990-2006) all indicate that Hood Canal and Strait of Juan de Fuca populations of summer-run chum salmon are not currently viable (Ford 2011).

Abundance and Productivity: Overall, the new information considered does not indicate a change in the biological risk category since the last status review in 2005 (Ford 2011). The spawning abundance of this species has clearly increased since the time of listing, although the recent abundance is down from the previous 5 years. However, productivity in the last 5-year period (2002-2006) has been very low, especially compared to the relatively high productivity in the 5-10 previous years (WDFW and Point No Point Treaty Tribes 2007). This is a concern for viability. Since abundance is increasing and productivity is decreasing, improvements in habitat and ecosystem function likely are needed.

The current average run size of 21,008 HCS chum adult spawners (17,556 natural-origin and 3,452 hatchery origin spawners; Table 23) is largely the result of aggressive reintroduction and supplementation programs throughout the ESU. In the Strait of Juan de Fuca population, the annual natural-origin spawners returns for Jimmycomelately Creek dipped to a single fish in 1999 and again in 2002 (Unpublished data, Norma Sands, NWFSC, December 19, 2006). From 2009 to 2013, Jimmycomelately Creek averaged 1,058 natural-origin spawners. Salmon and Snow Creeks have improved substantially. Natural-origin spawner abundance was 130 fish in 1999, whereas the average for Salmon and Snow creeks were 2,171 and 405, respectively, for the 2009-2013 period.

Table 23. Abundance of natural-origin and hatchery-origin HCS chum salmon spawners in escapements 2009-2013 (unpublished data, Mindy Rowse, NWFSC, Nov. 25, 2014).

Population	Spawning Aggregation	Natural-origin Spawners[a]	Hatchery-origin Spawners[b]	Expected Number of Outmigrants[c]
Strait of Juan de Fuca	Jimmycomelately Creek	1,058	1,867	427,781
	Salmon Creek	2,171	3	317,948
	Snow Creek	405	3	59,670
	Chimacum Creek	1,286	0	188,078
	Population Average[d]	5,219	1,879	1,038,083
Hood Canal	Big Quilcene River	3,064	0	448,110
	Little Quilcene River	623	0	91,114
	Big Beef Creek	120	0	17,550
	Dosewallips River	1,734	8	254,768
	Duckabush River	3,183	29	469,755

Population	Spawning Aggregation	Natural-origin Spawners[a]	Hatchery-origin Spawners[b]	Expected Number of Outmigrants[c]
	Hamma Hamma River	1,220	39	184,129
	Anderson Creek	1	0	146
	Dewatto River	52	4	8,190
	Lilliwaup Creek	186	160	50,603
	Tahuya River	69	577	94,478
	Union River	883	19	131,918
	Population Average[d]	11,946	1,189	1,920,994
ESU Average[d]		17,556	3,452	3,072,420

[a] Five-year geometric mean of post fishery natural-origin spawners (2008-2012).
[b] Five-year geometric mean of post fishery hatchery-origin spawners (2008-2012).
[c] Expected number of outmigrants=Total spawners*45% proportion of females*2,500 eggs per female*13% survival rate from egg to outmigrant
[d] Averages are calculated as the geometric mean of the annual totals (2008-2012

Limiting factors include (Hood Canal Coordinating Council 2005; NMFS 2007a; NOAA Fisheries 2011):

Nearshore and estuarine habitat throughout the range of the species has been altered by human activities. Nutrient loading has lowered dissolved oxygen concentrations, which can kill or stress marine organisms, including salmon. Residential and commercial development has reduced the amount of functioning habitat available for salmon rearing and migration. The loss of mudflats, eelgrass meadows, and macroalgae further limits salmon foraging and rearing opportunities in nearshore and estuarine areas.
Degraded freshwater habitat: Floodplain connectivity and function, channel structure and complexity, riparian areas and large wood supply, stream substrate, and stream flow have been degraded as a result of cumulative impacts of agriculture, forestry, and development.

2.4.3.2.11 Columbia River chum

Spatial Structure and Diversity: Columbia River (CR) chum includes all naturally-spawned populations of chum salmon in the Columbia River and its tributaries in Washington and Oregon, and progeny of three artificial propagation programs. The WLC-TRT identified 17 historical populations of CR chum salmon and aggregated these into four strata (Myers et al. 2006). CR chum salmon spawning aggregations identified in the mainstem Columbia River were included in the population associated with the nearest river basin.

The very low persistence probabilities or possible extirpations of most chum salmon populations are due to low abundance, productivity, spatial structure, and diversity. Although, hatchery production of chum salmon has been limited and hatchery effects on diversity are thought to have been relatively small, diversity has been greatly reduced at the ESU level because of presumed extirpations and the low abundance in the remaining populations (fewer than 100 spawners per year for most populations) (Lower Columbia Fish Recovery Board 2010; NMFS 2013a). The Lower Gorge population meets abundance and productivity criteria for very high levels of viability, but the distribution of spawning habitat (i.e., spatial structure) for the population has been significantly reduced (Lower Columbia Fish Recovery Board 2010); spatial structure may need to be improved, at least in part, through better performance from the Oregon portion of the population (NMFS 2013a).

Abundance and Productivity: Of the 17 populations that historically made up this ESU, 15 of them (six in Oregon and nine in Washington) are so depleted that either their baseline probability of persistence is very low or they are extirpated or nearly so (Lower Columbia Fish Recovery Board 2010; ODFW 2010; Ford 2011; NMFS 2013a). All three strata in the ESU fall significantly short of the WLC-TRT criteria for viability. Currently almost all natural production occurs in just two populations: the Grays/Chinook and the Lower Gorge. The Grays/Chinook population has a moderate persistence probability, and the Lower Gorge population has a high probability of persistence (Lower Columbia Fish Recovery Board 2010; NMFS 2013a).

WDFW regularly monitors several natural "index" populations in the basin, in Grays River, two in small streams near Bonneville Dam, and the mainstem area next to those two streams. Average annual natural escapement to the index spawning areas was approximately 1,300 fish from 1990 through 1998. The WDFW surveyed other (nonindex) areas in 1998 and found only small numbers of chum salmon (typically less than 10 fish per stream) in Elochoman, Abernathy, Germany, St. Cloud, and Tanner Creeks and in the North Fork Lewis and the Washougal Rivers. Consistent with the BRT status review (Ford 2011), the ODFW recovery plan concluded that chum are extirpated or nearly so in all Oregon Columbia River populations (ODFW 2010). A few chum are occasionally encountered during surveys or return to hatchery collection facilities, but these are likely either strays from one of the Washington populations or part of a few extremely small and erratic remnant populations. Recent estimates for the lower Columbia Gorge and Grays River chum salmon populations range from 10,000 to 20,000 adults. WDFW spawning surveys in the Grays/Chinook, Washougal, Lower Gorge, and Upper Gorge populations estimated an average of 8,508 adult chum for the years 2007-2011 (WDFW 2014). We do not have recent adult abundance data for any of the other populations.

The NWFSC publishes juvenile abundance estimates each year in the annual memorandum estimating percentages of listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River basin. Numbers for 2015 are not available at this time; however the average outmigration for the years 2010-2014 is shown in Table 24 (Ferguson 2010; Dey 2012; Zabel 2013, 2014a, 2014b).

Table 24. Average estimated outmigration for ESA-listed CR chum salmon (2010-2014).

Origin	Outmigration

Natural	2,978,550
Listed hatchery intact adipose	391,973
Listed hatchery adipose clipped	0

Limiting Factors include (NOAA Fisheries 2011; NMFS 2013a):

Degraded estuarine and nearshore marine habitat resulting from cumulative impacts of land use and flow management by the Columbia River hydropower system
Degraded freshwater habitat, in particular of floodplain connectivity and function, channel structure and complexity, stream substrate, and riparian areas and large wood recruitment as a result of cumulative impacts of agriculture, forestry, and development
Degraded stream flow as a result of hydropower and water supply operations
Loss of access and loss of some habitat types as a result of passage barriers such as roads and railroads
Reduced water quality
Current or potential predation from hatchery-origin salmonids, including coho salmon
An altered flow regime and Columbia River plume has altered the temperature regime and estuarine food web, and has reduced ocean productivity
Reduced access to off-channel rearing habitat in the lower Columbia River
Reduced productivity resulting from sediment and nutrient-related changes in the estuary
Juvenile fish strandings that result from ship wakes
Contaminants affecting fish health and reproduction

2.4.3.3 Coho

Adult coho salmon reach sexual maturity at 3 years, and die after spawning. Precocious 2 year olds, especially males, also make up a small percentage of the spawning population. Coho salmon adults migrate and spawn in small streams that flow directly into the ocean, or tributaries and headwater creeks of larger rivers (Sandercock 1991, Moyle 2002). Adults migrate upstream to spawning grounds from September through late December, peaking in October and November. Spawning occurs mainly in November and December, with fry emerging from the gravel in the spring, approximately 3 to 4 months after spawining. Juvenile rearing usually occurs in tributary streams, as small as 1 to 2 meters wide. They may spend 1 to 2 years in freshwater (Bell and Duffy 2007), or emigrate to an estuary shortly after emerging from spawning gravels (Tschaplinski 1988). Emigration from streams to the estuary and ocean generally takes place from March through May.

2.4.3.3.1 Central California Coast coho

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

Abundance and Productivity: Brown et al. (1994) estimated that annual spawning numbers of coho salmon in California ranged between 200,000 and 500,000 fish in the 1940's, which declined to about 100,000 fish by the 1960's, followed by a further decline to about 31,000 fish by 1991. More recent abundance estimates vary from approximately 600 to 5,500 adults (Good et al. 2005). Recent status reviews (Good et al. 2005; Williams et al. 2011) indicate that the CCC coho salmon are likely continuing to decline in number and many independent populations that supported the species overall numbers and geographic distributions have been extirpated. The current average run size for the CCC coho salmon ESU is 1,621 fish (1,294 natural-origin; 327 hatchery produced) (Table 25).

Table 25. Geometric mean abundances of CCC coho salmon spawners in 2006-2012 escapements by population.

Stratum	Population	Years	Spawners		Expected Number of Outmigrants[cd]
			Natural-origin[a]	Hatchery-origin[b]	
Lost Coast – Navarro Point	**Ten Mile River**	2010-2011	237	-	16,940
	Usal Creek	2009-2011	5	-	
	Noyo River	2006-2010	398	-	38,150
	Pudding Creek	2008-2012	116	-	
	Caspar Creek	2006-2010	31	-	
	Big River	2009-2011	116	-	8,120
	Albion River	2009-2011	9	-	630
Navarro Point – Gualala Point	**Navarro River**	2009-2011	197	-	13,790
	Garcia River	2009-2011	34	-	2,380
	Gualala River	-	-	-	-
Coastal	**Russian River**	2008-2012	20	323	2,030
	Salmon Creek	2008	9	-	

Stratum	Population	Years	Spawners		Expected Number of Outmigrants[cd]
			Natural-origin[a]	Hatchery-origin[b]	
	Walker Creek	2006-2008	4	-	280
	Lagunitas Creek	2007-2011	105	-	7,700
	Redwood Creek	2007-2011	5	-	
Santa Cruz Mountains	**Pescadero Creek**	-	-	-	-
	San Lorenzo River	-	-	-	560
	Waddell Creek	2007	2	-	
	Scott Creek	2008-2012	3	4	
	San Vicente Creek	2007-2008	1	-	
	Soquel Creek	2007	2	-	
ESU Average			**1,294**	**327**	**90,580**

[a] Source: http://swr.nmfs.noaa.gov/recovery/ccc_coho/
[b] J. Jahn, pers. comm., July 2, 2013
[c] Expected number of outmigrants=Total spawners*50% proportion of females*3,500 eggs per female*6.5% survival rate from egg to outmigrant
[d] Based upon natural-origin spawner numbers

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

Limiting Factors: Most of the populations in the CCC coho salmon ESU are currently doing poorly; low abundance, range constriction, fragmentation, and loss of genetic diversity is documented. The near-term (10 - 20 years) viability of many of the extant independent CCC coho salmon populations is of serious concern. These populations may not have enough fish to survive additional natural and human caused environmental change. NMFS has determined that currently depressed population conditions are, in part, the result of the following human-induced factors affecting critical habitat[27]: logging, agriculture, mining, urbanization, stream channelization, dams, wetland loss, and water withdrawals (including unscreened diversions for irrigation). Impacts of concern include altered stream bank and channel morphology, elevated water temperature, lost spawning and rearing habitat, habitat fragmentation, impaired gravel and wood recruitment from upstream sources, degraded water quality, lost riparian vegetation, and increased erosion into streams from upland areas (Weitkamp et al. 1995; Busby et al. 1996; 64 FR 24049; 70 FR 37160; 70 FR 52488). Diversion and storage of river and stream flow has dramatically altered the natural hydrologic cycle in many of the streams within the ESU.

2.4.4.3.2 S. Oregon/N. California Coast coho

Spatial Structure and Diversity: Southern Oregon/Northern California coastal (SONCC) coho This species includes all naturally-spawned populations of coho salmon in coastal streams from the Elk River near Cape Blanco, Oregon, through and including the Mattole River near Punta Gorda, California, and progeny of three artificial propagation programs (NMFS 2012c; Table 26).

Table 26. SONCC coho salmon ESA-listed hatchery stock annual juvenile production goals (ODFW 2011; CHSRG 2012).

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

Williams et al. (2006) designated 45 populations of coho salmon in the SONCC coho salmon ESU. These populations were further grouped into seven diversity strata based on the geographical arrangement of the populations and basin-scale genetic, environmental, and ecological characteristics. Across the coastal basins of the SONCC Coho Salmon ESU, there existed sufficient geographical and environmental variability resulting in the TRT dividing the coastal basins into three sub-strata. The northern sub-stratum includes basins from the Elk River to the Winchuck River, including the lower portion of the Rogue River. The central substratum includes coastal basins from the Smith River to the Mad River, including the lower portion of the

[27] Other factors, such as over fishing and artificial propagation have also contributed to the current population status of these species. All these human induced factors have exacerbated the adverse effects of natural environmental variability from such factors as drought and poor ocean conditions.

Klamath River. The southern stratum includes the Humboldt Bay tributaries south to the Mattole River, including the lower Eel River and Van Duzen River.

Abundance and Productivity: Although long-term data on abundance of SONCC coho salmon are scarce, available evidence from shorter-term research and monitoring efforts indicate that conditions have worsened for populations since the last formal status review was published (Williams et al. 2011b). Because the extinction risk of an ESU depends upon the extinction risk of its constituent independent populations and 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 (Williams et al. 2011b).

Recent returns of naturally-produced adults to the Rogue, Trinity, Shasta, and Scott rivers have been highly variable. Wild coho salmon estimates derived from the beach seine surveys at Huntley Park on the Rogue River ranged from 414 to 24,481 naturally produced adults between 2003 and 2012 (Table 27). Similar fluctuation are noted in the Trinity, Shasta, and Scott river populations. Overall, the average annual abundance, for populations where we have abundance data, of naturally produced fish is only 5,586. However, abundance data is lacking for the Eel, Smith, and Chetco rivers, the other major populations in the ESU, as well as the numerous smaller coastal populations. Actual abundance is therefore likely to be higher than this estimate.

Table 27. Estimates of the natural and hatchery adult SONCC coho salmon returns (ODFW 2014; Sinnen et al. 2011; Knechtle and Chesney 2011; Chesney and Knechtle 2011).

YEAR	Rogue River		Smith River Mill Creek	Trinity River		Klamath River		Redwood Creek	Freshwater Creek
						Shasta [a]	Scott		
	Hatchery	Natural	Natural	Hatchery	Natural	Natural	Natural	Natural	Natural
2003	7,296	6,805		24,211	3,941	187			
2004	9,092	24,509				373			731
2005	5,339	9,957		28,905	2,514	69			974
2006	3,496	3,911		18,673	1,405	47			789
2007	2,275	5,136		4,600	1,150	255	1,622		396
2008	158	414		8,684	1,298	31	62		262
2009	518	2,566		5,820	576	9	81		399
2010	752	3,671				44	927	373	89
2011	1,157	4,545				62	355	322	455
2012	1,423	5,474	482			115	> 201	803	624
2013	1,999	11,210	227					747	318
2014			260					705	
Average [b]	1,526	7,076	323	6,368	1,008	74	494	752	466

[a] Hatchery proportion unknown, but assumed to be low.
[b] 3-year average of most recent years of data.

While we currently lack data on naturally-produced juvenile SONCC 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 5,096 females returning (half of the average total number of natural spawners), approximately 14 million eggs may be expected to be produced annually. Nickelson (1998) found survival of coho from egg to parr in Oregon coastal streams to be around seven percent. Thus, we can state that the ESU could produce roughly 1,026,707 juvenile natural SONCC coho salmon each year. In addition, hatchery managers could produce approximately 775,000 listed hatchery juvenile coho each year (Table 26).

Limiting Factors: Threats from natural or man-made factors have worsened in the past 5 years, primarily due to four factors: small population dynamics, climate change, multi-year drought, and poor ocean survival conditions (NOAA Fisheries 2011; NMFS 2012c). Limiting factors include:

Lack of floodplain and channel structure
Impaired water quality
Altered hydrologic function (timing of volume of water flow)
Impaired estuary/mainstem function
Degraded riparian forest conditions
Altered sediment supply
Increased disease/predation/competition
Barriers to migration
Adverse fishery-related effects
Adverse hatchery-related effects

2.4.3.3.3 Oregon Coast coho

Spatial Structure and Diversity: Oregon coast (OC) coho includes populations of coho salmon in Oregon coastal streams south of the Columbia River and north of Cape Blanco. The Cow Creek stock (South Umpqua population) is included as part of the ESU because the original brood stock was founded from the local, natural origin population and natural origin coho salmon have been incorporated into the brood stock on a regular basis. The OC-TRT identified 56 populations; 21 independent and 35 dependent. The dependent populations were dependent on strays from other populations to maintain them over long time periods. The TRT also identified 5 biogeographic strata (Lawson et al. 2007).

A 2010 BRT noted significant improvements in hatchery and harvest practices have been made (Stout et al. 2012). However, harvest and hatchery reductions have changed the population dynamics of the ESU. Current concerns for spatial structure focus on the Umpqua River. Of the four populations in the Umpqua stratum, the North Umpqua and South Umpqua were of particular concern. The North Umpqua is controlled by Winchester Dam and has historically been dominated by hatchery fish. Hatchery influence has recently been reduced, but the natural productivity of this population remains to be demonstrated. The South Umpqua is a large, warm system with degraded habitat. Spawner distribution appears to be seriously restricted in this population, and it is probably the most vulnerable of any population in this ESU to increased temperatures.

Current status of diversity shows improvement through the waning effects of hatchery fish on populations of OC coho salmon. In addition, recent efforts in several coastal estuaries to restore lost wetlands should be beneficial. However, diversity is lower than it was historically because of the loss of both freshwater and tidal habitat loss coupled with the restriction of diversity from very low returns over the past 20 years.

Abundance and Productivity: It has not been demonstrated that productivity during periods of poor marine survival is now adequate to sustain the ESU. Recent increases in adult escapement do not provide strong evidence that the century-long downward trend has changed. The ability of the OC coho salmon ESU to survive another prolonged period of poor marine survival remains in question. Wainwright (2008) determined that the weakest strata of OC coho salmon were in the North Coast and Mid-Coast of Oregon, which had only "low" certainty of being persistent. The strongest strata were the Lakes and Mid-South Coast, which had "high" certainty of being persistent. To increase certainty that the ESU as a whole is persistent, they recommended that restoration work should focus on those populations with low persistence, particularly those in the North Coast, Mid-Coast, and Umpqua strata.

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. The three-year average of natural origin spawners for the years 2010-2012 is estimated at 229,872 total spawners (ODFW 2014b). 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 115,000 females returning (roughly half of 229,872) to this ESU, one may expect approximately 230 million eggs to be produced annually. Nickelson (1998) found survival of coho from egg to parr in Oregon coastal streams to be around 7%. Thus, we can estimate that roughly 16 million juvenile coho salmon are produced annually by the OC coho ESU.

Limiting Factors include (NOAA Fisheries 2011; Stout et al. 2012):

Degraded freshwater habitat: Floodplain connectivity and function, channel structure and complexity, riparian areas and large wood supply, stream substrate, stream flow, and water quality have been degraded as a result of cumulative impacts of agriculture, forestry, instream mining, dams, road crossings, dikes, levees, etc.
Fish passage barriers that limit access to spawning and rearing habitats
Adverse climate, altered past ocean/marine productivity, and current ocean ecosystem conditions have favored competitors and predators and reduced salmon survival rates in freshwater rivers and lakes, estuaries, and marine environments

2.4.3.3.4 Lower Columbia River coho

Spatial Structure and Diversity: Lower Columbia River (LCR) coho includes all naturally-spawned populations of coho salmon in the Columbia River and its tributaries in Washington and Oregon, from the mouth of the Columbia up to and including the Big White Salmon and Hood rivers; in the Willamette River to Willamette Falls, Oregon; and progeny of 25 artificial propagation programs.[28] Spatial diversity is rated "moderate" to "very high" for all the populations, except the North Fork Lewis River, which has a "low" rating for spatial structure.

Three status evaluations of LCR coho salmon status, all based on WLC-TRT criteria, have been conducted since the last NMFS status review in 2005 (McElhany et al. 2007; NMFS 2013). Out of the 24 populations that make up this ESU, 21 are considered to have a very low probability of persisting for the next 100 years, and none is considered viable (Lower Columbia Fish Recovery Board 2010; ODFW 2010; Ford 2011; NMFS 2013a).

Abundance and Productivity: In Oregon, the Clatskanie Creek and Clackamas River populations have "low" and "moderate" persistence probability ratings for A&P, while the rest are rated "very low." All of the Washington populations have "very low" A&P ratings. The persistence probability for diversity is "high" in the Clackamas population, "moderate" in the Clatskanie, Scappoose, Lower Cowlitz, South Fork Toutle, Coweeman, East Fork Lewis, and Sandy populations, and "low" to "very low" in the rest (NMFS 2013a). Uncertainty is high because of a lack of adult spawner surveys. Smolt traps indicate some natural production in Washington populations, though given the high fraction of hatchery origin spawners suspected to occur in these populations it is not clear that any are self-sustaining. Overall, the new information considered does not indicate a change in the biological risk category since the last status review (Ford 2011; NMFS 2011c; NMFS 2013a).

[28] The Elochoman Hatchery Type-S and Type-N coho salmon programs were eliminated in 2008. The last adults from these two programs returned to the Elochoman in 2010. NMFS has recommended that these two programs be removed from the ESU (NMFS 2011b).

Table 28 displays the most recent returns of naturally produced and hatchery LCR coho salmon. Based on the best available data and using a three year geometric mean, the estimated run size of LCR coho for 2015 is 20,765 naturally produced fish and 394,540 hatchery fish.

Table 28. Estimated abundance of adult LCR coho (ODFW and WDFW 2010b; Yakima/Klickitat Fisheries Project 2014).

Year	Total(1)	Natural(2)	Hatchery(2)
2011	275,989	13,799	262,190
2012	97,576	4,879	92,697
2013	390,828	19,541	371,287
Average(3)	219,149	10,957	208,192

(1) Estimated abundance is calculated by subtracting the number of fish that passed Willamette Falls, Lyle Falls on the Klickitat River, and The Dalles Dam from the total return for the Columbia River. Coho salmon that pass these features are not considered to be part of the LCR coho ESU.
(2) For LCR coho, the approximate percentages of origin are: 5% natural, 95% artificially propagated.
(3) Average is the geometric mean of the last three years of record.

NWFSC publishes juvenile abundance estimates each year in the annual memorandum estimating percentages of listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River basin. Numbers for 2015 are not available at this time, however the average outmigration for the years 2010-2014 is shown in Table 29 (Ferguson 2010; Dey 2012; Zabel 2013, 2014a, 2014b).

Table 29. Average estimated outmigration for ESA-listed LCR coho salmon (2010-2014).

Origin	Outmigration
Natural	839,118
Listed hatchery intact adipose	299,928
Listed hatchery adipose clipped	8,637,196

<u>Limiting Factors</u> include (NOAA Fisheries 2011; NMFS 2013a):

Degraded estuarine and near-shore marine habitat resulting from cumulative impacts of land use and flow management by the Columbia River hydropower system
Fish passage barriers that limit access to spawning and rearing habitats
Degraded freshwater habitat: Floodplain connectivity and function, channel structure and complexity, riparian areas and large wood supply, stream substrate, stream flow, and water quality have been degraded as a result of cumulative impacts of agriculture, forestry, and development
Hatchery-related effects
Harvest-related effects

An altered flow regime and Columbia River plume has altered the temperature regime and estuarine food web, and has reduced ocean productivity
Reduced access to off-channel rearing habitat in the lower Columbia River
Reduced productivity resulting from sediment and nutrient-related changes in the estuary
Juvenile fish strandings that result from ship wakes
Contaminants affecting fish health and reproduction

2.4.4.4 Sockeye

Sockeye salmon *(Oncorhynchus nerka*) inhabit riverine, marine, and lake environments from the Klamath River in Oregon and its tributaries north and west to the Kuskokwim River in western Alaska. With the exception of certain river-type and sea-type populations of sockeye, the vast majority of sockeye salmon spawn in or near lakes, where the juveniles rear for 1 to 3 years prior to migrating to sea. As sockeye generally require lakes for a portion of their life cycle, their distribution in river systems depend on the presence of usable lakes in the system; therefore, their distribution and abundance along the coast be more intermittent than for other Pacific salmon. Seven recognized ESUs occur within the the SWFSC research areas however only two are listed under the ESA: Snake River ESU, endangered, and Ozette Lake ESU, threatened.

2.4.3.4.1 Snake River sockeye

Spatial Structure and Diversity: Snake River (SR) sockeye includes all anadromous and residual sockeye salmon from the Snake River basin, Idaho, and artificially-propagated sockeye salmon from the Redfish Lake captive propagation program. The IC-TRT identified historical sockeye salmon production in at least five Stanley Basin and Sawtooth Valley lakes and in lake systems associated with Snake River tributaries currently cut off to anadromous access (e.g., Wallowa and Payette Lakes), although current returns of SR sockeye salmon are extremely low and limited to Redfish Lake (IC-TRT 2007).

Abundance and Productivity: This species is still at extremely high risk across all four basic risk measures (abundance, productivity, spatial structure and diversity. Although the captive brood program has been successful in providing substantial numbers of hatchery produced *O. nerka* for use in supplementation efforts, substantial increases in survival rates across life history stages must occur to re-establish sustainable natural production (Hebdon et al. 2004; Keefer et al. 2008). Overall, although the risk status of the SR sockeye appears to be on an improving trend, the new information considered does not indicate a change in the biological risk category since the last status review (Ford 2011).

Between 1997 and 2005, approximately 400 hatchery sockeye returned to the Stanley basin, total. Only 16 naturally produced adults returned to Redfish Lake between the time SR sockeye was listed as an endangered species in 1991 and 2005. Since that time, there has been a considerable improvement in the sockeye returns. From 2009 through 2012, an average of 1,348 adult sockeye (all from the broodstock program) passed Lower Granite Dam on their way to

Redfish Lake. The year 2012 saw the lowest numbers of that period—with only 470 fish being counted at Lower Granite Dam. These numbers have been updated somewhat with the 2014 returns—which numbered 2,786 fish. The new four-year average return to Lower Granite Dam (through 2014) is 1,373 (IDFG data).

Each spring, the NWFSC produces a memorandum estimating the number of ESA-listed Pacific salmon and steelhead smolts expected to arrive at various locations in the Columbia River basin. The averages of the five most recent projections for the SR sockeye salmon juvenile emigrants are displayed below in Table 30.

Table 30. Recent five-year average projected outmigrations for SR sockeye (Ferguson, 2009, 2010; Dey 2012; Zabel 2013; Zabel 2014a; Zabel 2014b).

Origin	Outmigration
Natural	15,560
Listed Hatchery: Adipose Clipped	124,767

The BRT, reviewing the status of the species in 2010 (Ford 2011), found that the recent increase in returns of hatchery-reared SR sockeye has reduced the risk of immediate loss, but that levels of naturally produced returns remain extremely low. Although the biological risk status of the ESU appeared to be on an improving trend, the new information did not indicate a change in category (extremely high risk) since the 2005 BRT status review.

Limiting Factors: The key factor limiting recovery of SR sockeye is survival outside of the Stanley Basin. Portions of the migration corridor in the Salmon River are impeded by water quality and temperature (Idaho Department of Environmental Quality 2011). Increased temperatures likely reduce the survival of adult sockeye returning to the Stanley Basin. The natural hydrological regime in the upper mainstem Salmon River Basin has been altered by water withdrawals. In most years, sockeye adult returns to Lower Granite suffer catastrophic losses (Reed et al. 2003) (e.g., > 50% mortality in one year) before reaching the Stanley Basin, although the factors causing these losses have not been identified. In the Columbia and lower Snake River migration corridor, predation rates on juvenile sockeye salmon are unknown, but terns and cormorants consume 12% of all salmon smolts reaching the estuary, and piscivorous fish consume an estimated 8% of migrating juvenile salmon (NOAA Fisheries 2011).

2.4.4.4.2 Lake Ozette sockeye

Spatial Structure and Diversity: This species includes all naturally spawned populations of sockeye salmon in Ozette Lake and streams and tributaries flowing into Ozette Lake, Washington, and progeny of two artificial propagation programs. The Lake Ozette (LO) Technical Recovery Team concluded that five extant spawning aggregations in Ozette Lake are different subpopulations within a single population (Currens et al. 2009; NMFS 2009a). The subpopulations can be grouped according to whether they spawn in tributaries or near lake beaches (NMFS 2009a).

Abundance and Productivity: LO sockeye salmon population sizes remain very small compared to historical sizes. Additionally, population estimates remain highly variable and uncertain, making it impossible to detect changes in abundance trends or in productivity in recent years. The most recent brood years (1999-2003) have had the lowest average recruits per spawner. Spatial structure and diversity are also difficult to appraise; there is currently no successfully quantitative program to monitor beach spawning or spawning at other tributaries. Assessment methods must improve to evaluate the status of this species and its responses to recovery actions. Overall, the new information considered does not indicate a change in the biological risk category since the last status review (Ford 2011).

The most recent five-year geometric mean (2006-2010) of natural-origin, LO sockeye salmon returning to spawn in the Lake Ozette watershed is 1,683 (Table 31).

Table 31. Five-year geometric means for adult natural-origin and hatchery-origin spawners for the LO sockeye salmon ESU (unpublished data, Norma Jean Sands, NWFSC, Apr. 10, 2012).

Year Range	Natural-origin Escapement	Hatchery-origin Escapement
1977-1980	1,746	0
1981-1985	1,700	0
1986-1990	2,432	17
1991-1995	849	85
1996-2000	2,285	307
2001-2005	3,431	285
2006-2010	1,683	33

Spawning habitat capacity estimates for beach and tributary habitats (combined) range from 90,000 to 120,000 adult OL sockeye salmon (PSTRT 2007). These estimates are based upon a relatively low spawning density target of one female per three sq. meters of suitable habitat. However, historical spawning density may have been as high as one female/sq. meter, which would triple the capacity estimates. Nonetheless, the most recent five-year average for natural origin adult sockeye escapement is only 1.9% of the lower estimate (1,716/90,000).

Juvenile LO sockeye abundance can be estimated from escapement data. Fecundity estimates for the ESU average 3,050 eggs per female (Haggerty et al. 2009), and the proportion of female spawners is assumed to be 50% of escapement. By applying fecundity estimates to the expected escapement of females (both natural-origin and hatchery-origin spawners – 858 females), the ESU is estimated to produce approximately 2.62 million eggs annually. Analyzing data from1991 to 2007 for the Lake Washington sub-basin, McPherson and Woodey (2009) found an average egg-to-fry survival rate of 13.5% (range 1.9-32.0%). Assuming a similar 13.5% egg-to-fry survival for Lake Ozette, the ESU should produce roughly 353,282 natural outmigrants annually.

Limiting factors include (NMFS 2009a; USDC 2009a; NOAA Fisheries 2011):

Degraded freshwater habitat: Floodplain connectivity and function, channel structure and complexity, riparian areas and large wood supply, lake beach spawning habitat, and stream substrate have been degraded as a result of cumulative impacts of forest practices, agriculture, and development.
Predation: Harbor seals and river otters, and predaceous non-native and native fish species, are reducing the abundance of adult fish that successfully spawn, and the abundance of sockeye smolts escaping seaward from the watershed each year.

2.4.3.5 Steelhead

Like Chinook salmon, steelhead are anadromous fish. General reviews for steelhead document much variation in life history (Shapavolov and Taft 1954; Barnhart 1986; Busby et al. 1996; McEwan 2001). Although variation occurs, steelhead usually live in freshwater for 2 years, then spend 1 or 2 years in the ocean before returning to their natal stream to spawn. Steelhead may spawn 1 to 4 times over their life.

Juvenile steelhead rear in edge-water habitats, moving gradually into pools and riffles as they grow larger. Cover is an important habitat component for juvenile steelhead, both as a velocity refuge and as a means of avoiding predation (Shirvell 1990; Meehan and Bjornn 1991). Steelhead, however, tend to use riffles and other habitats not strongly associated with cover during summer rearing more than other salmonids. Young steelhead feed on a wide variety of aquatic and terrestrial insects, and emerging fry are sometimes preyed upon by older juveniles. In riverine habitats, adequate flow, temperature, and food availability are important factors for survival and growth. Optimal temperatures for steelhead growth range between 10 and 20°C (Hokanson et al. 1977; Wurtsbaugh and Davis 1977; Myrick and Cech 2005). Variability in the diurnal water temperature range is also important for the survivability and growth of salmonids (Hokanson et al. 1977; Busby et al. 1996).

2.4.3.5.1 Southern California steelhead

Spatial Structure and Diversity: The geographic range of this DPS extends from the Santa Maria River, near Santa Maria, to the California–Mexico border, which represents the known southern geographic extent of the anadromous form of *O. mykiss*. NMFS described historical and recent steelhead abundance and distribution for the southern California coast through a population characterization (Boughton et al. 2006). Surveys in Boughton et al. (2005) indicate between 58 percent and 65 percent of the historical steelhead basins currently harbor *O. mykiss* populations at sites with connectivity to the ocean. Most of the apparent losses of steelhead were noted in the south, including Orange and San Diego counties (Boughton et al. 2005).

Abundance and Productivity: While 46 drainages support this DPS (Boughton et al. 2005), only 10 population units possess a high and biologically plausible likelihood of being viable and independent[29] (Boughton et al. 2006). Very little data regarding abundances of Southern California Coast steelhead are available, but the picture emerging from available data suggest very small (<10 fish) but surprisingly consistent annual runs of anadromous fish across the diverse set of basins that are currently being monitored (Williams et al. 2011). The most significant population that has been recently monitored is in Topanga Creek, where mark-recapture studies were done in 2007-2008. According to the authors (Bell et al. 2011), that data indicated a population of resident fish whose abundance is on the order of 500 individuals, including all size and age classes in Topanga Creek. It is believed that population abundance trends can significantly vary based on yearly rainfall and storm events within the range of the Southern California Coast DPS (Williams et al. 2011). A relatively large number of adult steelhead were observed in 2008, two years after an extended wet spring that presumably gave smolts ample opportunity to migrate to the ocean. Some of the strength of the 2008 season may also be an artifact of conditions that year. Low rainfall appears to have caused many spawners to get trapped in freshwater, where they were observed during the summer; in addition, low rainfall probably improved conditions for viewing fish during snorkel surveys, and for trapping fish in weirs (Williams et al. 2011). There is little new evidence to suggest that the status of the Southern California DPS has changed appreciably in either direction since publication of the most recent collections of status reviews (Good et al. 2005; NMFS 2011d; Williams et al. 2011).

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

2.4.3.5.2 South-Central California Coast steelhead

Spatial Structure and Diversity: On August 18, 1997, NMFS listed South-Central California Coast (SCCC) steelhead—only natural-origin fish—as a threatened species (62 FR 43937). The BRT evaluated the viability and extinction risk of naturally spawning populations and found high risks to abundance, productivity, and the diversity of the SCCC DPS and expressed particular concern for this DPS's connectivity and spatial structure. NMFS promulgated 4(d) protective

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

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

SCCC steelhead occupy rivers from the Pajaro River (Santa Cruz County, California), inclusive, south to, but not including, the Santa Maria River (San Luis Obispo County, California). Most rivers in this DPS drain from the San Lucia Mountain range, the southernmost section of the California Coast Ranges. Many stream and rive mouths in this area are seasonally closed by sand berms that form during the low water flows of summer.

Abundance and Productivity: In the mid-1960s the California Department of Fish and Wildlife estimated an annual run size of 17,750 adult steelhead spawning in this coastal DPS. The CDFG estimate, however, is just a midpoint number in the SCCC steelhead's abundance decline—at the point the estimate was made, there had already been a century of commercial harvest and coastal development. Current SCCC steelhead abundance is still not well known. Multiple short-term studies using different methodologies have occurred over the past decade.

Table 32. Geometric mean abundances of SCCC steelhead spawners from 2001-2012 escapements by population.

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

[a]Expected number of outmigrants=Total spawners*50% proportion of females*3,500 eggs per female*6.5% survival rate from egg to outmigrant
[b]Source: http://scceh.com/LinkClick.aspx?fileticket=dRW_AUu1EoU%3D&tabid=1772
[c]Kraft et al. 2013
[d]Sources: http://www.mpwmd.dst.ca.us/fishcounter/fishcounter.htm and http://www.mpwmd.dst.ca.us/wrd/lospadres/lospadres.htm.
[e]Allen and Riley 2012

[f]Garrapata Creek Watershed Council 2006
[g]Source: http://www.coastalrcd.org/zone1-1a/Fisheries%20Studies/AG_Steelhead_Report_Draft-small.pdf
[h]Source: http://www.coastalrcd.org/images/cms/files/MB%20Steelhead%20Abund%20and%20Dist%20Report.pdf
[i]City of San Luis Obispo 2006
[j]Baglivio 2012
[k]Stillwater Sciences et al. 2012

Both adult and juvenile abundance data is limited for this DPS. While we currently lack data on naturally-produced juvenile SCCC 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 32). Juvenile SCCC 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.

Limiting Factors: NMFS' most recent status reviews for SCCC steelhead (Williams et al. 2011; NMFS 2011d) identified habitat destruction and degradation as serious ongoing risk factors for this DPS. Urban development, flood control, water development, and other anthropogenic factors have adversely affected the proper functioning and condition of some spawning, rearing, and migratory habitats in streams designated as critical habitat. Urbanization has resulted in some permanent impacts to steelhead critical habitat due to stream channelization, increased bank erosion, riparian damage, migration barriers, and pollution (Good et al. 2005). Many streams within the DPS have dams and reservoirs that mute flushing stream flows, withhold or reduce water levels suitable for fish passage and rearing, physically block upstream fish passage, and retain valuable coarse sediments for spawning and rearing. In addition, some stream reaches within the DPS' designated critical habitat may be vulnerable to further perturbation resulting from poor land use and management decisions.

2.2.3.5.3 Central California Coast steelhead

Spatial Structure and Diversity: On August 18, 1997, NMFS listed Central California Coast (CCC) steelhead—both natural and some artificially-propagated fish—as a threatened species (62 FR 43937). NMFS promulgated updated 4(d) protective regulations for CCC steelhead on January 5, 2006 (71 FR 834). The section 4(d) protections (and limits on them) apply to natural and hatchery CCC steelhead with an intact adipose fin, but not to listed hatchery fish that have had their adipose fin removed.

The CCC steelhead DPS includes winter-run steelhead populations from the Russian River (Sonoma County) south to Aptos Creek (Santa Cruz County) inclusive and eastward to Chipps Island (confluence of the Sacramento and San Joaquin rivers) and including all drainages of San Francisco, San Pablo, and Suisun bays. Two artificial propagation programs were listed as part of the DPS—Scott Creek/Kingfisher Flat Hatchery (includes San Lorenzo River production) and Don Clausen Fish Hatchery (includes Coyote Valley Fish Facility production) winter-run steelhead hatchery stocks (Table 33).

Table 33. 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**

Historically, approximately 70 populations of steelhead existed in the CCC steelhead DPS (Spence et al. 2008, Spence et al. 2012). Many of these populations (about 37) were independent, or potentially independent, meaning they had a high likelihood of surviving for 100 years absent anthropogenic impacts (Bjorkstedt et al. 2005). The remaining populations were dependent upon immigration from nearby CCC steelhead DPS populations to ensure their viability (McElhany et al. 2000; Bjorkstedt et al. 2005).

Abundance and Productivity: While historical and present data on abundance are limited, CCC steelhead numbers are substantially reduced from historical levels. A total of 94,000 adult steelhead were estimated to spawn in the rivers of this DPS in the mid-1960s, including 50,000 fish in the Russian River – the largest population within the DPS (Busby et al. 1996). Near the end of the 20th Century, McEwan (2001) estimated the wild run population in the Russian River Watershed was between 1,700-7,000 fish. Abundance estimates for smaller coastal streams in the DPS indicate low but stable levels with recent estimates for several streams (Lagunitas, Waddell, Scott, San Vicente, Soquel, and Aptos creeks) of individual run sizes of 500 fish or less (62 FR 43937). CCC steelhead have experienced a serious decline in abundance and long-term population trends suggest a negative growth rate. This indicates the DPS may not be viable in the long term. Data from the 2008/09 and 2009/2010 adult CCC steelhead returns indicate a decline in returning adults across their range compared to other recent returns (e.g., 2006/2007, 2007/2008) (Jeffrey Jahn, NMFS, personal communication, August 2011). For more detailed information on trends in CCC steelhead abundance, see Busby et al. 1996, NMFS 1997a, Good et al. 2005, Spence et al. 2008, and Williams et al. 2011.

Both adult and juvenile abundance data is limited for this DPS. While we currently lack data on naturally-produced juvenile CCC steelhead, it is possible to make rough estimates of juvenile abundance from the available adult return data. Juvenile CCC steelhead abundance estimates come from the escapement data. 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 – 715 females), 2.5 million eggs are expected to be produced annually. With an estimated survival rate of 6.5 percent (Ward and Slaney 1993), the DPS should produce roughly 162,549 natural outmigrants annually (Table 34).

Table 34. Geometric mean abundances of CCC steelhead spawners from 2006-2012 escapements by population.

Stratum	Waterbody	Years	Abundance		Expected Number of Outmigrants[ab]
			Natural	Hatchery	
Northern Coastal	**Austin Creek[c]**	2010-2012	63	-	7,166
Northern Coastal	**Lagunitas Creek[d]**	2009-2013	71	-	8,076
Northern Coastal	**Walker Creek[e]**	2007-2010	29	-	3,299
Interior	**Dry Creek[c]**	2011-2012	33	-	3,754
Interior	**Russian River[f]**	2008-2012	230	3,451	26,163
Santa Cruz Mountains	**Aptos Creek[g]**	2007-2011	249	-	28,324
Santa Cruz Mountains	**San Gregario Creek[h]**	2006-2007	23	-	2,616
Santa Cruz Mountains	**San Lorenzo Creek[g]**	2007-2011	310	319	35,263
Santa Cruz Mountains	**Scott Creek[i]**	-	179	96	20,361
Santa Cruz Mountains	**Soquel Creek[g]**	2007-2011	230	-	26,163
Central Coastal	**Napa River[j]**	2009-2012	12	-	1,365
Total			**1,429**	**3,866**	**162,549**

[a]Expected number of outmigrants=Total spawners*50% proportion of females*3,500 eggs per female*6.5% survival rate from egg to outmigrant
[b]Based upon natural-origin spawner numbers
[c]Source: http://www.scwa.ca.gov/fisheries-monitoring/
[d]Ettlinger et al. 2012, Jankovitz 2013

[e]Source: http://marinwater.org/documents/1_WalkerCreekReportandRefs_March2010.pdf
[f]Natural abundance: Manning and Martini-Lamb (ed.) 2012;
Hatchery abundance source:
https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=44269&inline=true
[g]Source: http://scceh.com/LinkClick.aspx?fileticket=dRW_AUu1EoU%3D&tabid=1772
[h]Atkinson 2010
[i]Williams et al. 2011
[j]Koehler and Blank 2012

Limiting factors: Some loss of genetic diversity has been documented and attributed to previous among-basin transfers of stock and local hatchery production in interior populations in the Russian River (Bjorkstedt et al. 2005). Reduced population sizes and fragmentation of habitat in San Francisco streams has likely also led to loss of genetic diversity in these populations. DPS populations that historically provided enough steelhead immigrants 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 could slow their decline relative to other salmonid DPSs or ESUs in worse condition. The most recent status update concludes that steelhead in the CCC steelhead DPS remain "likely to become endangered in the foreseeable future" (Williams et al. 2011), as new and additional information available since the previous status review (Good et al. 2005) does not appear to suggest a change in extinction risk. On August 15, 2011, NMFS chose to maintain the threatened status of the CCC steelhead DPS (76 FR 50447).

2.2.3.5.4 California Central Valley steelhead

Spatial Structure and Diversity: On March 19, 1998, NMFS listed California Central Valley (CCV) steelhead—both natural and some artificially-propagated fish—as a threatened species (63 FR 13347). On January 5, 2006, NMFS reaffirmed the threatened status of the CCV steelhead and applied the DPS policy to the species because the resident and anadromous life forms of *O. mykiss* remain "markedly separated" as a consequence of physical, ecological and behavioral factors, and therefore warranted delineation as a separate DPS and promulgated 4(d) protective regulations for CCV steelhead (71 FR 834). The section 4(d) protections (and limits on them) apply to natural and hatchery CCV steelhead with an intact adipose fin, but not to listed hatchery fish that have had their adipose fin removed. On August 15, 2011, NMFS completed another 5-year status review of CCV steelhead and recommended that the CCV steelhead DPS remain classified as a threatened species (NMFS 2011d).

The CCV steelhead DPS includes steelhead populations spawning in the Sacramento and San Joaquin rivers and their tributaries. Two artificial propagation programs were listed as part of the DPS—Coleman National Fish Hatchery and Feather River Hatchery winter-run steelhead hatchery stocks (Table 35).

Table 35. 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**

CCV steelhead historically were well-distributed throughout the Sacramento and San Joaquin rivers (Busby et al. 1996). Although it appears CCV steelhead remain widely distributed in Sacramento River tributaries, the vast majority of historical spawning areas are currently above impassable dams. At present, all CCV steelhead are considered winter-run steelhead (McEwan and Jackson 1996), although there are indications that summer steelhead were present in the Sacramento River system prior to the commencement of large-scale dam construction in the 1940s (IEP Steelhead Project Work Team 1999). McEwan and Jackson (1996) reported that wild steelhead stocks appeared to be mostly confined to upper Sacramento River tributaries such as Antelope, Deer, and Mill creeks and the Yuba River. However, naturally spawning populations are also known to occur in Butte Creek, and the upper Sacramento mainstem, Feather, American, Mokelumne, and Stanislaus rivers (CALFED 2000). Incidental catches and observations of steelhead juveniles also have occurred on the Tuolumne and Merced Rivers during fall-run Chinook salmon monitoring activities, indicating that steelhead are widespread, if not abundant, throughout accessible streams and rivers in the Central Valley (Good et al. 2005).

Abundance and Productivity: Steelhead counts at the Red Bluff Diversion Dam (RBDD) have declined from an average annual count of 11,187 adults for the ten-year period beginning in 1967, to an average annual count 2,202 adults in the 1990's (McEwan and Jackson 1996). Estimates of the adult steelhead population composition in the Sacramento River (natural origin versus hatchery origin) have also changed over this time period; through most of the 1950’s, Hallock et al. (1961) estimated that 88 percent of returning adults were of natural origin, and this estimate declined to 10-30 percent in the 1990’s (McEwan and Jackson 1996). Furthermore, the California Fish and Wildlife Plan estimated a total run size of about 40,000 adults for the entire Central Valley, including San Francisco Bay, in the early 1960s (CDFG 1965). In 1991-92, this run was probably less than 10,000 fish based on dam counts, hatchery returns and past spawning surveys (McEwan and Jackson 1996).

Both adult and juvenile abundance data is limited for this DPS. While we currently lack data on naturally-produced juvenile CCV steelhead, it is possible to make rough estimates of juvenile abundance from the available adult return data. Juvenile CCV steelhead abundance estimates come from the escapement data (Table 36). 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 – 687 females), 2.4 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 156,293 natural outmigrants annually. In addition, hatchery managers could produce approximately 1.6 million ESA-listed hatchery juvenile CCV steelhead each year (Table 35).

Table 36. Abundance geometric means (2002-2010) for adult CCV steelhead natural- and hatchery-origin spawners.

Population	Years	Natural-origin Spawners	Hatchery-origin Spawners[a]	Expected Number of Outmigrants[bc]
American River[d]	2002-2005	308	1,326	35,035
Antelope Creek[e]	2007	140	-	15,925
Battle Creek[e]	2006-2010	377	1,396	42,884
Bear Creek[f]	2008-2009	119	-	13,536
Cottonwood Creek[f]	2008-2009	27	-	3,071
Clear Creek[e]	2005-2009	276	-	31,395
Cow Creek[f]	2008-2009	2	-	228
Feather River	2006-2010	-	504	-
Mill Creek[e]	-	15	-	1,706
Mokelumne River[e]	2006-2010	110	133	12,513
Total		**1,374**	**3,359**	**156,293**

[a] All hatchery-origin spawner data (2006-2010) from CHRSG 2012
[b] Expected number of outmigrants=Total spawners*50% proportion of females*3,500 eggs per female*6.5% survival rate from egg to outmigrant
[c] Based upon number of natural-origin spawners
[d] Hannon and Deason 2005
[e] CHSRG 2012
[f] Teubert et al. 2011

Limiting Factors: The status of CCV steelhead appears to have worsened since the 2005 status review (Good et al. 2005), when the BRT concluded that the DPS was in danger of extinction. New information available since Good et al. (2005) indicates an increased extinction risk (Williams et al. 2011). Steelhead have been extirpated from most of their historical range in this region. Habitat concerns in this DPS focus on the widespread degradation, destruction, and blockage of freshwater habitat within the region, and water allocation problems. Widespread hatchery production of introduced steelhead within this DPS also raises concerns about the potential ecological interactions between introduced and native stocks. Because the CCV steelhead population has been fragmented into smaller isolated tributaries without any large source population, and the remaining habitat continues to be degraded by water diversions, the population remains at an elevated risk for future population declines.

2.4.3.5.5 Northern California steelhead

Spatial Structure and Diversity: The range of Northern California (NC) steelhead DPS is defined to include all naturally spawned populations of steelhead in California coastal basins from Redwood Creek in Humboldt county southward to, but not including the Russian River (71 FR 834-862). It includes the basins of all the rivers and streams tributary to the Pacific Ocean between these two streams, including those in Humboldt, Trinity, Mendocino, Sonoma, Lake, Glenn, Colusa, and Tehama counties. Comprehensive geographic distribution information of areas currently occupied is not available for this DPS, but NC steelhead remain widely distributed (Williams et al. 2011).

Abundance and Productivity: NMFS has recognized the decline of NC steelhead populations for more than a dozen years, with available historical NC steelhead abundance data summarized and published in the NMFS west coast steelhead status review by Busby et al. (1996). Prior to 1960, estimates of abundance specific to this ESU were available from dam counts in the upper Eel River (Cape Horn Dam–annual average of 4,400 adult steelhead in the 1930s), the South Fork Eel River (Benbow Dam–annual average of 19,000 adult steelhead in the 1940s), and the Mad River (Sweasey Dam–annual average of 3,800 adult steelhead in the 1940s). In the mid-1960s, estimates of steelhead spawning populations for many rivers in this ESU totaled 198,000. By the mid 1990's, the only available estimates for this area were counts at Cape Horn Dam on the Eel River where an average of 115 total and 30 wild adults were reported (Busby et al.1996). The most recent status review update by Williams et al. (2011) reports a mixture of patterns in population trend information, with more populations showing declines than increases. However, given the preponderance of significant negative trends in the available data, there is concern that steelhead populations in this ESU may not be self-sustaining.

NC steelhead abundance and productivity has only recently been monitored. In 2009, CDFW began studies to determine population-level abundance estimates of NC steelhead. Three streams/rivers have fish counting facilities: Caspar Creek (weir), Pudding Creek (fish ladder), and South Fork Noyo River (dam). From these studies, we estimate that the NC steelhead DPS has an annual abundance of 3,607 adults (Table 37).

Table 37. Geometric mean abundances of NC steelhead spawners from 2006-2012 escapements by population.

Stratum	Waterbody	Years	Abundance	Expected Number of Outmigrants[a]
Northern Coastal	**Elk Creek[b]**	2011	59	6,711
	Little River[b]	2009-2013	13	1,479
	Mattole River[c]	2007-2011	17	1,934
	Redwood Creek[g]	2010-2013	610	69,388
	Freshwater Creek[h]	2009-2013	85	9,669
North Mountain-Interior	**Eel River[e]**	2008-2011	332	37,765
North-Central Coastal	**Big River[b]**	2009-2012	249	28,324
	Caspar Creek[b]	2009-2013	34	3,868
	Cottoneva Creek[b]	2009-2010, 2012	25	2,844
	Hare Creek[b]	2010-2011	2	228
	Juan Creek[b]	2012	39	4,436
	Noyo River[b]	2009-2012	407	46,296
	SF Noyo River[b]	2009-2013	101	11,489
	Pudding Creek[b]	2009-2012	27	3,071
	Ten Mile River[b]	2010-2012	290	32,988
	Usal Creek[b]	2009-2012	52	5,915
	Wages Creek[b]	2009-2011	58	6,598
Central Coastal	**Albion River[b]**	2009-2012	32	3,640
	Big Salmon Creek[b]	2009, 2012	101	11,489
	Brush Creek[b]	2009-2012	6	683
	Garcia River[b]	2009-2012	366	41,633
	Gualala River[b]	2006-2010	1,066	121,258
	Navarro River[b]	2009-2012	315	35,831
Total			**4,286**	**487,533**

[a]Expected number of outmigrants=Total spawners*50% proportion of females*3,500 eggs per female*6.5% survival rate from egg to outmigrant
[b]Gallagher and Wright 2009, 2011, and 2012; Gallagher et al. 2013
[c]Mattole Salmon Group 2011
[d]Duffy 2011
[e]Counts at Van Arsdale Fisheries Station (http://www.pottervalleywater.org/files/VAFS_fish_counts.csv), Harris and Thompson 2014
[f] De Haven 2010
[g] Metheny and Duffy 2014
[h] Ricker et al. 2014

Both adult and juvenile abundance data is limited for this DPS. While we currently lack data on naturally-produced juvenile NC steelhead, it is possible to make rough estimates of juvenile abundance from the available adult return data. Juvenile NC steelhead abundance estimates come from the escapement data. For the species, fecundity estimates range from 3,500 to 12,000; and the male to female ratio averages 1:1 (Pauley et al. 1986). By applying a conservative fecundity estimate of 3,500 eggs to the expected escapement of females (half of the escapement of spawners – 2,143 females), 7.5 million eggs are expected to be produced annually. With an estimated survival rate of 6.5 percent (Ward and Slaney 1993), the DPS should produce roughly 487,533 natural outmigrants annually (Table 37).

Limiting Factors: Land management activities such as timber harvest, agriculture, and mining have resulted in significant instream habitat degradation for NC steelhead, and continue to contribute to poor habitat conditions (65 FR 36074). It is known that dams on the Mad River and Eel River block large amounts of habitat historically used by NC steelhead (Busby et al. 1996, Spence et al. 2008). Also, the proportion of hatchery returns compared to wild stocks in recent returns to the Mad and Eel river basins have exposed their respective wild population to genetic introgression and the potential for deleterious interactions between native stock and introduced steelhead (Williams et al. 2011). Historical hatchery practices at the Mad River hatchery are of particular concern, and included out-planting of non-native Mad River hatchery fish to other streams in the DPS and the production of non-native summer steelhead (65 FR 36074). The conclusion of the 2005 status review (Good et al. 2005) echoes that of previous reviews. Abundance and productivity in this DPS are of most concern, relative to NC steelhead spatial structure (distribution on the landscape) and diversity (level of genetic introgression). The lack of data available also remains a risk because of uncertainty regarding the condition of some stream populations.

2.4.3.5.6 Upper Columbia River steelhead

Spatial Structure and Diversity: Upper Columbia River (UCR) steelhead includes all naturally-spawned steelhead populations below natural and manmade impassable barriers in streams in the Columbia River Basin upstream from the Yakima River, Washington, to the U.S.-Canada border, and progeny of six artificial propagation programs. Four independent populations of UCR steelhead were identified by the IC-TRT in the same upriver tributaries as for UC spring-run Chinook salmon (i.e., Wenatchee, Entiat, Methow, and Okanogan) and, similarly, no major population groupings were identified due to the relatively small geographic area involve (Ford 2011, NMFS 2011b). All extant populations are considered to be at high risk of extinction (Ford 2011). With the exception of the Okanogan population, the Upper Columbia populations rated as "low" risk for spatial structure. The "high" risk ratings for SS/D are largely driven by chronic high levels of hatchery spawners within natural spawning areas and lack of genetic diversity among the populations. The proportions of hatchery origin returns in natural spawning areas remain extremely high across the DPS, especially in the Methow and Okanogan River populations. Overall, the new information considered does not indicate a change in the biological risk category since the last status review (Ford 2011).

Abundance and Productivity: UCR steelhead populations have increased in natural origin abundance in recent years, but productivity levels remain low. The modest improvements in natural returns in recent years are probably primarily the result of several years of relatively good natural survival in the ocean and tributary habitats.

A review of data from the past several years indicates that natural steelhead abundance has declined or remained low in the major river basins occupied by this species since the early 1990s. However, returns of both hatchery and naturally produced steelhead to the upper Columbia have increased somewhat in recent years. Priest Rapids Dam is below the UCR steelhead production areas. The average 1997-2001 returns - counted at the Priest Rapids fish ladder - were approximately 12,900 steelhead. The average for the five years from 1992 through 1996 was 7,800 fish. In 2004 and 2005, it is estimated that totals of 18,727 and 12,143 UCR steelhead (respectively) returned to their spawning grounds (FPC 2005 and PCSRF 2007). However, returns to the upper Columbia are composed primarily of hatchery-origin fish. The percentage of the run over Priest Rapids of natural origin fish increased to over 25% in the 1980s then dropped to less than 10% by the mid-1990s. The median percent wild for 1997-2001 was 17% (Good et al. 2005). More recent data show that these trends have continued. Moreover, from the year 2009 through the year 2013, the five-year average escapement of UCR steelhead was 2,728 naturally produced adult fish and 7,936 hatchery propagated adult fish (Table 38).

Table 38. Average numbers of adult UCR steelhead (NWFSC 2015).

Population	Years	Total	Hatchery Origin	Natural Origin
Entiat River	2009-2013	777	574	203
Methow River	2009-2013	4,438	3,640	798
Okanogan River	2009-2013	2,346	2,117	229
Wenatchee River	2009-2013	3,103	1,605	1,498
Total		10,664	7,936	2,728

Juvenile abundance estimates are published each spring in an annual memorandum estimating percentage of ESA-listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River basin. The averages of the five most recent projections for the UCR steelhead juvenile outmigration are displayed below in Table 39.

Table 39. Recent five-year average projected outmigrations for UCR steelhead (Ferguson 2010; Dey 2012; Zabel 2103; Zabel 2014a; Zabel 2014b).

Origin	Outmigration
Natural	286,452
Listed Hatchery: Adipose Clipped*	658,692
Listed Hatchery: Intact Adipose*	175,528

*When the above species was listed, NMFS included certain artificially propagated (hatchery-origin) populations in the listing. Some of those listed fish have had their adipose fins clipped at their respective hatcheries and some have not.

Limiting Factors include (Upper Columbia Salmon Recovery Board 2007; NOAA Fisheries 2011):

Mainstem Columbia River hydropower–related adverse effects
Impaired tributary fish passage
Degraded freshwater habitat: Floodplain connectivity and function, channel structure and complexity, riparian areas and large woody debris recruitment, stream flow, and water quality have been degraded as a result of cumulative impacts of agriculture, forestry, and development.
Effects of predation, competition, and disease mortality: Fish management, including past introductions and persistence of non-native (exotic) fish species continues to affect habitat conditions for listed species.
Hatchery-related effects
Harvest-related effects

2.4.3.5.7 Snake River Basin steelhead

Spatial Structure and Diversity: Snake River (SR) Basin steelhead includes all naturally-spawned steelhead populations below natural and manmade impassable barriers in streams in the Snake River Basin of southeast Washington, northeast Oregon, and Idaho, and progeny of six artificial propagation programs. The IC-TRT identified 24 populations in five major groups (Ford 2011; NMFS 2011b). The IC-TRT has not assessed the viability of this species. The relative proportion of hatchery fish in natural spawning areas near major hatchery release sites is highly uncertain. There is little evidence for substantial change in ESU viability relative to the previous BRT and IC-TRT reviews. Overall, therefore, the new information considered does not indicate a change in the biological risk category since the last status review (Ford 2011).

Abundance and Productivity: The level of natural production in the two populations with full data series and the Asotin Creek index reaches is encouraging, but the status of most populations in this DPS remains highly uncertain. Population-level natural origin abundance and productivity inferred from aggregate data and juvenile indices indicate that many populations are likely below the minimum combinations defined by the IC-TRT viability criteria.

The longest consistent indicator of steelhead abundance in the Snake River basin is derived from counts of natural-origin steelhead at the uppermost dam on the lower Snake River (Lower Granite Dam). According to these estimates, the abundance of natural-origin steelhead at the uppermost dam on the Snake River has declined from a 4-year average of 58,300 in 1964 to a 4-year average of 8,300 ending in 1998. In general, steelhead abundance declined sharply in the early 1970s, rebuilt modestly from the mid-1970s through the 1980s, and declined again during the 1990s. From the year 2004 through the year 2009, the five-year average return to the ESU was 162,323 adult fish (Ford 2011); of these, approximately 90% were of hatchery origin (PCSRF 2007).

With a few exceptions, annual estimates of steelhead returns to specific production areas within the Snake River are not available. Overall, from the year 2010 through the year 2014, the five-year average escapement of SR steelhead was 46,336 naturally produced adult fish and 139,528 hatchery propagated adult fish (Table 40).

Table 40. Estimated numbers of adult Snake River steelhead (ODFW/WDFW 2014).

	A-run		B-run		Total	
Run Year	Hatchery	Wild	Hatchery	Wild	Hatchery	Wild
2009-10	260,095	39,759	19,048	4,480	279,143	44,239
2010-11	128,132	34,362	35,324	10,478	163,457	44,839
2011-12	120,643	35,471	19,526	4,680	140,169	40,151
2012-13	67,128	20,786	15,881	5,387	83,009	26,173
2013-14	74,000	25,058	6,802	2,278	31,860	76,278
Average	130,000	31,087	19,316	5,461	139,528	46,336

Juvenile abundance estimates are published each spring in an annual memorandum estimating percentage of ESA-listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River basin. The averages of the five most recent projections for the SR steelhead juvenile outmigration are displayed below in Table 41.

Table 41. Recent five-year average projected outmigrations for SR steelhead (Ferguson 2010; Dey 2012; Zabel 2013; Zabel 2014a; Zabel 2014b).

Origin	**Outmigration**
Natural	1,399,511
Listed Hatchery: Adipose Clipped	3,075,195

Origin	Outmigration
Listed Hatchery: Intact Adipose	971,028

Limiting Factors include (NMFS 2011d; NMFS 2011b):

Mainstem Columbia River hydropower–related adverse effects
Impaired tributary fish passage
Degraded freshwater habitat: Floodplain connectivity and function, channel structure and complexity, riparian areas and large woody debris recruitment, stream flow, and water quality have been degraded as a result of cumulative impacts of agriculture, forestry, and development
Impaired water quality and increased water temperature
Related harvest effects, particularly for B-run steelhead
Predation
Genetic diversity effects from out-of-population hatchery releases

2.4.3.5.8 Lower Columbia River steelhead

Spatial Structure and Diversity: Four strata and 23 historical populations of Lower Columbia River (LCR) steelhead occur within the DPS: 17 winter-run populations and six summer-run populations, within the Cascade and Gorge ecological subregions.[30] The DPS also includes the progeny of ten artificial propagation programs.[31] Summer steelhead return to freshwater long before spawning. Winter steelhead, in contrast, return from the ocean much closer to maturity and spawn within a few weeks. Summer steelhead spawning areas in the Lower Columbia River are found above waterfalls and other features that create seasonal barriers to migration. Where no temporal barriers exist, the winter-run life history dominates.

It is likely that genetic and life history diversity has been reduced as a result of pervasive hatchery effects and population bottlenecks. Spatial structure remains relatively high for most populations. Out of the 23 populations, 16 are considered to have a "low" or "very low" probability of persisting over the next 100 years, and six populations have a "moderate" probability of persistence (Lower Columbia Fish Recovery Board 2010, ODFW 2010; Ford 2011; NMFS 2013a). All four strata in the DPS fall short of the WLC-TRT criteria for viability (NMFS 2013a).

[30] The White Salmon and Little White Salmon steelhead populations are part of the Middle Columbia steelhead DPS and are addressed in a separate species-level recovery plan, the Middle Columbia River Steelhead Distinct Population Segment ESA Recovery Plan (NMFS 2009b).
[31] In 2007, the release of Cowlitz Hatchery winter steelhead into the Tilton River was discontinued; in 2009, the Hood River winter steelhead program was discontinued; and in 2010, the release of hatchery winter steelhead into the Upper Cowlitz and Cispus rivers was discontinued. In 2011, NMFS recommended removing these programs from the DPS. A Lewis River winter steelhead program was initiated in 2009, and in 2011, NMFS proposed that it be included in the DPS (NMFS 2011c).

Baseline persistence probabilities were estimated to be "low" or "very low" for three out of the six summer steelhead populations that are part of the LCR steelhead DPS, moderate for two, and high for one, the Wind, which is considered viable. Thirteen of the 17 LCR winter steelhead populations have "low" or "very low" baseline probabilities of persistence, and the remaining four are at "moderate" probability of persistence (Lower Columbia Fish Recovery Board 2010; ODFW 2010; NMFS 2013a).

Abundance and Productivity: The "low" to "very low" baseline persistence probabilities of most LCR steelhead populations reflects low abundance and productivity (NMFS 2013a). All of the populations increased in abundance during the early 2000s, generally peaking in 2004. Most populations have since declined back to levels within one standard deviation of the long term mean. Exceptions are the Washougal summer-run and North Fork Toutle winter-run, which are still higher than the long term average, and the Sandy, which is lower. In general, the populations do not show any sustained dramatic changes in abundance or fraction of hatchery origin spawners since the 2005 status review (Ford 2011). Although current LCR steelhead populations are depressed compared to historical levels and long-term trends show declines, many populations are substantially healthier than their salmon counterparts, typically because of better habitat conditions in core steelhead production areas (Lower Columbia Fish Recovery Board 2010; NMFS 2013a).

Since the last status evaluation, all populations increased in abundance during the early 2000s, generally peaking in 2004. Abundance of most populations has since declined back to levels close to the long-term mean. Exceptions are the Washougal summer and North Fork Toutle winter populations, for which abundance is higher than the long-term average, and the Sandy, for which abundance is below the long-term average. The North Fork Toutle winter steelhead population appears to be experiencing an increasing trend dating back to 1990, which is likely partially the result of recovery of habitat since the eruption of Mt. St. Helens in 1980. In general, the LCR steelhead populations do not show any sustained, dramatic changes in abundance since the previous status review (Ford 2011).

Table 42. Abundance estimates for LCR steelhead populations (Streamnet 2014; WDFW 2010a; WDFW 2010b; ODFW 2010a; WDFW 2011; NWFSC 2015).

Stratum (Run)	Population	Years	HOR(1)	NOR(2)	Recovery Target(3)
Cascade (Winter)	Upper Cowlitz and Cispus	2009-2013	614	535	
	Lower Cowlitz	2009	4559	400	500
	Tilton	2009-2013	256	251	200
	Coweeman	2009-2013	181	483	500
	South Fork Toutle	2009-2013	5	466	600
	North Fork Toutle	2009-2013	99	530	600
	Kalama	2009-2013	433	900	600

	North Fork Lewis	2009-2013	2,126		400
	East Fork Lewis	2009-2013	0	418	500
	Washougal	2009-2013	203	368	350
	Clackamas	2004-2008	682	1,669	10,655
	Sandy	2002-2006	0	769	1,510
Cascade (Summer)	Kalama	2009-2013	334	518	500
	North Fork Lewis	2009-2013	10,508		
	East Fork Lewis	2009-2013	114	916	500
	Washougal	2009-2013	605	704	500
Gorge (Winter)	Lower Gorge				1,104
	Upper Gorge	2009-2013		41	322
	Hood	2003-2007	380	438	1,633
Gorge (Summer)	Wind	2009-2013	42	866	1,000
	Hood	2003-2007	239	241	1,988

(1) Hatchery Origin (HOR) spawners.
(2) Natural Origin (NOR) spawners.

The Columbia River Compact, a joint effort between ODFW and WDFW, monitors salmon, steelhead, and other species abundance and harvest limits in the Columbia River basin. The Compact publishes Joint Staff Reports describing management guidelines for seasonal fisheries in the mainstem Columbia River and expectations for annual salmon and summer steelhead returns (http://wdfw.wa.gov/fishing/crc/). For the years 2009-2013, the average return of wild winter steelhead to the Columbia River mouth was 15,931, of which 9,393 were LCR steelhead DPS. Adding the estimated abundance of summer steelhead (Table 42) to this the average we would expect an annual return of roughly 11,117 naturally produced adult LCR steelhead. Also from Table 42, we would expect an annual return of roughly 23,000 hatchery produced adult LCR steelhead.

NWFSC publishes juvenile abundance estimates each year in the annual memorandum estimating percentages of listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River basin. Numbers for 2015 are not available at this time; however the average outmigration for the years 2010-2014 is shown in Table 43 (Ferguson 2010; Dey 2012; Zabel 2013, 2014a, 2014b).

Table 43. Average estimated outmigration for ESA-listed LCR steelhead (2010-2014).

Origin	Outmigration
Natural	447,659
Listed hatchery intact adipose	2,428
Listed hatchery adipose clipped	1,025,729

<u>Limiting Factors</u> include (NOAA Fisheries 2011; NMFS 2013a):

Degraded estuarine and nearshore marine habitat resulting from cumulative impacts of land use and flow management by the Columbia River hydropower system
Degraded freshwater habitat: Floodplain connectivity and function, channel structure and complexity, riparian areas and recruitment of large wood, stream substrate, stream flow, and water quality have been degraded as a result of cumulative impacts of agriculture, forestry, and development
Reduced access to spawning and rearing habitat mainly as a result of tributary hydropower projects and lowland development
Avian and marine mammal predation in the lower mainstem Columbia River and estuary
Hatchery-related effects
An altered flow regime and Columbia River plume has altered the temperature regime and estuarine food web, and has reduced ocean productivity
Reduced access to off-channel rearing habitat in the lower Columbia River
Reduced productivity resulting from sediment and nutrient-related changes in the estuary
Juvenile fish strandings that result from ship wakes
Contaminants affecting fish health and reproduction

2.4.3.5.9 Upper Willamette River steelhead

Spatial Structure and Diversity: Upper Willamette River (UWR) steelhead includes all naturally-spawned steelhead populations below natural and manmade impassable barriers in the Willamette River, Oregon, and its tributaries upstream from Willamette Falls to the Calapooia River. One stratum and four extant populations of UWR steelhead occur within the DPS. Historical observations, hatchery records, and genetics suggest that the presence of UWR steelhead in many tributaries on the west side of the upper basin is the result of recent introductions. Nevertheless, the WLC-TRT recognized that although west side UWR steelhead does not represent a historical population, those tributaries may provide juvenile rearing habitat or may be temporarily (for one or more generations) colonized during periods of high abundance. Hatchery summer-run steelhead that are released in the subbasins are from an out-of-basin stock, not part of the DPS. Additionally, stocked summer steelhead that have become established in the McKenzie River were not considered in the identification of historical populations (ODFW and NMFS 2011).

Abundance and Productivity: Since the last status review in 2005, UWR steelhead initially increased in abundance but subsequently declines and current abundance is at the levels observed in the mid-1990s when the DPS was first listed. The DPS appears to be at lower risk than the UWR Chinook salmon ESU, but continues to demonstrate the overall low abundance pattern that was of concern during the last status review. The elimination of winter-run hatchery release in the basin reduces hatchery threats, but non-native summer steelhead hatchery releases are still a concern for species diversity. Overall, the new information considered does not indicate a change in the biological risk category since the last status review (Ford 2011).

The majority of the UWR winter steelhead run return to freshwater in January through April, pass Willamette Falls from mid-February to mid-May, and spawn in March through June. Adult winter-run steelhead are counted at the Willamette Falls fishway ladder where the counts begin in November and end mid-May of the following year (Table 44). The number of winter-run steelhead passing over Willamette Falls during the winter of 2013 was 4,944 and the most recent five-year average is only at 6,030.

Table 44. Upper Willamette winter-run steelhead abundance (ODFW 2014b).

Year	Natural-origin Spawners
2009	2,813
2010	7,337
2011	7,441
2012	7,616
2013	4,944
Average	6,030

It is difficult to accurately estimate juvenile UWR steelhead abundance during the coming year. However, the average estimated outmigration (2010-2014) of naturally-produced smolts is 215,847 (Ferguson 2010; Dey 2012; Zabel 2013, 2014a, 2014b). As with other species, it is reasonable to assume that this figure could be substantially higher when other juvenile life stages are included. In addition, non-listed juvenile rainbow trout and unlisted juvenile steelhead occur in the same areas as the listed UWR steelhead; and it is very difficult to distinguish between them.

<u>Limiting Factors</u> include (NOAA Fisheries 2011; ODFW and NMFS 2011b):

Degraded freshwater habitat: Floodplain connectivity and function, channel structure and complexity, riparian areas and large wood recruitment, and stream flow have been degraded as a result of cumulative impacts of agriculture, forestry, and development
Degraded water quality and altered temperature as a result of both tributary dams and the cumulative impacts of agriculture, forestry, and urban development
Reduced access to spawning and rearing habitats mainly as a result of artificial barriers in spawning tributaries
Hatchery-related effects: impacts from the non-native summer steelhead hatchery program
Anthropogenic introductions of non-native species and out-of-ESU races of salmon or steelhead have increased predation and competition on native UWR steelhead.

2.4.3.5.10 Middle Columbia River steelhead

Spatial Structure and Diversity: Middle Columbia River (MCR) steelhead includes all naturally-spawned steelhead populations below natural and artificial impassable barriers in streams from above the Wind River, Washington, and the Hood River, Oregon (exclusive), upstream to, and including, the Yakima River, Washington, excluding steelhead from the Snake River basin; and progeny of seven artificial propagation programs. The IC-TRT identified 17 extant populations in this DPS (NMFS 2011b). The populations fall into four major population groups: the Yakima River Basin (four extant populations), the Umatilla/Walla-Walla drainages (three extant and one extirpated populations); the John Day River drainage (five extant populations) and the Eastern Cascades group (five extant and two extirpated populations) (NMFS 2009b; Ford 2011).

Abundance and Productivity: Returns to the Yakima River basin and to the Umatilla and Walla Walla Rivers have been higher over the most recent brood cycle, while natural origin returns to the John Day River have decreased. There have been improvements in the viability ratings for some of the component populations, but the MCR steelhead DPS is not currently meeting the viability criteria (adopted from the IC-TRT) in the MCR steelhead recovery plan (NMFS 2009b). In addition, several of the factors cited by Good et al. (2005) remain as concerns or key uncertainties. Natural origin spawning estimates of populations have been highly variable with respect to meeting minimum abundance thresholds. Overall, the new information considered does not indicate a change in the biological risk category since the last status review (Ford 2011).

The species' populations are generally well below the ICTRT's abundance thresholds for viability. Only the Deschutes (Eastside), Fifteen Mile Creek, and the North Fork John Day populations have recent 10-year averages that exceed the thresholds; the other 14 extant populations are all below the thresholds (though some are not far below) and a few represent only fractions of the numbers needed for viability (see Table 45). On a positive note, the most recent 20-year productivity averages are showing greater-than-replacement levels in all populations for which we have data. Moreover, from the year 2009 through the year 2013, the five-year average return to the ESU was 26,851 adult fish (NWFSC 2015); of these, approximately 9% were of hatchery origin.

Table 45. Annual escapement estimates of adult MCR steelhead for the years 2009-2012 (NWFSC 2015).

	Hatchery Origin				Natural Origin			
Population	2009	2010	2011	2012	2009	2010	2011	2012
Klickitat	842	822	302	293	391	120	296	179
Fifteenmile Creek	0	0	33	27	395	814	383	530
Deschutes River - eastside	145	226	340	506	1,662	1,385	1,466	1,949
Deschutes River - westside	93	110	62	25	328	893	1,175	1,206
Lower Mainstem John Day	778	230	419	654	3,546	1,121	2,197	3,436
Upper Mainstem John Day	31	23	22	21	732	739	1,062	1,035
North Fork John Day	163	91	59	94	3,909	2,931	2,906	4,589
Middle Fork John Day	85	55	74	70	2,029	1,765	3,618	3,424

South Fork John Day	73	13	19	42	1,758	418	915	2,057
Umatilla River	586	926	631	778	2,344	3,702	3,879	3,111
Walla Walla River	18	50	33	50	861	1,615	1,628	1,211
Touchet River	137	182	70	83	279	828	470	293
Satus Creek	11	85	46	78	1,042	2,745	2,278	1,877
Toppenish Creek	7	19	16	29	692	620	801	696
Naches River	9	62	42	65	1,114	2,138	1,965	1,657
Upper Yakima	0	19	11	15	216	366	365	354
Totals	2,976	2,911	2,179	2,830	21,300	22,202	25,404	27,603
Averages	Hatchery Origin Average =			2,724	Natural Origin Average =			24,127

Juvenile abundance estimates are published each spring in an annual memorandum estimating percentage of ESA-listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River basin. The averages of the five most recent projections for the MCR juvenile outmigration are displayed below in Table 46.

Table 46. Recent five-year average projected outmigrations for MCR steelhead (Ferguson 2010; Dey 2012; Zabel 2013; Zabel 2014a; Zabel 2014b).

Origin	Outmigration
Natural	609,458
Listed Hatchery: Adipose Clipped*	341,721
Listed Hatchery: Intact Adipose*	422,853

*When the above species was listed, NMFS included certain artificially propagated (hatchery-origin) populations in the listing. Some of those listed fish have had their adipose fins clipped at their respective hatcheries and some have not.

Limiting Factors include (NMFS 2009b; NOAA Fisheries 2011):

Degraded freshwater habitat: Floodplain connectivity and function, channel structure and complexity, riparian areas, fish passage, stream substrate, stream flow, and water quality have been degraded as a result of cumulative impacts of agriculture, forestry, tributary hydro system activities, and development
Mainstem Columbia River hydropower–related impacts
Degraded estuarine and nearshore marine habitat
Hatchery-related effects
Harvest-related effects
Effects of predation, competition, and disease

2.4.3.5.11 Puget Sound steelhead

Spatial Structure and Diversity: Steelhead populations can be divided into two basic reproductive ecotypes, based on the state of sexual maturity at the time of river entry (summer or winter) and duration of spawning migration (Burgner et al. 1992). The Puget Sound (PS) DPS includes all naturally spawned anadromous winter-run and summer-run steelhead populations in streams in the river basins of the Strait of Juan de Fuca, Puget Sound, and Hood Canal, Washington, bounded to the west by the Elwha River (inclusive) and to the north by the Nooksack River and Dakota Creek (inclusive), as well as the Green River natural and Hamma Hamma winter-run steelhead hatchery stocks. Non-anadromous ‘‘resident’’ *O. mykiss* occur within the range of PS steelhead but are not part of the DPS due to marked differences in physical, physiological,

The PS Steelhead TRT has completed a set of simple population viability analyses (PVAs) for these draft populations and MPGs within the DPS. No new estimates of productivity, spatial structure and diversity of PS steelhead have been made available since the 2007 review, when the BRT concluded that low and declining abundance and low and declining productivity were substantial risk factors for the species (USDC 2007). Loss of diversity and spatial structure were judged to be “moderate” risk factors. Since the listing of this species, this threat has not changed appreciably (Ford 2011).

Abundance and Productivity: The BRT considered the major risk factors facing PS steelhead to be: widespread declines in abundance and productivity for most natural steelhead populations in the ESU, including those in Skagit and Snohomish rivers (previously considered to be strongholds); the low abundance of several summer-run populations; and the sharply diminishing abundance of some steelhead populations, especially in south Puget Sound, Hood Canal, and the Strait of Juan de Fuca (Hard et al. 2007). For all but a few putative PS steelhead populations, estimates of mean population growth rates obtained from observed spawner or redd counts are declining—typically 3 to 10% annually—and extinction risk within 100 years for most populations in the DPS is estimated to be moderate to high, especially for draft populations in the putative South Sound and Olympic MPGs. Most populations within the DPS continue downward trends in estimated abundance, a few sharply so. Extinction risk within 100 years for most populations in the DPS is estimated to be moderate to high, especially for populations in the South Sound and Olympic MPGs.

For the most recent 5-year period of escapement estimates (2009-2013), run size is 14,615 spawners (Table 47).

Table 47. Abundance of PS steelhead spawner escapements (natural-origin and hatchery production combined) from 2009-2013.

Populations	Run	Years	Spawners[a]			Expected Number of Outmigrants[b]
			Total	NOR	HOR	
Nooksack River [c]	Winter	2009-2012	1,472	1,472	0	167,440
Samish River [c]	Winter	2009-2013	748	748	0	85,085
Skagit River [c]	Summer/Winter	2009-2013	6,385	6,066	319	726,294

Populations	Run	Years	Spawners[a]			Expected Number of Outmigrants[b]
			Total	NOR	HOR	
Stillaguamish River [c]	Winter	2009-2013	387	313	74	44,021
Snohomish-Skykomish Rivers [c]	Winter	2009-2013	2,387	1,933	454	271,521
Cedar River [d]	Winter	2009-2012	1	1	0	114
Green River [c]	Winter	2009-2013	621	590	31	70,639
Puyallup/Carbon River [c]	Winter	2009-2013	386	317	69	43,908
White River [c]	Winter	2009-2013	603	603	0	68,591
Nisqually River [c]	Winter	2009-2013	478	421	57	54,373
East and South Hood Canal [c]	Winter	2009-2013	139	139	0	15,811
Skokomish River [c]	Winter	2009-2013	602	602	0	68,478
West Hood Canal [c]	Winter	2009-2013	226	226	0	25,708
Dungeness River [e]	Winter	2009-2013	26	26	0	2,958
Sequim/Discovery Bay Independent Tributaries [d]	Winter	2009-2013	22	22	0	2,503
Strait of Juan de Fuca Independent Tributaries [d]	Winter	2009-2013	132	132	0	15,015
DPS average			14,615	13,621	994	1,668,371

[a] Geometric mean of post fishery spawners.
[b] Expected number of outmigrants=Total spawners*50% proportion of females*3,500 eggs per female*6.5% survival rate from egg to outmigrant.
[c] Source: Unpublished data, Robert Leland, WDFW, Nov. 24, 2014
[d] Source: https://fortress.wa.gov/dfw/score/score/species/steelhead.jsp?species=Steelhead
[e] Source: PNPTC et al. 2013

Steelhead are most abundant in the northern Puget Sound, with the Skagit and Snohomish rivers supporting the two largest winter-run steelhead populations. Hood Canal and Strait of Juan de Fuca populations are generally small with their populations averaging fewer than 400 natural-origin spawners annually.

Juvenile PS 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 both natural-origin and hatchery-origin spawners – 7,308 females), 25.58 million eggs are expected to be produced annually. With an estimated survival rate of 6.5% (Ward and Slaney 1993), the DPS should produce roughly 1.7 million natural outmigrants annually.

Limiting factors include (NOAA Fisheries 2011):

Widespread declines in adult abundance (total run size), despite significant reductions in harvest in recent years.
Threats to diversity posed by use of two hatchery steelhead stocks (Chambers Creek and Skamania) inconsistent with wild stock diversity throughout the DPS.
Declining diversity in the DPS, including the uncertain but weak status of summer-run fish in the DPS.
A reduction in spatial structure for steelhead in the DPS.
Reduced habitat quality through changes in river hydrology, temperature profile, downstream gravel recruitment, and reduced movement of large woody debris.
Increased flood frequency and peak flows during storms, reduced groundwater-driven summer flows in the lower reaches of many rivers and their tributaries in Puget Sound where urban development has occurred, has resulted in gravel scour, bank erosion, and sediment deposition.
Dikes, hardening of banks with riprap, and channelization, which have reduced river braiding and sinuosity, have increased the likelihood of gravel scour and dislocation of rearing juveniles.

2.5 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).

2.5.1 Sea Turtles

As described above in the status section, loggerhead, green, leatherback and olive ridley sea turtles have been and continue to be affected by numerous activities within the proposed action area. The proposed action area encompasses a vast portion of the ocean stretching from the coastal and offshore waters of the CCE in the north Pacific, through the oceanic waters of the ETP, where international activities such as fishing and commerce that affect sea turtles are conducted on a global scale by entities all around the world. Most of this activity is not well documented. Because impacts on all four species are similar, we look at the environmental baseline on all species together, calling out differences among species as appropriate.

Fisheries Interactions

Along the west coast of the U.S. in the CCE, all four sea turtle species considered in this opinion are occasionally reported and observed interacting with fishing gear, including pot/trap gear, gillnets, and hook and line recreational gear, with leatherbacks showing to be the more common species interacting with gear (Figures 6 and 7). Recent known interactions include a leatherback found entangled in sablefish trap gear fishing offshore of Fort Bragg in 2008, as well as live leatherback entanglements with the drift gillnet fishery off central California in 2009 and 2012. All four species of sea turtles considered in this opinion have been observed caught in the California drift gillnet fishery historically, although sea turtle interactions are considered rare events in this fishery (NMFS 2012 d). When considering the impact of U.S. west coast Federal fisheries on ESA-listed species of turtles, recent biological opinions have found no jeopardy to any of these species (NMFS 2012b, 2012d). There are two state gillnet fisheries in California that may interact with sea turtles: the set gillnet fishery targeting halibut and white seabass; and the small mesh drift gillnet fishery targeting yellowtail, barracuda, and white seabass. No sea turtle interactions have been documented recently in sporadic observer coverage of those fisheries.

Pelagic longline fisheries for swordfish and tuna based in Hawaii, which can range into areas of the ocean that may border or are within the CCE and ETP are also known to be susceptible to sea turtle bycatch. The shallow-set fishery for swordfish has traditionally interacted with more turtles than the deep-set fishery for tuna, although mortality rates of turtles in shallow-set gear is lower than in deep-set gear. The reason for the lower mortality rates in the shallow-set fishery is due to the gear being set at shallower depths, which allows turtles to reach the surface to breath. Loggerheads are particularly susceptible to shallow-set gear and in the 1990s the Hawaii-based shallow-set fishery interacted with several hundred loggerheads annually (NMFS 2012a). However, the shallow-set fishery was closed in 2001 and only re-opened in 2004 after instituting measures for reducing turtle interactions. This reformation of the Hawaii-based shallow-set fishery, including gear modifications and reduced effort, has resulted in an approximately 97 percent reduction in the average number of loggerhead interactions in this fishery since the 1990s (McCracken 2000; NMFS 2012a). Since 2005, the combined Hawaii-based longline fisheries have reduced their estimated loggerhead mortality to four annually (NMFS 2014b). For leatherbacks, the Hawaii-based longline fisheries combined have reduced their estimated mortality to seven annually since 2005 (NMFS 2014b). A small number of olive ridley and green turtle takes have also been documented in those fisheries. These fisheries have also both been recently determined not to be jeopardizing any ESA-listed sea turtles (NMFS 2012a; NMFS 2014b). The is also a deep-set longline tuna fishery operating out of U.S. west coast outside of the EEZ most commonly in waters that are adjacent or within the ETP. There has been 100% observer coverage in the fishery since 2005, and only 1 sea turtle, an olive ridley, has been observed captured (NMFS 2011e).

There are significant U.S. and international purse seine fisheries targeting tuna and other similar species that operate throughout the ETP. Data of turtle bycatch in these fisheries is reported through the IATTC observer program. The data suggest that the total mortality of all turtles across these fisheries from 2004-2013 was about 16 turtles per year, with the majority of those turtles being olive ridleys (IATTC data). Turtle bycatch mortality has been reduced significantly over the last decade compared to what was reported in the 1990's when turtle mortalities were typically estimated around 150 or more per year.

Estimating the total number of sea turtle interactions in other Pacific fisheries, many of which occur in part within or near the CCE and ETP and interact with the same sea turtle populations as U.S. fisheries, is difficult because of low observer coverage and inconsistent reporting from international fleets. However several attempts have been made for certain fisheries known to have significant sea turtle bycatch issues such as pelagic longlining. Lewison et al. (2004) estimated 1,000 – 3,200 leatherback mortalities and 2,600 – 6,000 loggerhead mortalities from pelagic longlining in the Pacific in 2000. Beverly and Chapman (2007) more recently estimated loggerhead and leatherback longline bycatch in the Pacific to be approximately 20 percent of that estimated by Lewison et al. (2004). Chan and Pan (2012) estimated that there were approximately 1,866 total sea turtle interactions of all species in 2009 in the central and North Pacific by comparing swordfish production and turtle bycatch rates from fleets fishing in the central and North Pacific area. Given that recent developments to reduce sea turtle bycatch in fisheries have been working their way into some international fisheries and the incomplete data sets and reporting that exist, the exact level of current sea turtle bycatch internationally is not clear. However, given the information that is available, we believe that international bycatch of sea turtles in fisheries throughout the Pacific Ocean, including areas that border or within the CCE and ETP, continues to occur at significant rates several orders of magnitude greater than what is being documented or anticipated in U.S. Pacific ocean fisheries.

Vessel Collisions

Vessel collisions are occasionally a source of injury and mortality to sea turtles along the west coast. A review of the strandings database for the U.S. west coast maintained by NMFS indicates that green and leatherbacks are reported most often as stranded due to the impact by vessels strikes, with olive ridleys rarely struck (Figures 5 and 6), likely because they are so rare off the California coast. Green turtles are particularly vulnerable to collisions when in coastal foraging areas in San Diego and Long Beach, while leatherbacks have been reported struck off central California, likely when they are foraging in or near the approach to the Ports of San Francisco and Oakland. The United States Coast Guard (USCG) is responsible for safe waterways under the Port and Waterways Safety Act (PWSA) and establishes shipping lanes. The USCG recently completed Port Access Route Studies for the Santa Barbara Channel and the approaches to San Francisco made recommended to the International Maritime Organization (IMO) that the traffic separation schemes be modified, in part, to reduce the co-occurrence of large ships and whales. NMFS does not know how these changes may affect sea turtles. The IMO gave final endorsement by the IMO in November 2012. The USCG is currently working on domestic rule making under the PWSA to codify these IMO approved changes. Lane changes are expected to go into effect June 1, 2013. Internationally, vessel collisions in coastal and oceanic waters are likely a threat to sea turtles, especially in some high density vessel traffic areas, although no data is available to quantify this threat throughout the proposed action area.

Other Threats

Strandings of sea turtles in the CCE along the U.S. west coast reflect in part the nature of interactions between sea turtles and human activities, as many stranding are associated with human causes. All four of these sea turtles species considered in this opinion have been observed entrained at power plants off coastal California, either alive, injured, or determined to be previously dead. A review of the stranding records indicates that green turtles are the most commonly reported species entrained at power plants (Figures 6 and 7). Since green turtles have been documented foraging in the warm water effluent near power plants, particularly in the San Diego and Long Beach California areas, we assume that they would be most affected. As documented in Figures 5 and 6, sea turtles (particularly olive ridleys) have been documented stranded off California through their encounters with marine debris, either through ingesting debris or becoming entangled in the debris. Other documented threats include illness, gunshot wounds and cold-stunning. Issues with coastal development, including dredging and beach renourishment, are believed to pose a threat as well. Because not all dead stranded sea turtles are necropsied, the stranding database does not provide full documentation of the source of many threats to sea turtles, and the causes of a majority of strandings are unknown.

NMFS issues scientific research permits to allow research actions that involve take of sea turtles within the CCE and ETP. Currently there are 4 permits that allow directed research on sea turtles, typically involving either targeted capture or sampling of individuals that may have stranded or incidentally taken in some other manner. These permits allow a suite of activities that include tagging, tracking, and collection of biological data and samples. These activities are intended to be non-injurious, with only minimal short term affects. But the risks of a sea turtle incurring an injury or mortality cannot be discounted as a result of directed research.

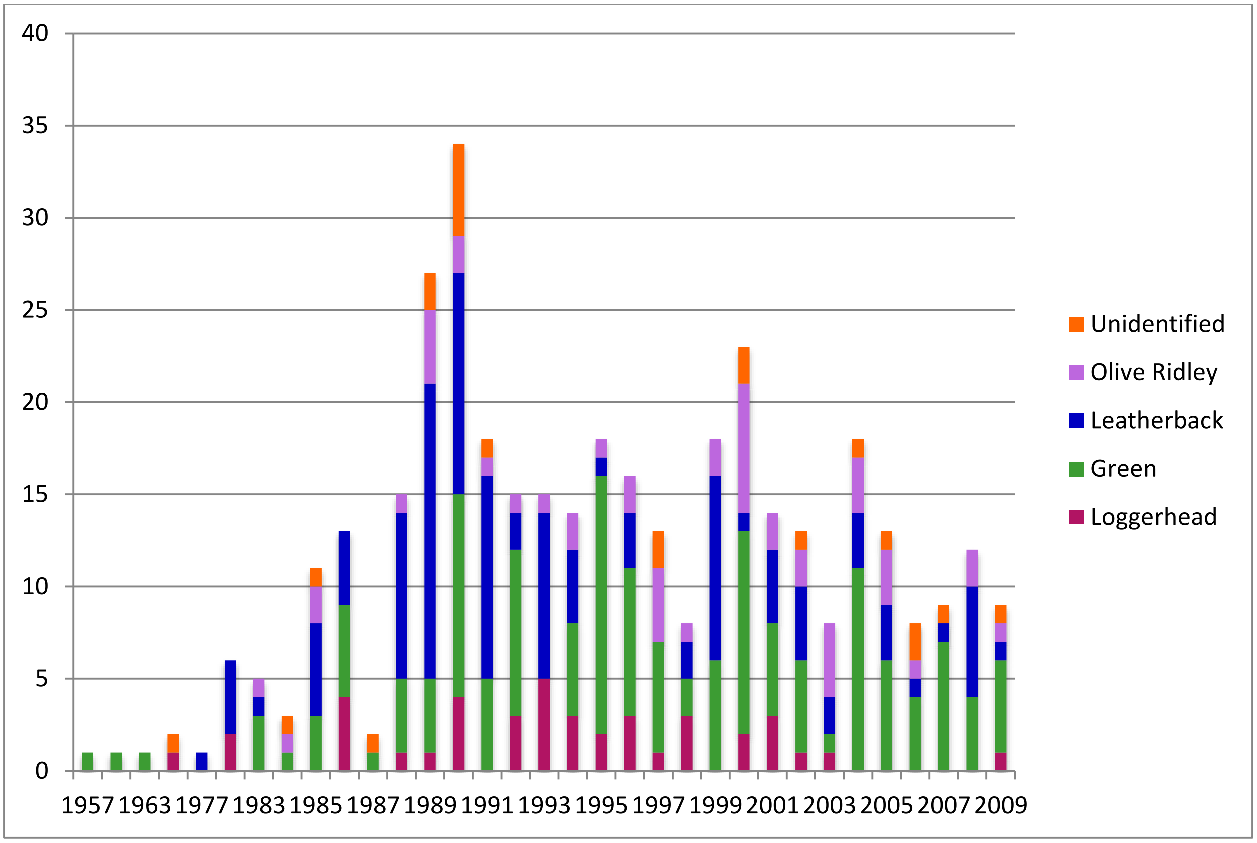

Figure 6. Sea turtle strandings documented off the U.S. west coast, 1957 – 2009.

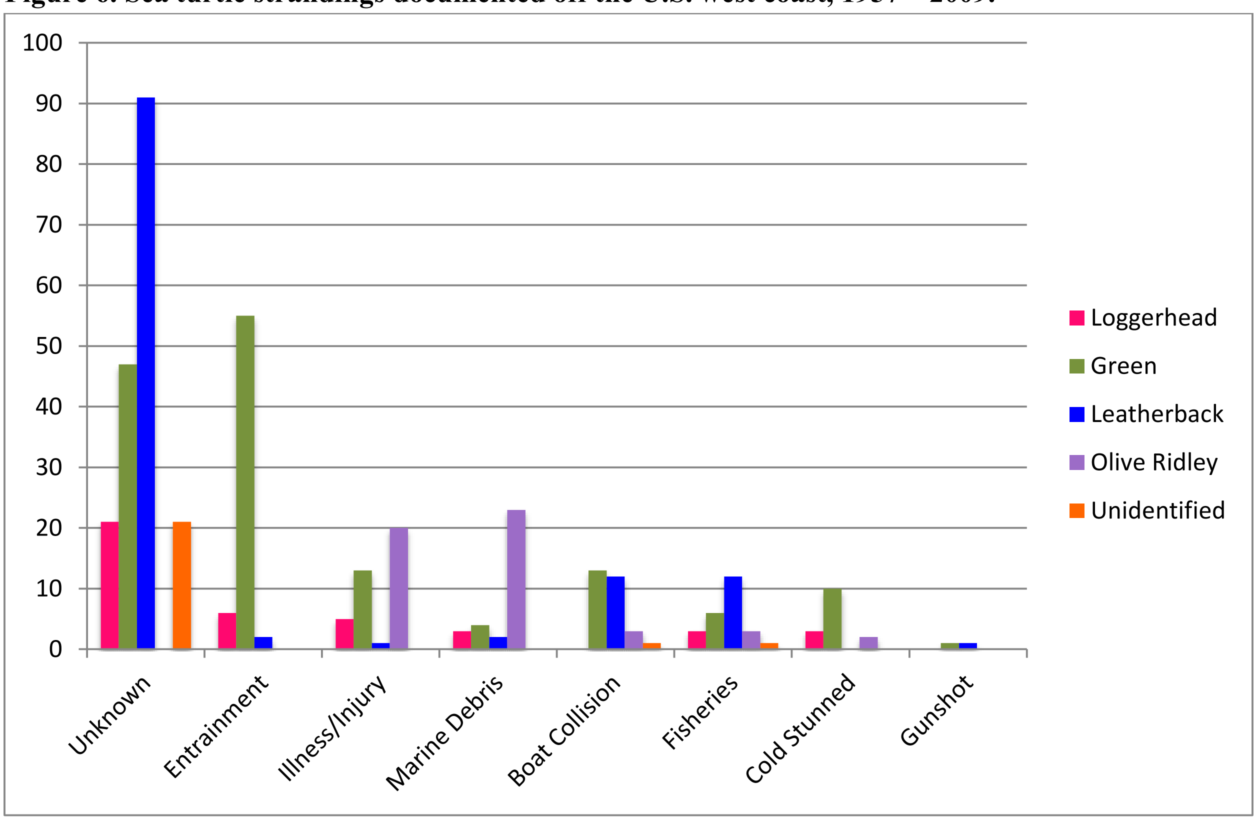

Figure 7. Known causes of sea turtle strandings off the U.S. west coast, 1957-2009.

2.5.2 Marine Fish

2.5.2.1 Eulachon, Southern DPS

Research Fisheries

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 eulachon. NMFS issues numerous section 10(a)(1)(A) scientific research permits allowing lethal and non-lethal take of listed species. We also authorized state scientific research programs under ESA section 4(d). Although eulachon take is not prohibited, the permit applicants are required to consult with NMFS on their take of the species. In 2012 NMFS estimated the lethal and non-lethal take from the research being permitted was about 2,500 fish and 1,000 fish, respectively, and much of this is occurring in coastal marine waters (NMFS 2012b).

Shrimp Fisheries Bycatch

Eulachon are taken as bycatch in shrimp trawl fisheries off the coasts of Washington, Oregon, and California in the CCE (NWFSC 2010). Offshore trawl fisheries for ocean shrimp (*Pandalus jordani*) extend from the west coast of Vancouver Island to the U.S. West Coast off Cape Mendocino, California (Hannah et al. 2003). Al-Humaidhi et al. (2012) provide estimates of the number of individual eulachon caught in the Oregon and California ocean shrimp trawl fishery as bycatch from 2004 to 2010 (except for 2006 when these fisheries were not observed). The total estimated bycatch of eulachon in the Oregon and California ocean shrimp fisheries ranged from 217,841 fish in 2004 to a high of 1,008,259 fish in 2010 (Al-Humaidhi et al. 2012). For all years observed, fleet-wide eulachon bycatch estimates in the Oregon ocean shrimp fishery were much higher than in the California fishery. In 2010, estimated eulachon bycatch in the Washington ocean shrimp fishery was 66,820 fish; and the total 2010 estimated eulachon bycatch for all three states combined was 1,075,081 (Al-Humaidhi et al. 2012). Eulachon encountered as bycatch in these fisheries come from a wide range of age classes but are all assumed to be part of the southern DPS.

2.5.2.2 Scalloped hammerhead shark, Eastern DPS

Internationally, the impacts of fisheries catch and bycatch on scalloped hammerheads are significant. Total worldwide catches of the hammerhead family have increased since the early 1990s from 75 tonnes in 1991 to a peak of 6,313 tonnes in 2010. This is in contrast to the catches of scalloped hammerhead sharks, which have decreased, for the most part, since reaching a maximum of 798 tonnes in 2002 (FAO Statistics; Miller et al. 2014). According to shark fin traders, hammerheads are one of the sources for the best quality fin needles for consumption, and fetch a high commercial value in the Asian shark fin trade (Abercrombie et al. 2005). Clarke et al. (2006) estimated that between 1 and 3 million hammerhead sharks, with an equivalent biomass of 60 – 70 thousand mt, are traded per year in Hong Kong, the world's largest fin trade market. In the eastern Pacific, catch and bycatch of scalloped hammerheads occurs throughout the region in fisheries ranging from artisianal gillnet and longline fishing, to industrial longline and purse seines. Often times data reported from the region are aggregated to categories such as "shark", making precise estimates of catch numbers difficult to obtain. The IATTC does report out catches of hammerheads observed in purse seine fisheries, indicating that as many as nearly 2,000 hammerheads have been observed in a single year, with approximately 50% of the catch consisting of scalloped hammerheads (Roman-Verdesoto and Orozco-Zoller 2005).

The Hawaii-based deep-set longline fishery, which occurs in areas that border or are within the CCE and ETP, catches scalloped hammerhead sharks as bycatch at very low levels. From 1995-2006, 56 scalloped hammerheads were caught on 26,507 observed sets in Hawaii longline fisheries (Walsh et al. 2009). There have been a total of 11 additional scalloped hammerheads observed in the deep-set longline and American Samoa longline fishery in recent years (unpublished PIRO observer data). However, none of these sharks would be considered part of the endangered Eastern Pacific DPS based on their catch location. No scalloped hammerheads have been documented as captured in fisheries along the U.S. west coast.

2.5.3 Salmonids

Status in the Marine Environment

Despite the importance of the marine phase of their life-cycle, there has been very limited information available on the status of the salmon ESUs while in the marine waters. Once salmon leave their natal rivers, they are difficult the track. Chinook salmon generally migrate out of their natal rivers within six months to a year of emergence and will spend one to seven years at sea. Coho will spend about 18 months in fresh water and approximately 6 or 18 months in the marine environment. Very little is known about steelhead in the ocean as they are rarely encountered or recovered in ocean salmon fisheries. Information on salmon abundance and distribution once they leave fresh water is based upon the recovery of salmon with CWTs in ocean fisheries. For over 30 years, the marine distribution and relative abundance of specific stocks, including ESA-listed ESUs, has been done using a representative hatchery stock (or stocks) to serve as proxies for the wild and hatchery fish within the ESUs. This assumes that hatchery and wild stocks have similarities in life histories and migrations in marine waters. The validity of using a hatchery stock as a proxy for a wild stock has been brought up as a serious issue in ocean salmon fisheries management. Differences in the performance, survival, behavior, and physical condition between natural and hatchery-origin salmonids have been identified in numerous studies (see Chittenden et al. 2009 for a review of some references). However, studies have focused on features associated with relative fitness with regard to early-life dynamics. Once in the marine environment, there is little evidence of exactly how these differences influence movement or exposure to harvest in fisheries. After examining nearly 2 million CWT recovery locations, Weitkamp and Neely (2002) found consistency between natural and hatchery coho CWT recovery patterns on the North American west coast, and concluded the use of hatchery populations as a proxy for marine distribution for coho was reasonable.

Catch and Bycatch in Commercial Fisheries

Since 1977, salmon fisheries in the exclusive economic zone (EEZ) (three to 200 miles offshore) off Washington, Oregon, and California have been managed under the salmon FMP. The take of ESA-listed salmon ESUs in the ocean and in-river salmon fisheries has been analyzed by the NMFS in a number of biological opinions and in each of these, NMFS found that salmon directed fisheries would not jeopardize the continued existence of ESA-listed salmon or NMFS has provided reasonable and prudent alternatives to avoid jeopardy. The salmon fisheries, both ocean harvest and in-river harvest, are managed to meet escapement objectives to protect ESA-listed and non-ESA-listed populations

Large numbers of salmon are caught incidentally in large commercial fisheries off the U.S. west coast, including: the bottom trawl and whiting components of the groundfish fishery off the coasts of Washington, Oregon, and California; and purse seine fisheries that target coastal pelagic species (CPS) such as sardines and squid. A number of section 7 consultations have been conducted to determine effects of the fishery on ESA-listed salmon. In each of the consultations, NMFS has determined that the incidental take of salmon in the fishery would not likely jeopardize the continued existence of the ESUs (mostly Chinook) under consideration (NMFS 1999; NMFS 2006a).

Other Factors Affecting Salmonids

Beyond the impacts of fisheries described above, at-sea survival of salmon can be affected by a number of manmade and natural factors once they reach the marine environment. Juvenile salmon are prey for marine seabirds, marine mammals, and larger fish. Adult salmon are prey to pinnipeds such as sea lions, harbor seals (NMFS 1997b) and killer whales in the Pacific Northwest (see section 2.2.1.1.4.1; Osborne 1999 and NMFS 2009c). In certain areas where salmon and predators are in close proximity in relatively high concentrations, predation has been identified as a significantly limiting factor for certain ESUs (e.g., sea lions at Bonneville Dam (NMFS 2008a).

The environmental conditions at the time of ocean entry and near the point of ocean entry are likely to be especially important in determining the survival of juvenile Chinook (Lindley et al. 2009). If ocean productivity and feeding conditions are good, growth will be high and starvation or the effects of size-dependent predation may be lower. Recent studies have provided evidence that growth and survival rates of salmon in the California Current off the Pacific Northwest can be linked to fluctuations in ocean conditions (Peterson et al. 2006; Wells et al. 2008). The correlation between various environmental indices that track ocean conditions and salmon productivity in the Pacific Ocean, both on a broad and local scale, provides an indication of the role they play in salmon survival in the ocean.

There is evidence to suggest that salmon abundance is linked to variation in climate effects on the marine environment. It is widely understood that variations in marine survival of salmon correspond with periods of cold and warm ocean conditions, with cold regimes being generally favorable for salmon survival and warm ones unfavorable (Behrenfeld et al. 2006; Wells et al. 2006). Both short term El Nino Southern Oscillation (ENSO) and longer term climate variability, (PDO), appear to play a part in salmon survival and abundance.

Research Effects

Although they have never been identified as a factor for decline or a threat preventing recovery, scientific research and monitoring activities have the potential to affect the species' survival and recovery by killing listed salmonids. For the year 2015, there are several section 10(a)(1)(A) and rule 4(d) scientific research permit authorizations allowing lethal and non-lethal take of listed salmon and steelhead (Tables 48 to 52).

Table 48. Total authorized take of Chinook salmon ESUs for scientific research and monitoring in 2015.

	Origin	Adults Handled	Adults Killed	Juveniles Handled	Juveniles Killed
Sacramento River winter-run Chinook	Natural	63	7	7,917	172
	Listed Hatchery Adipose Clip	28	-	2,135	914
Central Valley spring-run Chinook	Natural	3,180	76	981,236	17,758
	Listed Hatchery Adipose Clip	27,640	262	6,650	1,276
California Coastal Chinook	Natural	5,303	10	347,806	3,713
Snake River fall Chinook	Natural	434	8	1,762	78
	Listed Hatchery Intact Adipose	211	3	427	30
	Listed Hatchery Adipose Clip	249	6	860	43
	Natural	7,443	42	1,389,143	12,477
	Listed Hatchery Intact Adipose	3,254	6	119,592	1,196

Snake River spring/summer Chinook	Listed Hatchery Adipose Clip	1,602	7	168,605	1,854
Lower Columbia River Chinook	Natural	828	14	2,221,421	19,302
	Listed Hatchery Intact Adipose	62	2	3,978	118
	Listed Hatchery Adipose Clip	419	18	107,379	1,709
Upper Willamette River Chinook	Natural	166	6	72,072	1,190
	Listed Hatchery Intact Adipose	173	15	63	10
	Listed Hatchery Adipose Clip	-	-	16,240	368
Upper Columbia River spring Chinook	Natural	587	15	25,259	898
	Listed Hatchery Intact Adipose	414	12	11143	309
	Listed Hatchery Adipose Clip	270	11	1723	68
Puget Sound Chinook	Natural	812	49	404,914	11,447
	Listed Hatchery Intact Adipose	169	10	153,805	5,533
	Listed Hatchery Adipose Clip	2,049	167	101,002	12,247

Table 49. Total authorized take of chum salmon ESUs for scientific research and monitoring in 2015.

	Origin	Adults Handled	Adults Killed	Juveniles Handled	Juveniles Killed
Hood Canal summer-run chum	Natural	5,203	48	636,610	4,677
Columbia River chum	Natural	56	5	13,166	240
	Listed Hatchery Intact Adipose	-	-	562	18

Table 50. Total authorized take of coho salmon ESUs for scientific research and monitoring in 2015.

	Origin	Adults Handled	Adults Killed	Juveniles Handled	Juveniles Killed
Central California Coast coho	Natural	3,768	50	124,930	2,642
	Listed Hatchery Adipose Clip	-	-	24,560	843
Southern Oregon/Northern California Coast coho	Natural	121	10	126,584	1,627
	Listed Hatchery Adipose Clip	7	0	90	13
	Listed Hatchery Intact Adipose	13	6	1,340	745
Oregon Coast coho	Natural	15,408	158	701,161	15,070
	Listed Hatchery Adipose Clip	24	1	332	22
	Natural	3,273	37	216,707	2,733

Lower Columbia River coho	Listed Hatchery Intact Adipose	253	4	5,206	187
	Listed Hatchery Adipose Clip	3,767	85	97,828	2,043

Table 51. Total authorized take of sockeye salmon ESUs for scientific research and monitoring in 2015.

	Origin	Adults Handled	Adults Killed	Juveniles Handled	Juveniles Killed
SR Sockeye*	Natural	158	4	10571	510
	Listed Hatchery	105	4	158	11
Ozette Lake sockeye	Natural	9	4	26	3
	Listed Hatchery Adipose Clip	5	-	31	3
	Listed Hatchery Intact Adipose	-	-	-	-
*The adult take for sockeye salmon represents both natural fish and adults generated by the captive broodstock program.					

Table 52. Total authorized take of steelhead DPSs for scientific research and monitoring in 2015.

	Origin	Adults Handled	Adults Killed	Juveniles Handled	Juveniles Killed
Southern California steelhead	Natural	115	0	3924	150
South-Central California steelhead	Natural	37	2	22,644	243
Central California Coast steelhead	Natural	1,067	25	194,581	4,473
	Listed Hatchery Adipose Clip	2	2	1,510	47
California Central Valley steelhead	Natural	3,490	96	56,771	1,761
	Listed Hatchery Adipose Clip	3,822	264	20,418	806
Northern California steelhead	Natural	3,325	7	284,504	2,548
Upper Columbia River steelhead	Natural	-	-	28,730	1,038
Snake River Basin steelhead	Natural	13,728	150	458,111	5,713
	Listed Hatchery Intact Adipose	10,063	109	78,087	886
	Listed Hatchery Adipose Clip	10,424	124	69,082	846
Lower Columbia River steelhead	Natural	2,919	32	67,557	1,395
	Listed Hatchery Intact Adipose	-	-	788	26
	Listed Hatchery Adipose Clip	179	8	56,534	845
Upper Willamette River steelhead	Natural	274	4	6,539	151

Middle Columbia River steelhead	Natural	4,128	40	128,785	2,304
	Listed Hatchery Intact Adipose	223	12	17,181	370
	Listed Hatchery Adipose Clip	950	12	25,471	736
Puget Sound steelhead	Natural	1,471	32	65,126	1,212
	Listed Hatchery Intact Adipose	-	-	7,319	131

Actual take levels associated with these activities are almost certain to be a good deal lower than the authorized levels. There are two reasons for this. First, most researchers do not handle or kill the full number of juveniles (or adults) they are allowed. Our research tracking system reveals that for the past five years researchers, on average, ended up taking approximately only 33 percent of the number of juvenile salmonids and 31 percent of the adults they requested and the actual mortality was only 9 percent of requested for juveniles and 2 percent for adults. Second, the estimates of mortality for each proposed study are purposefully inflated to account for potential accidental deaths and it is therefore very likely that fewer fish - especially juveniles - would be killed during any given research project than the researchers are allotted, in some cases many fewer.

2.6 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.

Approach to the Effects Analysis

NMFS determines the effects of the action using a sequence of steps. In this analysis, the first step identifies stressors (or benefits) associated with the proposed action with regard to listed species. The second step identities the magnitude of stressors (e.g., duration, extent, and frequency of the stressor and how many individuals of a listed species will be exposed to the stressors; *exposure analysis).* The third step describes how the exposed individuals are likely to respond to these stressors (e.g., behavioral changes or the injury or mortality rate of exposed individuals; *response analysis).* The final step in determining the effect of the action is establishing the risks those responses pose to listed resources *(risk analysis).* In this step of our analysis, we will relate information on the number and age (or life stage), if applicable, of the individuals likely to be exposed to the proposed action's effects, along with the likely responses of those individuals to the proposed action, to an expected impact on the populations or subpopulations those individuals represent.

For the purposes of this proposed action, we have identified four potential sources of impact to ESA-listed species and designated critical habitats from SWFSC research activities: (1) capture or entanglement in gear used for biological or oceanographic sampling (both incidental and directed); (2) vessel collision; (3) exposure to noise from use of oceanographic equipment and vessels that may produce sound levels that can produce injury or disrupt behavior; and (4) potential reductions in prey through removals from survey sampling. Due to the extensive proposed project action area, the variety of research actions covered by this opinion, and diverse range of ESA-listed species and designated critical habitats that may be encountered by SWFSC research activities, the exposure to these individual stressors varies according by species. In the opinion, we describe the general nature, source, and extent of each stressor, and then relate the specific exposure of each ESA-listed species or designated critical habitat to complete the response and risk analysis for each ESA-listed entity.

The analyses of how SWFSC research may affect ESA-listed species led us to determine that only one of the four potential impacts identified above that was likely to adversely affect any ESA-listed species was incidental and directed capture or entanglement in SWFSC research survey gear. Additionally, we determined that not all ESA-listed species that may be found in the action area were likely to be susceptible to capture or entanglement, due to the nature of their potential exposure or interactions with survey gear. Table 53 below identifies the ESA-listed species that may be adversely affected by each SWFSC research survey.

Table 53. ESA-listed species expected to be subject to incidental and directed capture or entanglement according to gear type and survey name.

Survey Gear	
Trawl	
Survey name	**ESA-listed species captured or entangled**
Coastal Pelagic Species	4 species of sea turtles; eulachon; 28 species of salmonids
Juvenile Salmon*	4 species of sea turtles; eulachon; 28 species of salmonids
Juvenile Rockfish	4 species of sea turtles; eulachon; 28 species of salmonids
CalCOFI	none
Habitat Surveys	4 species of sea turtles; eulachon; 28 species of salmonids
Marine Mammal (CCE and ETP)	none
Antarctic	none
Longline	
Highly Migratory Species (CCE and ETP)	4 species of sea turtles; scalloped hammerhead in ETP
Sablefish	none
Thresher Shark	4 species of sea turtles
Habitat Surveys	4 species of sea turtles

Various Gears	
COAST	none
PacOOS	none
Deep-set Buoy Gear	none
White Abalone Survey	none

* Also includes possible limited use of a beach seine in coastal waters.

For the species that were determined likely to be adversely affected, we analyze all four potential impacts identified above for those species together in the effects analysis of this section, although we do provide reference to information presented or discussed more thoroughly for other species in the "Not Likely to Adversely Affect" Determinations section 2.2 to support those analyses as needed.

2.6.1 Exposure and Response

2.6.1.1 Capture or Entanglement

As described in the proposed action, the SWFSC conducts a number of surveys for various species of fish using trawls, longline, and buoy gear, as well as oceanographic/environmental sampling using various other equipment such as bongo nets, egg sampler, video, current profilers, and CTDs. Capture or entanglement in survey gear has the potential to cause harm through injury or mortality to individuals, and is considered an adverse effect in this opinion. Available information regarding historic interactions between SWFSC research gear and ESA-listed species, supplemented by additional information from relevant commercial fisheries and general understanding and expectations for how marine life might be expected to interact with these gears, has been used to determine the likely future extent of impacts to ESA-listed species resulting from incidental or directed capture or entanglement with SWFSC research.

The gear types most likely to directly interact with ESA-listed species during SWFSC research are those gears that designed for the active capture of fish during surveys: fish trawl nets, longlines, and buoy gear. These gears are similar to ones used familiarly in commercial fishing operations that are known to result in or believed to be at some risk of bycatch with ESA-listed species. The SWFSC has documented the extent of capture and entanglement with ESA-listed species using these gears in the DEA, and this section of the opinion will focus on the potential effects of these gears. For the other types of gear (plankton and small-mesh towed nets, oceanographic sampling devices, video cameras, and ROV deployments), we have determined these do not likely pose any risk to ESA-listed species because of the gear's small size, slow deployment speeds, and/or structural details that make them unlikely or unconducive to incidental capture or entanglement of ESA-listed fish, marine mammals, or sea turtles. These gears are not used for directed targeting of any ESA-listed species. For salmonid species, significant larval/juvenile development occurs in the freshwater systems of their origins before they head out to ocean waters. Additionally, there has been no documentation of any direct interactions with these devices or gear types in SWFSC research historically. As a result, we will not be considering them further. However, we acknowledge that during SWFSC research the officer on watch and crew will be monitoring for any unusual or currently unforeseen circumstances that may arise at a sampling site using any of these gears, and will be instructed to use their professional judgment and discretion to avoid any potential risks to protected species during deployment of all research equipment, as interactions are not impossible.

As discussed in the DEA and associated MMPA LOA application, the SWFSC has a history of incidental capture and entanglement of several marine mammal species, including: Pacific white-sided dolphins (*Lagenorhynchus obliquidens*), California sea lions, northern right whale dolphins (*Lissodelphis borealis*), and northern fur seals (*Callorhinus ursinus*) (Table 4.2-7 *in* DEA). However, none of these marine mammals are listed under the Endangered Species Act. In the development of their LOA application, the SWFSC considered the possible risk of incidental capture for ESA-listed marine mammals as being unlikely based on the lack of historical interactions, and did not apply for authorization under the MMPA to incidentally capture or entangle ESA-listed marine mammal species. In this opinion, we consider potential effects on ESA-listed marine mammal species arising from possible capture or entanglement in the "Not Likely to Adversely Affect" determinations, section 2.2.1.

2.6.1.1.1 Sea Turtles

Given the broad scope of SWFSC research activities occurring throughout the CCE and ETP, there is substantial general overlap between SWFSC research and ESA-listed species of sea turtles discussed in this opinion. Because hard shelled species of sea turtles are generally more densely populated in warmer ocean waters, much of the proposed action area where SWFSC surveys occur in the northern portion of the CCE north of Point Conception is outside of areas where high densities of any hard shelled turtles may be expected. However, the sea turtle stranding record does indicate that loggerhead, green, and olive ridley turtles do periodically occur in coastal waters all along the U.S. west coast (NMFS stranding data), and it is possible that sea turtles could be incidentally captured or entangled in SWFSC surveys in the CCE at any time, especially during summer/fall when water temperatures would be expected to be warmest throughout the U.S. west coast. Leatherback turtles may be found foraging in coastal upwelling areas all along the U.S. west coast in the summer and fall, although most likely in central and northern portions of the U.S. west coast. Given the historic strandings and fisheries bycatch known to have occurred and the available information on sea turtle migrations in ocean waters throughout the Pacific, it is clear that SWFSC research occurring in the southern CCE and throughout the waters of the ETP overlaps with areas where all four of these species would be expected to occur, in varying densities. Research that occurs in the Antarctic would not be expected to overlap with any sea turtle species.

As described in the proposed action, the distribution of SWFSC research using active capture survey gear in the CCE ranges across a wide swath of the U.S. EEZ with varying intensity throughout the year. For example, in the spring, pelagic trawling for juvenile rockfish is fairly concentrated within a relatively small area near the coast in central and southern California, while pelagic trawling for CPS is spread throughout the entire EEZ across the entire coast. In summer, pelagic trawling occurs in fairly wide-spread fashion, but pelagic longlines and deep-set buoy gear for HMS species are also set off southern California. In the fall, HMS pelagic longline and buoy gear sampling continues in a similar fashion, but pelagic trawling is more limited to southern California. In the winter, a limited amount of pelagic trawling occurs off central and southern California. Bottom longline surveys for sablefish are conducted off of central California throughout the entire year.

In the ETP, historically there has not been any use of active capture fishing gear for surveys. However, under the proposed action, the SWFSC proposes to initiate a pelagic longline survey for HMS species in the ETP at some point in the future, most likely during the summer months. Given the early planning stages of this proposed action, no finer details other than somewhere in the ETP can be provided in terms of possible locations. However, unlike the marine mammal surveys where survey vessels recording observations and collecting oceanographic data may transit fairly freely within the EEZ of other countries, it is unclear if any effort which involves or resembles the direct capture of commercial fishery resources using active fishing gears such as longlines would or could occur within the EEZ of foreign nations, particularly nearshore reef environments. To do so would most likely involve prior consent and/or a permit from a foreign nation. As such, we assume this survey effort would most likely occur somewhere on the high seas, with a smaller possibility of occurring in more coastal waters.

Despite the exposure of sea turtles to active fishing survey gear used by the SWFSC in the CCE, there has been only one incidental capture/entanglement of a sea turtle recorded throughout the history of their research programs. During the 2011 SWFSC Juvenile Salmon Survey, a leatherback sea turtle (likely a sub-adult) was incidentally caught in a Nordic 264 surface trawl fishing due west of Pigeon Point, San Mateo County, California. Once the net was pulled onto the deck of the research vessel, it became apparent that the leatherback sea turtle had been caught, along with a large haul of jellyfish. The crew immediately loosened the net around the turtle's head to allow breathing during extraction from the net. The turtle was breathing while in the net, and the crew opened the net and extracted the turtle within three minutes. Once out of the net, the turtle showed no signs of severe injuries, and was released alive. The turtle was subsequently observed swimming and breathing normally at the surface behind the vessel. Mitigation measures in use at the time of the sea turtle interaction included a sea turtle watch (3-

4 observers) before and during the trawl. Although the Juvenile Salmon Survey is the only survey where a sea turtle has been taken, other trawl surveys are also conducted in the CCE in areas where any of these sea turtles species considered in this opinion may occur. Therefore, we conclude this one event reflects the general risk of capture for sea turtles in all survey trawls in the CCE, which is to say a rare event is possible at any time.

While there is an apparent risk for sea turtle interactions with SWFSC longline research gear in the CCE, including entanglement in lines and/or being hooked during depredation on the bait or fish captured on the line, there have been no recorded incidents of sea turtle interactions with SWFSC research longline gear in the CCE to date. Also, the deep-set buoy gear survey has not captured or entangled a sea turtle. This gear is specifically designed to avoid interactions with protected species while catching desirable highly migratory species as a possible alternative commercial fishing gear to other gears like drift gillnets and longlines that are known to be susceptible to turtle bycatch. Previously, NMFS has consulted under section 7 of the ESA on research efforts involving buoy gear and concluded this research was not likely to adversely affect any ESA-listed species, including sea turtles (NMFS 2010a; 2014c). All evidence indicates that this conclusion is still valid, and we do not expect sea turtles to be adversely affected by proposed surveys using deep-set buoy gear.

Even though there is overlap between sea turtles and SWFSC research in the CCE, the interaction rate between sea turtles and SWFSC trawl survey gear in the CCE is expected to be very small in the CCE based on the historical performance of SWFSC research. Given the known overlap and generally accepted vulnerability of sea turtles to trawl gear, it is likely that the gear configuration and survey protocols that have been used for deployment have been effective to some degree at reducing the exposure of sea turtles to SWFSC research gear to a point where capture or entanglement in trawl gear can be classified as simply a very rare event that cannot be completely discounted.

During trawling operations, nets are fished at or very near the surface, minimizing the extent of the water column that is exposed to the trawl net. Turtles are air breathers and do require time at the surface, but also spend time diving in the water column searching for prey. While pelagic trawls are not exempt from sea turtle bycatch potential, traditionally much more attention has been placed on the significance of turtle bycatch in bottom trawl fisheries that occurs in near shore coastal waters. During trawling operations, the SWFSC employs monitoring procedures prior to setting gear and institutes a “move-on” rule if sea turtles are present to avoid the risk of capture. Additionally, survey tow times are relatively short, typically no longer than 30 minutes. In recent years, pelagic trawls involving the Nordic 264 have been using a marine mammal excluder device with a 5” bar spacing to prevent marine mammals from being captured and trapped in the back end (codend) of the trawl net (Figure A-1 *in* DEA). Similar in concept to turtle excluder devices (TEDs) that have been used for decades to reduce turtle bycatch of many species in trawl fisheries around the world, this device may well be effective at minimizing the chance of a sea turtle being captured and trapped in the codend as well. All of these measures appear to have worked together to help minimize the risk of sea turtle bycatch in survey trawl gear, as only one event has happened. These same survey protocols are expected to continue in the future under this proposed action.

Given the one documented interaction with a sea turtle (a leatherback), we assume it is still possible that a sea turtle could encounter SWFSC survey trawls in the CCE, despite the efforts to avoid interaction and move away after observing any turtles present. NMFS also assumes that while MMEDs are likely very effective at preventing turtles from being captured in survey trawls, they are not 100% effective as entanglement in the netting with a flipper or in the MMED grid/opening is possible. In addition, some survey trawls are executed without MMEDs. While activity that occurs in certain areas like central California in the summer and fall may be more likely to encounter leatherback sea turtles, other activities in southern California are more likely to encounter green, loggerheads, or olive ridley sea turtles. Effectively, any of these four species may be captured/entangled in trawl gear, and there isn't enough information to distinguish relative risk among these species from only one historical incident. Although multiple interactions of sea turtles over any period of time are possible, the historical record does not support this as a likely outcome within a survey year, especially given the efforts to minimize the risks to sea turtles described above. As a result, we expect that up to one sea turtle may be captured in the SWFSC survey trawl gear during the course of any year anywhere the SWFSC conducts survey trawls as described in the proposed action. That one turtle could come from any of the four ESA-listed species that have been discussed in this opinion.

Any sea turtle that is subject to forced submergence in a trawl net is at risk of drowning and death. The protocols for SWFSC survey trawls typically employ a short tow time (30 minutes) which is expected to minimize the risk of drowning. In shrimp fisheries in the Atlantic, restriction of tow times to 55 minutes or less is considered a mitigation measure that reduces the risks of drowning for sea turtles captured in that fishery to an extent where TED use is not required, because of the known ability of sea turtles to normally hold their breath for this period of time, even under duress of capture in fishing gear (50 CFR 22.3.206(d)(3)(i)). While it is not impossible for a sea turtle to drown forcibly submerged for 30 minutes or less, we infer it is unlikely. As a result, we expect that the single sea turtle that may be captured each year in a SWFSC survey trawl net will survive.

During longline operations, the SWFSC also employs monitoring and "move-on" protocols during operations. During pelagic longlines, gear configurations such as circle hooks and use of mackerel bait that have been demonstrated to reduce the interaction and mortality rates of sea turtles caught in pelagic longline gear are used during some surveys, although sometimes J hooks and/or market squid are still used for some surveys. Soak times are relatively short for most surveys (2-4 hours for all pelagic longline surveys other than the deep-set longline for swordfish), compared to standard commercial longline fishery operations where soak times may be 8-12 hours or more. Bottom longline surveys for sablefish do not specifically offer any additional modifications to avoid sea turtle bycatch, but the general configuration of setting gear at roughly 400 m depth in central California presents very little risk of sea turtle bycatch. Leatherback turtles that may be in the area during the summer and fall are not likely to spend any time at those bottom depths, and are only really at limited risk of entangling in the buoy lines at each of the longline string. While no historical interactions have been documented, the possibility of encounter and subsequent hooking or entanglement remains a very small possibility.

In the ETP, the SWFSC has never used longlines or any other type of active fishing gear that is prone to turtle bycatch. Instead, research activity has traditionally been more focused on marine mammal sighting cruises and oceanographic monitoring. However, the SWFSC has proposed expanding longline sampling for highly migratory species to the ETP. At this time, it is not possible to pinpoint any exact locations for where this activity may occur. Based on the general distribution and density of some sea turtles being greater in the warmer waters of the ETP, especially for some hard-shelled turtle species such as olive ridleys, and the known issues with sea bycatch in longline gear in or adjacent to the ETP described previously in this opinion, the risks of encounters and subsequent hooking or entanglement with sea turtles cannot be discounted.

The ability to quantitatively assess the risk of SWFSC survey interactions with sea turtles in the CCE or ETP without any historical record of sea turtle interactions with the SWFSC research longline survey gear in the ETP or the CCE is limited. Survey protocols for most HMS species (mainly sharks) include use of relatively short longlines (200-400 hooks in a few miles of gear) and relatively short soak times (2-4 hours) compared to commercial pelagic longline fishing operation that may use over 1000 hooks in 30 miles of gear soaking for at least 8 hours or more. The limited amount of deep-set longline survey effort for swordfish that may include soak times up to 8 hours proposed for both the CCE and ETP also involves many fewer hooks and much shorter total miles of gear compared to commercial longline operations. In addition, with the SWFSC employing the same minimization and avoidance measures in the ETP as the CCE, risks to sea turtles are still expected to be relatively minimal.

In order to gauge the possible extent of sea turtle capture/entanglement in HMS surveys using longline gear set in the CCE and ETP over time, we look at the available data on sea turtle bycatch using from commercial fisheries in areas that most closely represent the proposed action area as much as possible. In the CCE, recent U.S. commercial longline fisheries have been limited to only a small amount of effort in a deep-set tuna fishery operating on the high seas. While this effort is covered by fishery observers, it is a very limited data set. Internationally, reliable data on sea turtle bycatch rates in the ETP is virtually non-existent. Recently, the IATTC has instituted agreements for minimal observer coverage in longline fisheries in the ETP (IATTC Resolution C-11-08), but this effort has yet to produce readily available information regarding sea turtle bycatch in longline fisheries throughout the region.

In terms of readily available information that may provide some indication of risks to sea turtles from SWFSC longline survey gear and interaction rates with longline gear in the CCE and ETP, the best information comes from the Hawaii longline fisheries. The Hawaii longline fisheries include both shallow-set and deep-set longline fisheries for HMS species in areas of the central and eastern Pacific that are at least adjacent to, and within to some degree, some portions of the CCE and ETP. The Hawaii longline fisheries also do reflect in some part the use of both shallow and deep gear for HMS species by the SWFSC. The Hawaii longline fisheries are large fisheries in terms of relative fishing effort, and observer coverage is 100% in the shallow-set fishery and approximately 20% in the deep-set fishery each year.

The most recent estimates of sea turtle catch per unit effort (CPUE - generally represented as the number of turtles taken per set or ~1000 hooks) and estimated mortality rates by species in Hawaii longline fisheries are presented in Table 54 below (taken from NMFS 2012a and 2014a).

Table 54. Summary of sea turtle catch rates (individuals per 1000 hooks or 1 set) and estimated mortality rates attributed to the shallow-set and deep-set Hawaii longline fisheries.

	CPUE (per 1000 hooks)		Mortality rates	
Species	shallow	deep	shallow	deep
leatherback	0.0047	0.0005	0.22	0.36
loggerhead	0.0061	0.0001	0.19	0.72
olive ridley	0.0003	0.0007	0.19	0.95
green	0.0006	0.0001	0.19	0.93

From Table 54, it is apparent that shallow-set longline fisheries based out of Hawaii have higher interactions with most sea turtle species than deep-set, with the exception of olive ridleys which have a slightly higher CPUE in the deep-set fishery. The proposed action involves both shallow and deep-set longline surveys, although survey longlines are not necessarily identical to these commercial longlines, for reasons discussed below. As an initial gauge of the relative risks associated with sea turtle bycatch in SWFSC survey longlines, we use the highest CPUE from either the shallow or deep-set Hawaii longline fishery to project estimates of sea turtle bycatch annually by species using the maximum total number of hooks that may be set cumulatively in the CCE and ETP annually under the proposed action, independent of the specific proportion of shallow/deep-set longline survey that may actually occur (Table 55).

Table 55. Maximum annual longline survey effort in the CCE and ETP, and annual estimates of turtle captures/entanglements in SWFSC longline research using CPUEs from Hawaii observer

data assuming highest interaction rates from either shallow or deep-set fishery sea turtle CPUEs (Table 54 above).

	sets	max hook/set	total hooks		Species	Projected estimate using max CPUE	
CCE HMS	60	400	24000		leatherback	0.3384	shallow
CCE Habitat	20	400	8000		loggerhead	0.4392	shallow
CCE Thresher	40	400	16000		olive ridley	0.0504	deep
ETP HMS	60	400	24000		green	0.0432	shallow
		Total	72000				

Assuming that sea turtle interaction rates in SWFSC longline surveys in the CCE and ETP were represented to some degree by the rates observed in Hawaii, the worst case scenarios lead to projected entanglements/capture of less than one for all species in all longline surveys combined each year. Olive ridley and green sea turtles captures would only very rarely be expected to occur. Leatherback and loggerhead are more commonly encountered in shallow-set longline gear in Hawaii-based fisheries; although given the relative small number of total hooks that are expected to be set at most each year by the SWFSC, the relative likelihood of interactions within a given year for any species is still fairly small under these assumptions.

Realistically, SWFSC gear is even less likely to take sea turtles than are Hawaii fisheries even though they have overlap geographically to some degree. Instead of extended soak times in excess of 8 hours used in commercial fisheries, most of the SWFSC research surveys involve soak times only 2-4 hours. Although not quantifiable, this is expected to qualitatively reduce the potential for sea turtle interactions compared to commercial fisheries. In addition to soak times, the SWFSC only sets up to 400 hooks at a time in pelagic longline surveys. This effectively reduces the time it takes to retrieve gear (minimizing soak time of all hooks), and allow for more targeted avoidance of areas where turtle interactions may be higher. In commercial fisheries, pelagic longlines typically extend for 20+ miles ranging across wide areas where the relative local abundance of turtles may vary greatly. The shorter longlines associated with the SWFSC research can be placed within a more localized area where the SWFSC may be better able to avoid exposure to turtles if they detect them in an area. This is further supported by the efforts of the SWFSC to monitor and detect sea turtle prior to and during the setting of longline gear, and take action to delay or suspend longline surveys to avoid potential sea turtle takes, as necessary.

The fact that the SWFSC has never taken a sea turtle in any of the longline surveys conducted in the CCE, shallow or deep-set, supports the conclusion that the interaction rates of commercial fisheries in relative close proximity to locations where SWFSC research occurs may not be fully representative of the expected interaction rates of SWFSC longline surveys. While there is not the same longline survey history in the ETP that exists in the CCE, we believe the evidence (though qualitative) supports the conclusion that SWFSC longline research is less likely than commercial fisheries to encounter and capture/entangle sea turtles regardless of where the surveys occur. However, especially over the course of time, we cannot discount the likelihood that a sea turtle could be taken by SWFSC longline surveys in the CCE or ETP. We do not expect regular interactions each survey year, but expect that a rare event similar to what was described above for survey trawls, could occur any year where the SWFSC conducts longline surveys. As a result, we expect that up to one sea turtle may be captured in the SWFSC longline survey gear during the course of any year anywhere the SWFSC conducts longline surveys as described in the proposed action.

The relative chances that any particular capture or entanglement would involve any particular species of sea turtle is difficult to characterize given the limited amount of information that is available on the specific location of future SWFSC longline research and the vast proposed action area. In Hawaii fisheries, interaction with loggerheads and leatherbacks are more likely than olive ridleys or greens. However, throughout the ETP, olive ridleys are more common species, as they are most often documented observed taken in large commercial purse seine fisheries that operate in the ETP (unpublished IATTC observer data). Given the vast project action area and the wide distribution of all these sea turtles throughout the area, and the lack of any specific information that reliably predicts sea turtle interaction rates by species in SWFSC research surveys, we conclude that the probability of any turtle interaction with SWFSC longline research is relative equal, and that the very rare occurrence of one sea turtle capture during the course of any year could be any of the four species discussed in this opinion.

Incidental capture or entanglement in longline gear can lead directly to mortality, typically associated with drowning, or to subsequent mortality resulting from injuries sustained (see Ryder et al. 2006 for information of post-hooking mortality estimates). In Table 54, we describe the estimated mortality rates applied to anticipated sea turtle captures in the Hawaii longline fisheries based on the historical observation of injuries/mortalities of turtles captured in those fisheries using the Ryder et al. 2006 criteria. For the hard shelled turtles and leatherbacks, expected mortality rates are relatively low (19% and 22% respectively) in shallow-set longline gear. This is due largely to the ability of sea turtles to reach the surface after most hooking/entangling events in shallow-set gear. Recent gear modifications including use of circle hooks and increased awareness of proper handling and release also contribute to minimizing the extent of injuries for turtles caught in Hawaii longline fisheries. As described in the proposed action, most SWFSC surveys involve similarly shallow gear so that any turtle captured/entangled in that gear should be able to reach the surface. In deep-set gear, mortality rates are typically expected to much higher for hard shelled turtles (70%-95%), mostly because the gear (and specifically the hook/gangion) is set too deep to allow for turtles to reach the surface if hooked or entangled. Leatherback mortality rates in deep-set gear are expected to only be slightly higher than in shallow-set gear (36%). Leatherback turtles are more commonly observed entangled in various other portions of the gear such as floatlines, branchlines, and main lines, and not necessarily hooked at deep depths. Also, leatherback turtles have the strength necessary to carry substantial segments of attached gear to the surface where they can breathe until the gear can be retrieved or removed, which significantly increases the chance for survival.. Based on the CPUEs in Table 54, leatherbacks are not commonly captured in deep-set longline fisheries (10X more likely to be observed captured/entangled in shallow-set gear

As discussed previously, the distinctions between SWFSC research longlines and commercial pelagic longlines are also important to consider in terms of assessing potential response of sea turtles captured/entangled in SWFSC longline gear. Although deep-set longlines are part of the proposed action, shallow-set longlines are the most likely source of turtle interactions during SWFSC research activities. Instead of extended soak times of 8 or more hours that are associated with commercial longline fisheries, soak times are expected to be only 2-4 hours in shallow-set longline surveys. This should reduce the potential for drowning or other significant injuries to some degree by ensuring more rapid response to a captured/entangled sea turtle than in normal commercial fishing settings. Due to the lack of historical sea turtle bycatch in SWFSC longline survey trawls, it is not possible to quantify the potential difference in mortality rates for sea turtles caught in survey longlines compared to commercial fisheries, considering all these factors. However, we conclude that direct mortality rates are likely to be reduced due to minimized soak times and the nature of survey operations. Given all this information, we conclude that any sea turtle captured or entangled in SWFSC longline research gear will most likely survive the interaction. However, there is still a chance that any sea turtle could sustain injuries that would make it likely to die, based on the Ryder et al. (2006) criteria (injury classified as 50% or more likely to lead to mortality). While some SWFSC research surveys incorporate circle hooks, which have been shown to minimize the extent of injuries such as ingestion of hooks for some species (see Read 2007 for review), not all SWFSC surveys do so because of target catch performance. Given the available information and the difficulty in relating SWFSC research operations specifically to commercial pelagic longline fishing, we cannot quantify the likelihood of a significant injury for any single turtle capture/entanglement event in SWFSC longline research, which is already difficult to predict given the lack of previous interactions between sea turtles and SWFSC longline gear. However, during SWFSC research, we expect any sea turtle (or marine mammal) interaction to receive full attention and priority handling to minimize the extent of injuries or gear that may remain attached to animals released at all times. Based on the general expectations of relatively low mortality rates for sea turtles captured in shallow-set longline gear (Table 54), which is far more likely to interact with sea turtles than deep-set gear (Table 54), it is most likely that any turtle captured/entangled would not be killed or receive significant injuries. As a result, we expect that the single sea turtle that may be captured each year in a SWFSC longline survey gear will survive.

In summary, we expect that: (1) up to two sea turtles may be captured or entangled in SWFSC research during any year; (2) these two turtles will be released alive and are expected to survive; and (3) these turtles may be from any of the four species discussed in this opinion.

Handling and Sampling

As described in section 1.3.4.4, the handling of any live sea turtles once captured, includes the standard methods consistent with the protocol required for safe sea turtle handling in 50 CFR 223.206(d)(1). If practicable, the SWFSC intends to conduct basic biological data collection and sampling. NMFS routinely authorizes biological sampling of sea turtles captured in directed research that includes tissue sampling, as well as more invasive sampling techniques. Based on the described methods of cleansing and disinfection, infection of the tissue biopsy site would not be expected. At most, we expect turtles would experience brief, minimal discomfort during the process. It is not expected that individual turtles would experience more than short-term stress during tissue sampling. Researchers who examined turtles caught two to three weeks after sample collection noted the sample collection site was almost completely healed. During a more than 5 year period of tissue biopsying using sterile techniques, NMFS researchers encountered no infections or mortality resulting from this procedure (NMFS 2006b). Bjorndal et al. (2010) investigated the effects of repeated skin, blood and scute sampling on juvenile loggerhead growth. Turtles were sampled for each tissue type three times over a 120-day period. The researchers found that repeated sampling had no effect on growth rates; growth rates of sampled turtles were not significantly different from control animals. Turtles exhibited rapid healing at the sampling site with no infection or scarring. Further, all turtles increased in body mass during the study indicating that sampling did not have a negative impact on growth or weight gain. The researchers concluded that the sampling did not adversely impact turtle physiology or health (Bjorndal et al. 2010). Consequently, we believe the impact of collecting tissue samples is minor and will not have any significant effect on any species of sea turtle that may be captured or entangled in SWFSC research gear. The wounds caused by biological sampling (skin, tissue plug and/or subcutaneous fat) would be expected to heal in a few days. In the unlikely event that any sea turtle is killed, we expect the SWFSC will be able to salvage the dead animal or collect parts for return to the SWFSC for further investigation under authorities provided in sections 50 CFR 222.310 and 50 CFR 223.206.

2.6.1.1.2 Eulachon, Southern DPS

Eulachon are found in the northern portion of the CCE along the U.S. west coast in nearshore ocean waters out to 1,000 feet (300 m) in depth. As a result, there is a potential for interaction with SWFSC research survey trawls year-round. Typically, bycatch of eulachon has been associated with commercial fisheries in the Pacific Northwest such as groundfish and pink shrimp trawls that operate at or near the ocean bottom. SWFSC research trawls are generally operated at or near the surface. As a result, the bycatch of eulachon in SWFSC research trawls has been very limited, although it does occur. Across all surveys, the average catch of eulachon each year is < 1 kg per year (DEA). Specifically, from 2006-2010, eulachon catch occurred in the CPS surveys, and only in 2008 (unpublished SWFSC data). In that year, a total of 0.133 kg was caught. While bycatch of eulachon does not appear to be common in SWFSC research trawls on an annual basis, we expect it will periodically occur. In order to be conservative and for the sake of rounding small numbers, we assume that up to 1 kg of eulachon could be captured annually in SWFSC research trawls. This is equivalent to about 25 fish based on an average weight of approximately 40 grams (NMFS 2013b).

The disposition of eulachon that have been incidentally captured in SWFSC trawls has not been previous reported. Bycatch in commercial fishing trawls can lead to injury and death as a result of being crushed in the weight of all the catch being forced into the codend during the tow and subsequent retrieval of the trawl. This is even more likely for small fish such as eulachon. Based on our knowledge of survival of fishes with similar life histories, the marine mortality rate for eulachon could be potentially substantial. For example, the annual mortality rate of adult Pacific herring has been estimated at 50 percent (Hourston and Haegele 1980), and the annual mortality rate of 4- to 5-year-old capelin has been estimated as high as 93 percent (Dommansnes and Røttingen 1985). During SWFSC research, tows are relatively short (30 minutes) and catches are not typically as large as what is expected during commercial fishing. Therefore, it is possible that survival rates, including handling time during sampling, for eulachon captured and returned to the water could be relatively high. However, delayed mortality as a result of injury or increased susceptibility to predation is also possible. Without any means to accurately characterize the response of eulachon in terms of proportional survival, we assume that all captured eulachon would die.

Handling and Sampling

Because we assume that all eulachon will die as a result of incidental capture in survey trawls, there are no additional considerations with the potential fate of any individuals that are not killed and subsequently released alive. The expectation is that the SWFSC will only retain dead eulachon for preservation and subsequent scientific study by the NWFSC, so no additional impacts to eulachon related to sampling activities are considered.

2.6.1.1.3 Scalloped Hammerhead Shark, Eastern DPS

Scalloped hammerhead sharks are found throughout the ETP, and as far north as southern California, usually in or adjacent to relatively shallow waters surrounding continental shelves, reefs, or other bottom features. As indicated above, this species is subject to commercial fisheries catch and bycatch, including pelagic longline gear. To date, no scalloped hammerheads have been captured during SWFSC HMS longline research surveys in the CCE. Even though the CCE is within the known range of the Eastern Pacific DPS, it is the extreme northern end of their range and their presence off California has been only been rarely documented. As a result, we do not expect longline research survey efforts in the CCE to incidentally capture/entangle any scalloped hammerhead sharks.

As part of the proposed action, the SWFSC is planning on conducting research surveys for HMS using longline gear in the ETP. Based on what is known about scalloped hammerheads and risks of catch/bycatch in the ETP previously described in this opinion, the risks of encounters and subsequent hooking or entanglement with Eastern Pacific DPS scalloped hammerhead sharks is expected to be higher in the ETP. It is also possible that the unlisted (under the ESA) Central Pacific DPS population could be present and encountered by SWFSC HMS research longline surveys, depending on exactly where these surveys occur. At this time, it is not possible to pinpoint any exact locations for where this activity may occur, so it is not possible to precisely characterize the risks of interactions between either scalloped hammerhead DPS with SWFSC research gear. Generally speaking, we expect SWFSC HMS surveys to occur in oceanic waters on the high seas, although permission may be obtained from foreign governments to conduct research inside their EEZs. Although we consider the risks of incidental scalloped hammerhead capture/entanglement minimal given the limited extent of SWFSC research survey effort in the ETP that has been proposed, we cannot discount the possibility that this may occur, especially considering that HMS surveys are designed to catch sharks.

In order to determine the possible extent of scalloped hammerhead bycatch in ETP surveys, we looked to available information regarding scalloped head bycatch rates in Hawaii commercial longline fisheries. While not directly comparable in terms of potential effort locations and gear configurations, Hawaii longline fisheries do extend into the western boundaries ETP, and the data come from fishery observers. There is the best information that we have, as observer data from international longline fisheries generally do not generally exist or are not available. More typically, international fisheries data rely upon landed catch totals without reference to effort data. In general, we consider pelagic longline fisheries data to be fairly representative of the relative risk of scalloped hammerhead interactions of the pelagic HMS surveys planned by the SWFSC, as opposed to any coastal longline fisheries that may operate in waters where scalloped hammerhead density may be significantly higher.

Looking at available observer data from Hawaii described in section 2.5.2.2, a total of 56 scalloped hammerheads have observed captured in over 26,500 sets observed in both the shallow and deep-set Hawaii longline fisheries. Assuming a general average of about 1000 hooks per set, we can calculate the observed CPUE, by numbers of hooks set (Table 56). Using this information, we can apply the CPUE to the maximum expected number of hooks that the SWFSC may set in the ETP per year to predict the number of scalloped hammerheads that may be encountered by SWFSC HMS longline research gear (Table 56).

Table 56. Predicted annual scalloped hammerhead interactions in SWFSC ETP HMS longline surveys using Hawaii longline observer data.

	observed scalloped hammerheads	total sets	estimated total hooks (1000/set)	CPUE/hook
HI longline	56	26,507	26,507,000	0.000002
	predicted scalloped hammerheads per year		estimated total hooks at 400/set	
ETP survey	0.048	60	24,000	0.000002

The result using general assumptions about longline bycatch rates for scalloped hammerheads in longline gear is an estimated 0.05 scalloped hammerhead sharks may be captured/entangled each year in SWFSC HMS research surveys. As discussed in section 2.6.1.1.1, SWFSC longline survey gear is not directly comparable with commercial longline fishing gear and catch rates of species would expected to be less given reduced soak times for research surveys compared to commercial gear. However, available data does support the conclusion that the interaction rate of scalloped hammerheads with longline survey gear is expected to be low during proposed surveys. In order to be conservative and for the sake of rounding small numbers, we expect that up to one scalloped hammerhead may be incidentally captured or entangled during any year when HMS longline surveys occur in the ETP.

The expected mortality rate for scalloped hammerheads captured/entangled in longline gear is relatively high. Some species of sharks, including scalloped hammerheads, are considered obligate ram ventilators, relying on constant movement to force oxygenated water over their gills (Carlson et al. 2004). Capture in longline fisheries can restrict their movement which can effectively lead to drowning for ram ventilating species. The direct observed mortality rate for scalloped hammerhead has been documented at over 90% in a shark fishery on the U.S. east coast (Morgan and Burgess 2007), although this fishery was a bottom longline fishery targeting sharks as opposed to a pelagic longline fishery. In that study, soak time duration was shown to be significant factor influencing survival rates (Morgan and Burgess 2007). As discussed previously, SWSC longline surveys are typically shorter than commercial longline fishery soak times, and survival rates for scalloped hammerhead sharks may be higher than what has been documented in bottom longline commercial fisheries. However, given the sensitivity of ram ventilating sharks to being captured in gear, we believe it is likely that mortality rates would be relatively high. As a result, we assume that the one scalloped hammerhead that may be caught annually in SWFSC longline survey gear would be killed.

Handling and Sampling

Because we assume that any scalloped hammerhead captured or entangled in SWFSC longline gear will die as a result of this interaction, there are no additional considerations with the potential fate of any individuals that may be released alive.

2.6.1.1.4 Salmonids

Salmonids are found in nearshore and oceanic waters of the CCE along the U.S. west coast overlapping with much of SWFSC's survey trawl research. While the specific oceanic distributions of salmonid ESUs listed under the ESA are not well understood outside the bounds of ocean fisheries catch and coded wire tag data, generally Chinook, coho, chum, sockeye, and steelhead salmon are known to be widely distributed throughout the northern Pacific. Based on the general life cycle of all salmon, it can be inferred that the likelihood of encountering any specific ESU increases in nearshore coastal waters during the time of year when adult fish are maturing and preparing to return to those origins of spawning, typically distinguished by run timing (e.g., spring or fall), or when juveniles have just recently entered the ocean to begin their maturation process.

Incidental capture in SWFSC survey trawls

Historically, SWFSC research surveys have incidentally captured salmonids during survey trawling in the CCE. Chinook and coho are the species that are most commonly identified, although chum, sockeye, and steelhead salmon have also been observed in SWFSC research trawls. Information describing the incidental capture of salmonids during recent SWFSC trawl surveys has been provided in the DEA, as well as in supplemental information provided by the SWFSC during this consultation. The following tables describe the salmonid bycatch in juvenile rockfish and CPS research trawls in recent years.

Table 57. Total number of individual salmon incidentally taken during SWFSC juvenile rockfish surveys conducted off the US west coast 2007-2011.

Year	salmon*
2007	3
2008	0
2009	2
2010	0
2011	0
Total	5

* salmon not identified to species

Table 58. Total number and estimated weight (kg) of fish caught during annual CPS surveys conducted by the SWFSC 2008-2012.*

	All Years		2008		2009		2010		2011		2012	
Species	#	weight	#	weight	#	weight	#	weight	#	weight	#	weight
All Salmon	142	230.8	0	0.0	0	0	0	0.0	0	0.0	0	0.0

Chum	3	3.3	2	1.0	0	0	0	0.0	0	0.0	1	2.3
Coho	60	131.0	50	110.0	0	0	0	0.0	0	0.0	10	21.0
Steelhead	1	0.3	0	0.0	1	0.3	0	0.0	0	0.0	0	0.0
Chinook	73	95.2	48	67.2	0	0	3	6.0	0	0.0	22	22.0
Unknown	5	1.0	0	0.0	0	0	0	0.0	0	0.0	5	1.0

* In general, these catches occurred within 50 nm of the US west coast.

In the DEA, the SWFSC describes the amount of salmon that have been captured during juvenile salmon surveys as part of the total amount of salmon biomass that could be considered "removed," largely because individuals captured in that survey are sacrificed for genetic analysis and stock identification. As described in the proposed action, those impacts are as a result of directed scientific research authorized under a section 10 ESA permit. In this opinion, we will consider the total impact of all salmon capture during survey trawls, although we must delineate between take that occurs incidental to other activities and take that occurs as a result of directed research. The total amount of incidental salmon catch, as well as the amount of incidental catch by species, varies significantly by year. Chinook and coho salmon are more regularly documented captured by SWFSC research gear than other salmon species, which is generally consistent with what could be expected based on U.S. west coast salmon abundances in the portion of the CCE where SWFSC research occurs. In addition to the information provided in Table 58, 0.015 kg of sockeye (presumably one juvenile fish) was reported caught in CPS survey in 2008 by the SWFSC.

In order to estimate the amount of incidental salmon bycatch that may occur during future SWFSC research cruises, we examine the record of incidental salmon bycatch provided above. In 2008, the CPS survey took 50 Chinook and 48 coho. These are the largest annual totals for each species by considerable margins, including several years of recent SWFSC research where no Chinook or coho were incidentally captured. The maximum amount of chum, sockeye, and steelhead that have been recorded during any year of recent CPS surveys is 2, 1, and 1, respectively. The juvenile rockfish survey has recorded as many as 3 salmon incidentally captured in a year, although the species was not identified. Although it is likely those unidentified salmon were Chinook or coho, based on what can be generally expected in terms of encounters with salmonid species along the U.S. west coast, it is possible that some or all of those salmon could have been chum, sockeye, or steelhead. As a result, we will assume those 3 salmon could have belonged to any salmonid species. Using these worst case scenarios, we estimate the maximum amount of salmon incidental capture that can be expected across all SWFSC research cruises that are not engaged in directed salmonid research (Table 59).

Table 59. Maximum number of individuals that may be incidentally captured by SWFSC research surveys during any year.

	Total	sub-adult	juvenile
Chinook	53	48	5
chum	5	5[1]	5[1]

coho	51	26[2]	26[2]
sockeye	4	4[1]	4[1]
steelhead	4	4[1]	4[1]

[1] It is possible that all individuals could be either sub-adults or juveniles.
[2] Rounding up from 25.5.

The ESA section 10 permit distinguishes between potential mortality for sub-adults, although all juveniles are presumed killed because of sampling and collection protocols during the juvenile salmon survey. For incidental take in non-salmon surveys, we can't readily distinguish between the proportion of individuals that were juveniles and sub-adults in recent SWFSC surveys based on the information provided. In a 2008 consultation on the sardine survey, NMFS concluded that Chinook catch was expected to be mostly juvenile (90%), but that coho catch was expected to be approximately 50% juvenile-to-sub-adult (NMFS 2008b). Without any new information readily available, we will continue to rely upon those assumptions about the expected age classes of salmonids that will be incidentally capture in SWFSC research based on data that was available previously. As a result, we expect that 90% of Chinook that may be incidentally captured by SWFSC research surveys, or 48 individuals, will be juveniles, and that 10% (5 individuals) will be sub-adults. For coho, we expect 26 individuals that may be incidentally captured by SWFSC research surveys will be juveniles, and 26 will be sub adults (Table 59). For chum, sockeye, and steelhead, the amount of incidental capture historically is so low and infrequent that there is limited ability to predict what may occur in the future. At this time, we assume that any individuals could be a juvenile or sub-adult. For the purposes of this opinion, we will consider the worst case scenario that all individuals from these species will be sub-adults, since sub-adults are more likely to contribute to spawning potential in the near future, although we acknowledge that any chum, sockeye, or steelhead incidentally captured could also be all juveniles, or some combination of both, as well.

Based upon anecdotal reports from past surveys, juvenile and yearling salmon are often observed dead while sub-adult salmon that have been incidentally captured during SWFSC survey trawl operations are often alive when retrieved from the net and can be successfully returned to the water (NMFS 2008b). For fish released live, it is well known that injuries and stress such as abrasions, internal crushing, loss of scales, and physical exhaustion can occur to fish during the capture process. These injuries have the potential to lead to delayed mortality for bycatch discards as a result of the damage, or through impaired behavior leading to increased probability of predation (Davis 2002; Ryer 2004; Ryer et al. 2004). Little data currently exists that can accurately quantify the discard mortality of most species in any fishery or research trawl setting. It is clear from what work has been done that many factors related to the environmental conditions and the biology of certain fish species play a role (Davis 2002; Ryer 2004; Ryer et al. 2004). The relatively short duration of the tow time (30 minutes), and the relatively small amount of catch typically seen in previous surveys should help minimize the level of stress and injury induced on captured salmon by the proposed action. However, some amount of delayed mortality cannot be eliminated. Previously, NMFS has consulted on salmon bycatch that occurs in CPS trawl surveys conducted by SWFC, and assumed for analytical purposes that all salmon incidentally captured in those surveys may be killed (NMFS 2008b). Without any way to more accurately characterize the relative survival that could be expected during incidental capture at this time, we will assume that mortality would occur for all salmon incidentally captured in the SWFSC survey trawls.

Given the expected numbers of salmon for each species that may be incidentally captured in SWFSC research survey trawls each year, we consider how these incidental captures may be spread out among the various ESA-listed ESUs and DPS throughout the CCE. Based upon 30 years of collecting and analyzing CWTs, salmon that are born north of Cape Falcon, OR are believed to travel north during their marine life stages. Salmon born south of Cape Falcon generally remain in the coastal waters off southern Oregon and California (Weitkamp and Neely 2002; Weitkamp 2010). All of the Columbia River and Puget Sound ESUs analyzed in this BO are generally found in the marine waters off the Columbia River or farther north. Sockeye and chum stocks are also generally understood to travel north in marine waters, as encounters with those species are more common in marine fisheries (both incidental or directed salmon fisheries) in areas further north. Steelhead stock distributions in marine waters remains largely unknown, with only the most general assumption that any steelhead found in coastal marine waters is probably more likely associated with neighboring DPS origins.

In addition to the relative uncertainty about how salmon distribute in the ocean, especially during the course of a year, we do not have enough information to pinpoint exactly where salmon will be incidentally captured in SWFSC research survey trawls. At this time, we assume that salmon may be captured anywhere throughout the CCE where salmon and SWFSC trawl surveys may co-occur; effectively from the U.S.-Canadian border south to the Mexican border, although salmon are rarely encountered in marine waters south of Point Conception. At this time, there is no full-scale CCE model that can provide a reliable estimate of the relative proportions of ESUs that may constitute CCE salmon (Chinook and coho) populations, across the year or at any given time. The available information suggests that there are differences between the stock compositions between the northern and southern marine waters off the U.S. coast. Recent information collected from ocean salmon fisheries using Genetic Stock Identification (GSI) techniques also highlight how dynamic the stock composition within any given area, at least in terms of CPUE in fisheries, may be as the year progresses (e.g., Satterthwaite et al. 2014). Given that salmon are not inherently distributed equally throughout the CCE, we look to find some information that can be used the characterize the worst case scenarios where the proportions of any ESA-listed salmon ESU may be highest (either in the southern or northern portions of the CCE) to estimate the proportion of the salmon that may be incidentally captured which may belong to ESA-listed ESUs.

In order to understand the possible proportions of ESA-listed ESUs that may be incidentally captured, we look at two sources of information regarding relative stock compositions of Chinook and coho in both the southern and northern portions of the CCE. In the southern area (off California and southern Oregon), we use the stock compositions from salmon captured in the SWFSC juvenile salmon survey, derived from GSI data used to generate the directed section 10 permit take application for this survey discussed in this opinion. In the northern area (off northern Oregon and Washington), we use information describing the stock compositions of Chinook and coho bycatch in marine waters off the sardine fishery conducted off Oregon and Washington, based on information derived from the Fisheries Regulation Assessment Model (FRAM) used to help manage salmon ocean fisheries (NMFS 2010b).[32] For salmon bycatch in the sardine fishery, the stock composition proportions presented here represent 5-year averages within the northern area as tabulated by FRAM. Table 60 illustrates the relative stock composition proportions for ESA-listed ESU in two different CCE areas based on these two data sources, as way to assess possible stock composition proportions of Chinook and coho incidentally captured in SWFSC research survey trawls.

Table 60. Stock compositions of Chinook and coho in SWFSC juvenile salmon surveys and sardine fishery, used to represent possible stock composition proportions of salmon incidentally capture by SWFSC research survey trawls in southern and northern marine waters respectively.

	Stock Composition Proportions	
	SWFC Salmon Survey (southern area)	Sardine Fishery Bycatch (northern area)
ESA-listed Chinook		
Sacramento River winter-run	0.003	0.000
Central Valley spring-run	0.030	0.000
California coastal	0.040	0.000
Snake River fall	0.002	0.003
Snake River spring/summer	0.000	0.000
Lower Columbia River	0.003	0.063
Upper Willamette River	0.001	0.041
Upper Columbia River spring	0.001	0.000
Puget Sound	0.001	0.033
ESA-listed coho		
Central California coast	0.124	0.000
S. Oregon/N. California coast	0.559	0.000
Oregon Coast	0.253	0.540
Lower Columbia River	0.065	0.482
Non-listed Chinook		
Central Valley Fall/Late Fall	0.920	0.270

[32] The stock composition of salmon bycatch in the sardine fishery presented here were derived by looking at the stock composition in two fishing areas (defined as Area 1 and Area 2 in FRAM) and selecting the higher proportion for each stock to represent the worst case scenario of highest proportion that may be expected. See Table 19 in NMFS 2010b for more details.

Non-listed Columbia River	0.000	0.662

In order to characterize the worst case scenario where the proportional incidental take of any ESA-listed ESU may be highest during SWFSC research, we apply to the total expected take of juvenile and sub-adult Chinook and coho each year and generate take estimates for each ESA-ESU using the higher of the possible stock composition proportions from either the southern or northern area. For example, in the southern area, CVS Chinook may constitute 3% of all Chinook incidentally captured. In northern areas, this ESU is not expected to constitute any measurable proportion of Chinook that are incidentally captured. Therefore, we assume that at most CVS may constitute 3% of Chinook captured anywhere in the CCE. Table 61 describes the results for estimating how many individuals may be incidentally captured by the SWFSC for each ESA-listed ESU, by age class, using the higher stock composition proportion as a maximum. It is important to note that stock composition proportions and total Chinook and coho numbers do not add up to the 53 Chinook and 51 coho we expect that the SWFSC may encounter in total, as non-listed populations would be expected to constitute the majority of Chinook populations, as well as at least some portion of coho populations, and here we are estimating the maximum possible extent of take for each ESU depending on exactly where these salmon may be encountered. For simplification, all decimals have been rounded up. For ESA-listed ESUs that do not constitute a measureable proportion in either the southern or northern area using this analysis, we conservatively assume that it is possible that at least 1 individual could be incidentally captured (either juvenile or adult). While ESA-listed ESUs are generally composed of natural and hatchery individuals, we conservatively assume that all individuals that may be captured by SWFSC research surveys could be natural origin fish.

Table 61. Estimated maximum number of sub-adult and juvenile Chinook and coho that may be incidentally captured each year by SWFSC research, by species.

	Maximum Stock Composition Proportions	Stock Composition of SWFSC Incidental Capture – 5 Sub-adults and 48 Juveniles			
ESA-listed Chinook		sub-adult	juvenile	sub-adult	juvenile
Sacramento River winter-run	0.003	0.02	0.14	1	1
Central Valley spring-run	0.030	0.15	1.44	1	1
California coastal	0.040	0.20	1.92	1	2
Snake River fall	0.003	0.02	0.14	1	1
Snake River spring/summer	0.000	0.00	0.00	1	1
Lower Columbia River	0.063	0.32	3.02	1	4
Upper Willamette River	0.041	0.21	1.97	1	2
Upper Columbia River spring	0.001	0.01	0.05	1	1
Puget Sound	0.033	0.17	1.58	1	2
ESA-listed coho		Stock Composition of SWFSC Incidental Capture – 26 Sub-adults and 26 Juveniles			
Central California Coast	0.124	3.21	3.21	4	4
S. Oregon/N. California Coast	0.559	14.53	14.53	15	15
Oregon Coast	0.540	14.04	14.04	15	15
Lower Columbia River	0.482	12.53	12.53	13	13

For sockeye, chum, and steelhead, we do not have enough information to determine the likely stock composition or population origin for any individuals that may be incidentally captured by SWFSC research survey trawls. As a result, we assume all individuals could be from any ESU/DPS (Table 62).

Table 62. Estimated maximum number of sub-adult and juvenile chum, sockeye, and steelhead that may be incidentally captured by SWFSC research, by species.

ESA-listed ESU	SWFSC Incidental Capture		
	Total[1]	sub-adult	juvenile
Hood Canal summer run chum	5	5	5
Columbia River chum	5	5	5
Snake River sockeye	4	4	4
Ozette Lake sockeye	4	4	4
Southern California steelhead	4	4	4
South-Central California steelhead	4	4	4
Central California Coast steelhead	4	4	4
California Central Valley steelhead	4	4	4
Northern California steelhead	4	4	4
Upper Columbia River steelhead	4	4	4
Snake River Basin steelhead	4	4	4
Lower Columbia River steelhead	4	4	4
Upper Willamette River steelhead	4	4	4
Middle Columbia River steelhead	4	4	4
Puget Sound steelhead	4	4	4

[1] Total reflects the possibility that takes could be all sub-adult, all juvenile, or some combination of both.

Directed capture in SWFSC Juvenile Salmon Survey

The proposed SWFSC juvenile salmon survey includes the direct capture take of ESA-listed salmonids via survey trawling and possibly also beach seining. Because the research activities occur exclusively at sea, spatially separated from salmonid critical habitat designated under the ESA, the proposed research activities would have no measurable effects on ESA-listed salmonid habitat. The actions are therefore not likely to jeopardize any of the listed salmonids by reducing the ability of that habitat to contribute to their survival and recovery.

The primary effect of the proposed research would be on the listed species in the form of capturing and handling the fish, collecting tissue samples, and intentional mortality. Capturing, handling, tissue sampling, and releasing fish generally leads to stress and other minor effects that are difficult to assess in terms of their impact on individuals, let alone entire species. In most cases, fish fully recover rapidly from brief instances of capture and handling..

Table 3 in section 1.3.3 describes the amount of directed take on ESA-listed salmonids that has been proposed by the SWFSC, by ESU/DPS, life stage origin, and take action. The following subsections describe the types of activities being proposed. The activities would be carried out by trained professionals using established protocols. The effects of the activities are well documented and discussed in detail below. The opinion includes NMFS' pre-established set of mitigation measures outlined in the proposed action. These measures are incorporated into project approval as part of the conditions to which the- researcher must adhere.

Trawls

Trawls are cone-shaped, mesh nets that are towed, typically, along benthic habitat (Hayes 1983; Hayes et al. 1996). Rectangular doors, attached to the towing cables, keep the mouth of the trawl open. Most trawls are towed behind a boat, but small trawls can be operated by hand. As fish enter the trawl, they tire and fall into the codend. 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. 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. (Hayes 1983; Stickney 1983; Hayes et al. 1996).

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. Although researchers have clipped all fins at one time or another, the current preference is to clip the adipose, pelvic, or pectoral fins. In section 10(a)(1)(A) permit 19320, a fin clip smaller than 25 mm^2 will be removed from either lobe of the caudal fin, in addition to having three to five scales removed from the mid-dorsal region. Many studies have examined the effects of fin clips on fish growth, survival, and behavior. The results of these studies are somewhat varied; however, it can be said that fin clips do not generally alter fish growth. Studies comparing the growth of clipped and unclipped fish generally have shown no differences between them (e.g., Brynildson and Brynildson 1967). Moreover, wounds caused by fin clipping usually heal quickly—especially those caused by partial clips.

Mortality among fin-clipped fish is also variable. Some immediate mortality may occur during the marking process, especially if fish have been handled extensively for other purposes (e.g., stomach sampling). Delayed mortality depends, at least in part, on fish size; small fishes have often been found to be susceptible to it and Coble (1967) suggested that fish shorter than 90 millimeters are at particular risk. The degree of mortality among individual fishes also depends on which fin is clipped. Studies show that adipose- and pelvic-fin-clipped coho salmon fingerlings have a 100 percent recovery rate (Stolte 1973). Recovery rates are generally recognized as being higher for adipose- and pelvic-fin-clipped fish in comparison to those that are clipped on the pectoral, dorsal, and anal fins (Nicola and Cordone 1973).

Sacrifice

In many instances for the proposed section 10 permit, it is necessary to kill a captured fish in order to gather the data the study is designed to produce. In such cases, determining effect is a very straightforward process: the sacrificed fish are forever removed from the gene pool.

2.6.1.2 Vessel Collisions

Collisions of ships and marine animals can cause major wounds, which may lead to the death of the animal. An animal at the surface could be struck directly by a vessel, a surfacing animal could hit the bottom of a vessel, or an animal just below the surface could be cut by a vessel's propeller. The severity of injuries typically depends on the size and speed of the vessel (Knowlton and Kraus 2001; Laist et al. 2001; Vanderlaan and Taggart 2007).

2.6.1.2.1 Sea Turtles

Collisions between SWFSC research vessels and sea turtles are possible since turtles must come to the surface to breathe, and may spend time resting or foraging near the surface. Along the U.S west coast, strandings believed to be associated with vessel strikes are one of the most common sources of sea turtle strandings[33] (LeRoux et al. 2011; Figure 7). Whether these strikes are associated more commonly with larger vessels more similar to SWFSC research vessels or smaller vessels used for recreation or other purposes is unknown. To date, the SWFSC has not reported any incidents of sea turtle vessel strikes during their research cruises, although it is possible that vessel strikes with sea turtles could occur undetected. During all research cruises, the SWFSC maintains constant watch and will slow down or take evasive maneuvers to avoid collisions with marine species such as sea turtles and marine mammals (see 2.2.1.1.2 for analysis of marine mammal collisions). The officer on watch, Chief Scientist (or other designated member of the Scientific Party), and crew standing watch on the bridge visually scan for marine mammals, sea turtles, and other ESA-listed species (protected species) during all daytime operations. Bridge binoculars (7X) are used as necessary to survey the area as far as environmental conditions (lighting, sea state, precipitation, fog, etc.) will allow. SWFSC research vessels operational speed is typically relatively slow; 4 knots or less during operations and approximately 10 knots while cruising under transit. At any time during a survey or in

[33] Approximately 30 instances of sea turtle strandings of all species associated with vessel collisions documented along the U.S. west coast from 1957-2009; Figure 6).

transit, any crew member that sights any protected species that may intersect with the vessel course immediately communicates their presence to the bridge for appropriate course alteration or speed reduction as possible to avoid incidental collisions. Consequently, if a sea turtle is observed, SWFSC research vessels will slow down or otherwise take evasive action to avoid collisions. Given the lack of any historical information suggesting SWFSC research vessels present any particular risk of sea turtle strikes and efforts to avoid turtles while conducting research or in transit, the risks of vessel collisions for sea turtles during SWFSC research activities are remote.

2.6.1.2.2 Marine Fish and Salmonids

Vessel collision is not known to be significant threat to species of marine fish, including salmonids, eulachon, and scalloped hammerhead sharks. While collisions are possible at/near the surface, it is likely that most fish are either somewhere in the water column below vessels or are readily able to avoid vessels with evasive swimming maneuvers. The lateral line system of fishes likely contributes to their ability to detect the presence of oncoming vessels through changes in water pressure. Without any further information suggesting that marine fish are subject to vessel collisions, we assume these are unlikely events for marine fish.

2.6.1.3 Exposure to Noise

Noise is generally thought of as any sound that is undesirable because it interferes with communication, is intense enough to damage hearing, diminishes the quality of the environment, or is otherwise annoying. As one of the potential stressors to marine species, noise and acoustic influences may seriously disrupt communication, navigational ability, and social patterns. Many marine animals use sound to communicate, navigate, locate prey, and sense their environment. Estimating sound exposures potentially leading to behavioral and physical effects as a result of intermittent high frequency sounds from active acoustic devices used in fisheries research is challenging for a variety of reasons. Among these is the wide variety of operating characteristics of these devices, variability in sound propagation conditions throughout the typically large areas in which they are operated, uneven (and often poorly understood) distribution of marine species, differential (and often poorly understood) hearing capabilities in marine species, and the uncertainty in the potential for effects from different acoustic systems on different species.

As part of the proposed action and in support of the MMPA LOA application and DEA, the SWFSC characterized the acoustic footprint of SWFSC research activities as a result of use of active acoustic devices for oceanographic and biological sampling purposes (see section 1.3.1.4.6 for description of acoustic sources) in order to assess the potential injury or MMPA harassment of marine mammals as defined by the MMPA resulting from use of these acoustic sources. This opinion considers the potential impact of these active acoustic sources on all ESA-listed species that may be found in the vast proposed action area covered by SWFSC research vessels. Our analysis of likely impacts as a result of this stressor concluded that active acoustic devices used by the SWFSC were not likely to adversely affect ESA-listed marine mammals (see section 2.2.1.1.3). Because the analyses conducted by the SWFSC are most linked to impacts on marine mammals, section 2.2.1.1.3 contains a more complete description of the how the acoustic footprint was analyzed by the SWFSC in reference to potential for adverse effects to marine mammals.

2.6.1.3.1 Sea Turtles

Unlike for marine mammals, NMFS has yet to establish specific noise criteria for sea turtles exposure to underwater sound relative to potential injury or temporary loss of hearing. While the number of published studies on the impacts of sound on sea turtles is small, the available data does suggest that sea turtles have better hearing at low frequencies (≤ 1000 Hz) (Ridgeway et al. 1969; Lenhardt 1994; Bartol and Ketten 2003; Martin et al. 2012; Dow-Piniak et al. 2012). As a result, active acoustic sources used by the SWFSC during research activity are not expected to be detectable by any species of sea turtles, and no effects from high frequency sound use are anticipated (see sections 1.3.1.4.6 and 2.2.1.1.3 for details on the frequencies of SWFSC active acoustics, which are in generally in excess of 20 kHz). Given the relative low frequencies of vessel noise, it is likely that sea turtles can detect the presence of passing vessels, which produce low frequency sounds (see section 2.2.1.1.3.5 for more information). However, we do not expect any discernable effects from a short duration exposure to a vessel in transit or temporarily located in an area for only a matter of hours at most.

2.6.1.3.2 Marine Fish and Salmonids

Fish react to underwater sounds that are especially strong and/or intermittent low frequency sounds. Short duration, sharp sounds can cause overt or subtle changes in fish behavior and local distribution. Hastings and Popper (2005) identified several studies that suggest fish may relocate to avoid certain areas of sound energy. Additional studies have documented effects of sounds on fish, although several are based on studies of lower frequency sound in support of large multi-year bridge construction projects (e.g., Scholik and Yan 2001, 2002; Popper and Hastings 2009) compared to the relative high frequency active acoustic sources used by the SWFSC. Sound pulses at received levels of 160 dB re 1 μPa may cause subtle changes in fish behavior. Sound pressure levels of 180 dB re 1 μPa may cause noticeable changes in behavior (Pearson et al. 1992; Skalski et al. 1992), and sound pressure levels of sufficient strength have been known to cause injury to fish and fish mortality. If there is any detection of loud sounds by fish, the most likely reaction would be temporary behavioral avoidance of the area.

Sonars and other active acoustic sources used by the SWFSC are generally operated at frequencies well above the hearing ranges of most fishes and invertebrates, with the exception of some clupeid fishes, including shads and menhaden, which can detect and respond to ultrasonic frequencies (see Popper 2008; Hawkins et al. 2014 for review). Hearing thresholds have been determined for about 100 living fish species. These studies show that, with few exceptions, fish cannot hear sounds above about 3-4 kHz, and that the majority of species are only able to detect sounds to 1 kHz or even below. The hearing capability of Atlantic salmon (*Salmo salar*) indicates relatively poor sensitivity to sound (Hawkins and Johnstone 1978). Laboratory experiments yielded responses only up to 580 Hz and only at high sound levels. The Atlantic salmon is considered to be a hearing generalist, and this is probably the case for all other salmonids studied to date based on studies of hearing (see Popper 2008 for review). The hearing ranges for other species of ESA-listed fish species that may be exposed to active acoustic sources used by the SWFSC (eulachon, green sturgeon, totoaba, and scalloped hammerhead sharks) has not been described, but generally speaking we do not expect these species are able to detect high frequency sound from active acoustic sources used during SWFSC research. One possible exception could be eulachon, given the general similarity as a small, schooling fish commonly preyed upon by echolocating marine mammals, with some clupeid species that apparently can detect high frequency sound. While the hearing capabilities of eulachon is uncertain, even if high frequency hearing exists for them, the most likely impact of temporary exposure to high frequency active sources is temporary disturbance that will not result in any significant impact to the health of the individuals.

Given that ESA-listed fish all have low frequency hearing ranges, we expect they would be able to detect the presence of SWFSC research vessels, at least to some degree. There have been some investigations into the impact of low frequency sounds, typically associated with high intensity activities (and low frequency) such as pile-driving and explosives. In general, results indicate that with the possible exception of very loud sources (sound levels well in excess of 200 dB re µPa) only fish with swim bladders and that are located very near impulsive sources for extended periods of time are likely to be injured (see Popper et al. 2014 for review). The sound pressure levels produced by SWFSC research vessels would in all cases be substantially lower than what might cause injuries (see section 2.2.1.1.3 for more information). As a result, we do not expect that any sounds produced by active acoustic sources or vessel noise will affect any ESA-listed or candidate fish species in any way that will decrease their fitness or impact their survival.

2.6.1.4 Prey reductions

SWFSC research surveys, primarily use of trawl gear, results in the capture of many species of fish and invertebrates that are sources of prey for ESA-listed species. Longline surveys typically encounter large pelagic or benthic species such as HMS sharks, swordfish, or sablefish, that are not likely to be common prey items for the ESA-listed species considered in this opinion. Table 63 below describes the average annual catch of some potential important prey for ESA-listed and relative totals for all SWFSC research activities (including the juvenile salmon survey) in comparison to any allowable catch levels in U.S. west coast fisheries. Virtually all of these catches are associated with trawl activities.

Table 63. Average annual catch of potential forage species for ESA-listed species from all surveys from 2007-2011 (DEA). Allowable biological catch (ABC) in commercial fisheries, along with the proportion of ABC that corresponds to SWFSC totals is also described.

Fish	Average annual total catch (kg)	ABC commercial catch (metric tons)	SWFSC percentage of ABC
Jack mackerel	392	31,000	<0.0001%
Jacksmelt	330	N/A	N/A
Northern anchovy	1,201	34,750	<0.0001%
Pacific hake (whiting)	1,045	2 million	<0.0001%
Pacific mackerel	7,534	42,375	0.0002
Pacific sardine	1,564	84,681	0.0002
Shortbelly rockfish	412	23,500	<0.0001%
Yellowtail rockfish	117	4,320	<0.0001%
Invertebrates			
Market Squid	470	N/A	N/A
Humboldt squid	80	N/A	N/A
Euphausiid (krill)	991	N/A	N/A
Sea nettle jellyfish	18,473	N/A	N/A
Moon jellyfish	2,623	N/A	N/A
Fried-egg jellyfish	33	N/A	N/A
Unidentified salp	24	N/A	N/A

The specific diets of sea turtles do vary by species and life stage, although jellyfish and other invertebrates may be significant sources of food during pelagic life stages, especially for leatherbacks (see section 2.2.5.3 for analysis of leatherback critical habitat). Eulachon and salmonids likely feed on invertebrates such as krill in the ocean, and salmonids likely also feed on small forage fish such as sardines and anchovies as they mature. Scalloped hammerhead sharks also feed on fish such as sardines and mackerel, although they may consume a wide variety of fishes or large invertebrates especially as they mature. However, almost all the largest prey removals come from the CCE during trawl surveys which does not overlap much with the expected distribution of scalloped hammerheads. Although total biomass of many of these species may be difficult to estimate over the entire project area, it does appear that SWFSC removals (assuming mortality to all of the individuals captured in survey trawls), is a very small fraction of the allowable harvest levels where established (0.0002% or less). The impact of these small levels of prey removal will not be detectable among the total biomass in the CCE area for species commonly occurring in SWFSC research trawls such as mackerel and sardines.

The average annual research catch of Pacific sardines in SWFSC surveys (1,564 kg, or 1.5 metric tons (mt)) is a very small fraction of the total estimated biomass along the west coast from British Columbia south to Baja, Mexico, which was recently estimated at 97,000 mt (Hill et al. 2015). The 2015 estimate represents a very low total biomass estimate historically, where the mt biomass of sardines is typically estimated in the millions. The 2015 biomass estimate is likely low enough to prevent any directed harvest during 2015. Both the total biomass and allowable harvest rates of sardine are expected to fluctuate, and the small levels of prey removals associated with SWFSC research will be undetectable among the total biomass and the commercial harvest for sardines. The average annual catch of anchovies in the course of all the SWFSC research surveys in the past five years is about 1.2 mt. Biomass estimates are not available for this species but the overfishing level has been set at 139,000 mt and commercial harvests off the U.S. Pacific coast average about 2,100 mt per year (2010 data; Hill et al. 2011). For jack mackerel, average combined SWFSC research catch (0.39 mt) compares to an overfishing level of 126,000 mt and recent commercial harvests of about 309 mt (2010 data; Hill et al. 2011). There are other species of fish and invertebrates captured in lesser amounts during research surveys that might be used as prey by ESA-listed species to some degree, but, as exemplified by these three species that are commonly captured and are common prey items, the proportions of research catch compared to overall biomass and when added to other sources of prey removal such as commercial harvest is very small.

In addition the relative low levels of total magnitude of prey removals from SWFSC research minimizing the impact on ESA-listed species, the nature of SWFSC research typically moving from station to station spreads out small prey removals across large areas of the project area over extended periods of time as opposed to concentrating them in certain areas/times where localized prey depletions which could potentially lead to adverse effects on foraging efficiency or nutritional deficiencies for individuals. Models sophisticated enough to combine information on the relative effects of varying prey densities, foraging efficiency, and nutritional needs at an individual or population level for these ESA-listed species do not exist. However, we do not expect that small prey removals spread out across large areas in space and time is likely to significantly affect the fitness or survival of any ESA-listed species considered in this opinion. Additional consideration of prey removals on ESA-listed species and designated critical habitats within the action area can be found in section 2.2.

2.6.1.5 Effect of Issuing the MMPA LOA and ESA Section 10 Permit

In this opinion, we are considering the potential effects of issuing a LOA under the MMPA which authorizes the incidental injury, mortality and harassment of marine mammals resulting from the SWFSC research activities. Associated with the proposed LOA, the SWFSC is required to implement measures to minimize impacts to marine mammals, including use of MMEDs and other protocols for avoiding interactions where feasible. These measures are incorporated into the proposed action and are described in section 1.3.4. In addition, the LOA requires monitoring and reporting of marine mammal takes. We do not expect issuance of the LOA to lead to any impacts on ESA-listed species that have not already been described above in section 2.2 or 2.6.1 in this opinion.

Issuance of the ESA section 10 permit formalizes protocols for handling and minimizing impacts on ESA-listed salmon in conjunction with the research goals of the juvenile salmon survey, as well as requirements for monitoring and reporting. These measures have been described in section 1.3.4. As a result, we do not expect any additional impacts beyond what is already being considered in section 2.2 or 2.6.1 in this opinion to occur as a result of issuance of this permit for the juvenile salmon survey.

2.6.2 Risk

As described in the analysis of effects in section 2.6.1, we expect adverse effects on ESA-listed species from incidental and direct capture or entanglement in research survey gear as a result of SWFSC research activities. Based on the number of individuals expected to be adversely affected and the likely response, we relate those impacts to the population(s) of each species to determine the risk of these adverse effects to the population(s). Given the spatial extent of proposed activities, it is possible that multiple populations of a given species may be adversely affected. The risk analysis will assess the potential impact of incidental and direct capture or entanglement of individuals for all populations that may be adversely affected as the species or population listed under the ESA.

2.6.2.1 Sea Turtles

In section 2.6.1, we determined that up to 1 sea turtle may be captured on entangled in survey trawls in the CCE during any year. We expect that sea turtle to be released alive (and handled well as required to maximize survival). Similarly, we determined that up to 1 sea turtle may be captured or entangled in longline survey gear during any year, either in the CCE or ETP. We expect that it would be a live turtle, released with minor injuries such that it is likely to survive, given the Ryder et al. (2006) criteria. There is not enough information available to assess exactly which individuals from these populations are at most risk to interactions with SWFSC research gear, so we assume that any turtle could be an adult or juvenile, and a male or female. Generally, we assume that adult females are the most important members of sea turtle populations for the purposes of assessing reproductive output potential. A full assessment of risk for effects analysis under the ESA relates the nature of stressors and response to the population affected. For completeness, here we consider the specific populations that are likely impacted by the proposed action.

For leatherback sea turtles, any turtle that may be captured or entangled in the CCE would most likely belong to the western Pacific population, particularly leatherbacks from Jamursba-Medi, based on the known migratory patterns discussed in section 2.4.1.1. In the ETP, it is more likely that any leatherback that may be captured or entangled (in longline gear only) could belong to the highly endangered eastern Pacific population, which is currently at very low abundance. For loggerhead sea turtles, any individual that may be captured or entangled in the CCE or ETP is expected to be from the North Pacific population originating from Japan, based on tracking information discussed in section 2.4.1.2. However, it has recently become known that loggerhead turtles can be found foraging off the coast of Peru and Chili, and genetic studies indicate that those turtles originate from southern hemisphere nesting stocks in eastern Australia or New Caledonia (Alfaro-Shigueto 2012). For olive ridley sea turtles, any individual that may be captured or entangled in SWFSC research gear in the CCE or ETP will be from the eastern Pacific population, and may well be from the endangered Mexico nesting beach origin, especially in the CCE. Similarly for green sea turtles, any individual that may be captured or entangled in SWFSC research gear will likely be from the eastern Pacific population, especially in the CCE.

While capture or entanglement during SWFSC research is considered "take" under the definition and regulatory standards of the ESA, even for animals that ultimately survive the encounter, the nature of incidents where no mortality or other significant effect to potential successful reproduction occurs poses no risks to populations or species. Although up to 2 sea turtles may be captured or entangled each year in SWFSC research gear, and these turtles may belong to the same population or species, no detectable impact to abundance, productivity, structure, or diversity of those populations or species is expected. In this opinion, we do want to acknowledge concern about risks of post-release mortality for any turtle that is released alive, particularly after being injured in longline gear. Following the Ryder et al. (2006) criteria, we have considered only the likelihood of post-release mortality following any single capture/entanglement event. If the SWFSC were to demonstrate a pattern of multiple sea turtle captures/entanglements over the 5-year period, we will evaluate the relative likelihood that a post-release mortality has occurred over all the interactions. If we determine it is likely that over time there has been at least one mortality that can be attributed to SWFSC research interactions, then we will conclude that impacts from SWFSC research have exceeded what has been anticipated in this opinion.

2.6.2.2 Marine Fish

2.6.2.2.1 Eulachon, Southern DPS

The analysis of the proposed action has determined that up to 1 kg of eulachon, or approximately 25 individuals, may be captured in SWFSC research survey trawls and removed from the population each year. The distinction between eulachon populations, and specifically the Southern DPS, is based on the geographic location of freshwater spawning migrations. The distribution of eulachon in the ocean is not well understood, and it is possible that any eulachon encountered in the North Pacific Ocean could belong to the ESA-listed or non-listed population. Since any eulachon that will be encountered as incidental catch in SWFSC survey research trawls will come from the relative southern end of Pacific eulachon range in the ocean, and for the sake of conservative consideration of potential impacts to ESA-listed eulachon from SWFSC research activities, we assume that all eulachon encountered by SWFSC research trawls will be from the ESA-listed Southern DPS.

There are no readily available current abundance estimates for this species, only the more qualitative assessment that this species has declined significantly from historical abundance. Most of what has been inferred about the eulachon population trend comes from catch records in various locations, where eulachon landings were historically counted in the millions of pounds, and more recently in just the tens of thousands. Changes in management schemes and fishing effort complicate the interpretation of these records, but clearly eulachon biomass is many orders of magnitude greater throughout the CCE than the 1 kg that may be removed by SWFSC research trawls. However, there are a few estimates of spawning biomass available for some of the river systems within the Southern DPS. In the Fraser River in British Columbia, spawning biomass estimates suggest that at least 200,000-900,000 eulachon spawned in each year from 2004-2009 (Gustafson et al. 2010), and spawning in the lower Columbia was estimated around 19 million individuals in 2011. Some of the offshore biomass indexes (not biomass estimates per se) refer to relative biomass in the hundreds and thousands of metric tons for areas such as the West Coast Vancouver Island and Queen Charlotte Sound indices. Clearly, the number of eulachon distributed in the marine environment must be described in terms of many millions of fish. As a result, we conclude that the loss of 25 individuals per year will lead to a small but insignificant reduction in abundance or productivity of the Southern DPS of eulachon, but will not have any detectable effect on spatial structure or diversity of this population.

2.6.2.2.2 Scalloped Hammerhead, Eastern DPS

The analysis of the proposed action has determined that up 1 scalloped hammerhead shark may be captured/entangled in SWFSC longline survey gear any year longline surveys are conducted in the ETP. Given the sensitivity of this species of shark to being restrained in fishing gear, we assume it is likely to die as a result of that event. There is no information available to indicate what age or sex this one individual is the most likely to be, so it is possible that this could be any member of the population, including an adult female generally considered the most valuable member of most populations in terms of measuring reproductive capacity. Although it is possible that a scalloped hammerhead caught in ETP could be from a non-listed DPS such as the Central Pacific DPS, depending on exactly where in the ETP this interaction occurred, for the sake of conservative consideration of potential impacts to ESA-listed scalloped hammerheads from SWFSC research activities, we assume it is from the ESA-listed Eastern Pacific DPS. As described in section 2.4.2.2, the abundance of the Eastern Pacific DPS is estimated to be on the order of 10's of millions. As a result, we conclude that the loss of one individual per year will not lead to a meaningful reduction in abundance or productivity of the Eastern Pacific DPS of scalloped hammerhead, or to any detectable effect on spatial structure or diversity of this population.

2.6.2.3 Salmonids

In the "Status of the Species" section above, we estimated the average annual abundance for adult and juvenile ESA-listed salmonids. For most of the ESA-listed species, we estimated abundance for adult returning fish and outmigrating smolts. We estimated parr abundance for SONCC and OC coho salmon. For hatchery propagated juvenile salmonids, we use hatchery production goals. Table 64 (below) displays the estimated annual abundance of hatchery-propagated and naturally produced ESA-listed salmonids.

Table 64. Summary of estimated annual abundance of salmonids.

Species	Life Stage	Natural	Listed Hatchery Intact Adipose[1]	Listed Hatchery Adipose Clip[1]
Sacramento River winter-run Chinook	Adult	2,023	-	83
	Smolt	161,840	-	193,900
Central Valley spring-run Chinook	Adult	7,464	-	6,414
	Smolt	1,552,885	-	2,178,601
California Coastal Chinook	Adult	7,144	-	-
	Smolt	1,298,065	-	-
Snake River fall Chinook	Adult[1]	14,438	30,475	
	Smolt	570,821	3,780,129	3,076,642
Snake River spring/summer Chinook	Adult[1]	20,422	60,058	-
	Smolt	1,454,727	1,164,078	4,381,302
Lower Columbia River Chinook	Adult[1]	13,594	22,868	-
	Smolt	13,271,270	1,070,253	35,337,495
Upper Willamette River Chinook	Adult[1]	11,061	38,135	-
	Smolt	1,813,726	42,420	6,006,713
	Adult[1]	3,170	5,887	-

Upper Columbia River spring Chinook	Smolt	570,965	931,815	504,620
Puget Sound Chinook	Adult	18,127	11,089	-
	Smolt	2,337,280	5,992,150	36,617,500
Hood Canal summer run chum	Adult	17,556	3,452	-
	Smolt	3,072,420	275,000	-
Columbia River chum	Adult	12,239	428	-
	Smolt	2,978,550	391,973	-
Central California Coast coho	Adult	1,294	-	327
	Smolt	90,580	-	225,825
Southern Oregon/Northern California Coast coho	Adult	10,193	6,368	1,526
	Parr	1,026,707	575,000	200,000
Oregon Coast coho	Adult	192,431	1,753	-
	Parr	13,470,170	60,000	0
Lower Columbia River coho	Adult	10,957	208,192	-
	Smolt	839,118	299,928	8,637,196
Snake River sockeye	Adult	-	-	1,373*
	Smolt	15,560	-	124,767
Ozette Lake Sockeye	Adult	1,683	33	-
	Smolt	353,282	45,750	259,250
Southern California steelhead[2]	Adult	N.A.	-	-
	Smolt	N.A.	-	-
South-Central California steelhead	Adult	695	-	-
	Smolt	79,057	-	-
Central California Coast steelhead	Adult	1,429	-	3,866
	Smolt	162,549	-	648,891
California Central Valley steelhead	Adult	1,374	-	3,359
	Smolt	156,293	-	1,600,653
Northern California steelhead	Adult	4,286	-	-
	Smolt	487,533	-	-
Upper Columbia River steelhead	Adult	2,728	7,936	-
	Smolt	286,452	175,528	658,692
Snake River Basin steelhead	Adult	46,336	139,528	-
	Smolt	1,399,511	971,028	3,075,195

Lower Columbia River steelhead	Adult	11,117	23,000	-
	Smolt	447,659	2,428	1,025,729
Upper Willamette River steelhead	Adult	6,030	-	-
	Smolt	215,847	-	-
Middle Columbia River steelhead	Adult	24,127	2,724	-
	Smolt	540,850	426,556	347,113
Puget Sound steelhead	Adult	13,621	994	-
	Smolt	1,668,371	64,000	155,897

[1] We do not have separate estimates for adult adipose fin-clipped and intact adipose fin hatchery fish.
[2] There is no reliable estimates of abundance for either adults or juveniles of this DPS.

In this section we combine the effects of both the direct take of salmonids (authorized via section 10(a)(1)(A) permit 19320; Table 3) and the incidental take of salmonids (Tables 61 and 62) to determine the potential risk of the proposed actions on each ESU/DPS (Table 65). As noted previously, permit 19320 would authorize the SWFSC FED to take ESA-listed salmonids via Nordic surface trawl and beach seine. The primary effects of requested direct take on ESA-listed salmonids will result from intentional mortality in addition to stress and other sub-lethal effects caused by capturing, handling, and tissue sampling fish. Because the incidental effects may be less easily predicted, the precautionary principle was applied, and all incidental take is considered to result in mortality for the following analysis. For this reason, the analysis represents a worst-case scenario with regards to incidental take.

Table 65 provides a summary of requested or expected take for each ESU and DPS of salmonid. Both direct and incidental take is proposed and/or expected. For the purposes of this analysis, all incidental take is considered to result in mortality, but again, this assumption is precautionary. Direct take includes intentional directed mortality and tissue sampling, which is not predicted to result in any mortality – in part because captures that are injured and therefore not likely to survive will be sacrificed and counted as intentional directed mortality. All juvenile captures are subject to intentional directed mortality, but many sub-adult captures are tissue sampled and released (Table 65). The proportion of sub-adult captures that are tissue sampled versus those that are sacrificed varies by species, life stage, and origin (Table 65). Of the 28 species potentially affected by this research, 18 are subject to incidental take only, and 10 are subject to both direct and incidental take.

Table 65. Summary of total requested/expected take for each ESU and DPS by take action and take type.

Salmonid ESU/DPS	Life Stage	Origin	Take Type	Take Action	Total Take	Total Mortality
	Juvenile	Natural	Direct	IDM	2	2

Sacramento River-run winter Chinook		Natural	Incidental		1	1
	Sub-adult	Natural	Direct	IDM	3	3
		Natural	Incidental		1	1
Central Valley spring-run Chinook	Juvenile	Natural	Direct	IDM	23	23
		Listed Hatchery Adipose Clip	Direct	IDM	82	82
		Natural	Incidental		1	1
	Sub-adult	Natural	Direct	IDM	3	3
		Natural	Direct	C/M,T,ST/R	8	0
		Listed Hatchery Adipose Clip	Direct	IDM	3	3
		Listed Hatchery Adipose Clip	Direct	C/M,T,ST/R	6	0
		Natural	Incidental		1	1
California coastal Chinook	Juvenile	Natural	Direct	IDM	31	31
		Natural	Incidental		2	2
	Sub-adult	Natural	Direct	IDM	26	26
		Natural	Direct	C/M,T,ST/R	34	0
		Natural	Incidental		1	1
Snake River fall Chinook	Juvenile	Natural	Incidental		1	1
	Sub-adult	Natural	Incidental		1	1
Snake River spring/summer Chinook	Juvenile	Natural	Incidental		1	1
		Listed Hatchery Adipose Clip	Direct	IDM	2	2
	Sub-adult	Natural	Incidental		1	1
Lower Columbia River Chinook	Juvenile	Natural	Incidental		4	4
	Sub-adult	Natural	Direct	C/M,T,ST/R	1	0
		Listed Hatchery Adipose Clip	Direct	C/M,T,ST/R	1	0
		Natural	Incidental		1	1
Upper Willamette River Chinook	Juvenile	Natural	Incidental		2	2
	Sub-adult	Natural	Incidental		1	1
	Juvenile	Natural	Incidental		4	4

Upper Columbia River spring Chinook	Sub-adult	Natural	Incidental		1	1
Puget Sound Chinook	Juvenile	Natural	Incidental		2	2
	Sub-adult	Natural	Incidental		1	1
Hood Canal summer-run chum	Juvenile	Natural	Incidental		5	5
	Sub-adult	Natural	Incidental		5	5
Columbia River chum	Juvenile	Natural	Incidental		5	5
	Sub-adult	Natural	Incidental		5	5
Central California coast coho	Juvenile	Natural	Direct	IDM	16	16
		Listed Hatchery Intact Adipose	Direct	IDM	16	16
		Natural	Incidental		4	4
	Sub-adult	Natural	Direct	IDM	4	4
		Natural	Direct	C/M,T,ST/R	3	0
		Listed Hatchery Intact Adipose	Direct	IDM	4	4
		Listed Hatchery Intact Adipose	Direct	C/M,T,ST/R	3	0
		Natural	Incidental		4	4
Southern Oregon/Northern California Coast coho	Juvenile	Natural	Direct	IDM	48	48
		Listed Hatchery Intact Adipose	Direct	IDM	48	48
		Listed Hatchery Adipose Clip	Direct	IDM	11	11
		Natural	Incidental		15	15
	Sub-adult	Natural	Direct	IDM	13	13
		Natural	Direct	C/M,T,ST/R	10	0
		Listed Hatchery Intact Adipose	Direct	IDM	13	13

		Listed Hatchery Intact Adipose	Direct	C/M,T,ST/R	10	0
		Listed Hatchery Adipose Clip	Direct	IDM	3	3
		Listed Hatchery Adipose Clip	Direct	C/M,T,ST/R	11	0
		Natural	Incidental		15	15
Oregon Coast coho	Juvenile	Natural	Incidental		15	15
	Sub-adult	Natural	Incidental		15	15
Lower Columbia River coho	Juvenile	Natural	Incidental		13	13
	Sub-adult	Natural	Incidental		13	13
Snake River sockeye	Juvenile	Natural	Incidental		4	4
	Sub-adult	Natural	Incidental		4	4
Ozette Lake sockeye	Juvenile	Natural	Incidental		4	4
	Sub-adult	Natural	Incidental		4	4
Southern California steelhead	Juvenile	Natural	Incidental		4	4
	Sub-adult	Natural	Incidental		4	4
South-Central California steelhead	Juvenile	Natural	Incidental		4	4
	Sub-adult	Natural	Incidental		4	4
Central California Coast steelhead	Juvenile	Natural	Direct	IDM	7	7
		Listed Hatchery Adipose Clip	Direct	IDM	1	1
		Natural	Incidental		4	4
	Sub-adult	Natural	Direct	IDM	7	7
		Natural	Direct	C/M,T,ST/R	1	0
		Listed Hatchery Adipose Clip	Direct	IDM	7	7
		Natural	Incidental		4	4
California Central Valley steelhead	Juvenile	Natural	Direct	IDM	4	4
		Listed Hatchery Adipose Clip	Direct	IDM	2	2

		Natural	Incidental		4	4
	Sub-adult	Natural	Direct	IDM	4	4
		Natural	Direct	C/M,T,ST/R	1	0
		Listed Hatchery Adipose Clip	Direct	IDM	15	15
		Natural	Incidental		4	4
Northern California steelhead	Juvenile	Natural	Direct	IDM	7	7
		Natural	Incidental		4	4
	Sub-adult	Natural	Direct	IDM	7	7
		Natural	Direct	C/M,T,ST/R	1	0
		Natural	Incidental		4	4
Upper Columbia River steelhead	Juvenile	Natural	Incidental		4	4
	Sub-adult	Natural	Incidental		4	4
Snake River Basin steelhead	Juvenile	Natural	Incidental		4	4
	Sub-adult	Natural	Incidental		4	4
Lower Columbia River steelhead	Juvenile	Natural	Incidental		4	4
	Sub-adult	Natural	Incidental		4	4
Upper Willamette River steelhead	Juvenile	Natural	Incidental		4	4
	Sub-adult	Natural	Incidental		4	4
Middle Columbia River steelhead	Juvenile	Natural	Incidental		4	4
	Sub-adult	Natural	Incidental		4	4
Puget Sound steelhead	Juvenile	Natural	Incidental		4	4
	Sub-adult	Natural	Incidental		4	4

Notes: C/M,T,ST/R=Capture/Mark, Tag, Sample Tissue/Release; IDM = Intentional Directed Mortality.

Table 66 compares the total requested/expected take (incidental and direct) to the species' estimated abundance. The total take represents the maximum estimate of the total take that could result from the proposed activities. Very few fish are handled, but all take could potentially result in mortality. However, as the table illustrates the number of fish that would be killed under the proposed action - even if the entire allotment were used and all incidental take resulted in mortality - represents a tiny fraction of the abundance of any ESU/DPS. In addition, the sub-adult life stage for each ESU/DPS is compared against the adult life stage abundance, as there are no direct data available to provide an estimate of sub-adult abundance. Assuming some level of mortality between the sub-adult and adult life stages, the sub-adult abundance is actually larger than the abundance used for each comparison (i.e., the percent of ESU/DPS handled and killed for the sub-adult life stage for each ESU/DPS is smaller than what is presented).

Table 66. Summary of total proposed/expected take relative to abundance by ESU/DPS.

Salmonid ESU/DPS	Life Stage	Origin	Total Take (Direct and Incidental)	Percent of ESU/DPS Handled	Total Mortality (Direct and Incidental)	Percent of ESU/DPS Killed
Sacramento River winter-run Chinook	Juvenile	Natural	3	0.002	3	0.002
	Sub-adult	Natural	4	0.198	4	0.198
Central Valley spring-run Chinook	Juvenile	Natural	24	0.002	24	0.002
		Listed Hatchery Adipose Clip	82	0.004	82	0.004
	Sub-adult	Natural	12	0.161	4	0.054
		Listed Hatchery Adipose Clip	9	0.140	3	0.047
California coastal Chinook	Juvenile	Natural	33	0.003	33	0.003
	Sub-adult	Natural	61	0.854	27	0.378
Snake River fall Chinook	Juvenile	Natural	1	0.0002	1	0.0002
	Sub-adult	Natural	1	0.007	1	0.007
Snake River spring/summer Chinook	Juvenile	Natural	1	0.0001	1	0.0001
		Listed Hatchery Adipose Clip	2	0.00005	2	0.00005
	Sub-adult	Natural	1	0.005	1	0.005
Lower Columbia River Chinook	Juvenile	Natural	4	0.00003	4	0.00003
	Sub-adult	Natural	2	0.015	1	0.007
		Listed Hatchery (Adipose Clip and Intact Adipose)	1	0.004	0	0
Upper Willamette River Chinook	Juvenile	Natural	2	0.0001	2	0.0001
	Sub-adult	Natural	1	0.009	1	0.009
Upper Columbia River spring Chinook	Juvenile	Natural	4	0.001	4	0.001
	Sub-adult	Natural	1	0.032	1	0.032
Puget Sound Chinook	Juvenile	Natural	2	0.0001	2	0.0001
	Sub-adult	Natural	1	0.006	1	0.006
Hood Canal summer-run chum	Juvenile	Natural	5	0.0002	5	0.0002
	Sub-adult	Natural	5	0.028	5	0.028
Columbia River chum	Juvenile	Natural	5	0.0002	5	0.000
	Sub-adult	Natural	5	0.041	5	0.041
Central California coast coho	Juvenile	Natural	20	0.022	20	0.022
		Listed Hatchery	20	0.009	20	0.009

		Intact Adipose				
	Sub-adult	Natural	11	0.850	8	0.618
		Listed Hatchery Intact Adipose	12	3.670	5	1.529
Southern Oregon/Northern California Coast coho	Juvenile	Natural	63	0.006	63	0.006
		Listed Hatchery Intact Adipose	48	0.008	48	0.008
		Listed Hatchery Adipose Clip	11	0.006	11	0.006
	Sub-adult	Natural	38	0.373	28	0.275
		Listed Hatchery Intact Adipose	23	0.361	13	0.204
		Listed Hatchery Adipose Clip	14	0.917	3	0.197
Oregon Coast coho	Juvenile	Natural	15	0.0001	15	0.000
	Sub-adult	Natural	15	0.008	15	0.008
Lower Columbia River coho	Juvenile	Natural	13	0.002	13	0.002
	Sub-adult	Natural	13	0.119	13	0.119
Snake River sockeye	Juvenile	Natural	4	0.026	4	0.026
	Sub-adult*	Natural	4	0.291	4	0.291
Ozette Lake sockeye	Juvenile	Natural	4	0.001	4	0.001
	Sub-adult	Natural	4	0.238	4	0.238
Southern California steelhead	Juvenile	Natural	4	N.A.	4	N.A.
	Sub-adult	Natural	4	N.A.	4	N.A.
South-Central California steelhead	Juvenile	Natural	4	0.005	4	0.005
	Sub-adult	Natural	4	0.576	4	0.576
Central California Coast steelhead	Juvenile	Natural	11	0.007	11	0.007
		Listed Hatchery Adipose Clip	1	0.0002	0	0
	Sub-adult	Natural	12	0.840	11	0.770
		Listed Hatchery Adipose Clip	7	0.181	7	0.181
	Juvenile	Natural	8	0.005	8	0.005

California Central Valley steelhead		Listed Hatchery Adipose Clip	2	0.0001	2	0.0001
	Sub-adult	Natural	9	0.655	8	0.582
		Listed Hatchery Adipose Clip	15	0.447	15	0.447
Northern California steelhead	Juvenile	Natural	11	0.002	11	0.002
	Sub-adult	Natural	12	0.280	11	0.257
Upper Columbia River steelhead	Juvenile	Natural	4	0.001	4	0.001
	Sub-adult	Natural	4	0.147	4	0.147
Snake River Basin steelhead	Juvenile	Natural	4	0.0003	4	0.0003
	Sub-adult	Natural	4	0.009	4	0.009
Lower Columbia River steelhead	Juvenile	Natural	4	0.001	4	0.001
	Sub-adult	Natural	4	0.036	4	0.036
Upper Willamette River steelhead	Juvenile	Natural	4	0.002	4	0.002
	Sub-adult	Natural	4	0.066	4	0.066
Middle Columbia River steelhead	Juvenile	Natural	4	0.001	4	0.001
	Sub-adult	Natural	4	0.017	4	0.017
Puget Sound steelhead	Juvenile	Natural	4	0.0002	4	0.0002
	Sub-adult	Natural	4	0.029	4	0.029

The only ESU/life stage/origin that may be taken at a percentage of abundance greater than 1% is hatchery origin (intact adipose) CCC coho salmon sub-adults, for which 12 individuals (3.67%) may be taken and five of those individuals (1.529%) may be killed. It should be noted that this relatively high potential rate of mortality is for a hatchery stock that is considered to be of less conservation value for the ESU compared to the natural origin adult population. We also concede that we do not have an estimate for the potential proportion of juvenile or sub-adult SC steelhead that may be impacted as a result of incidental capture in SWFSC research, since no population estimates for any life stage are available. Based on our general knowledge, it may be that the CCC coho ESU, which is similarly listed as endangered, and the S-CC steelhead DPS, which is a close neighbor to SC Steelhead and is exposed to many similar threats as SC steelhead DPS fish are, may be the most useful proxies for comparisons in terms of a crude comparison of relative similarities in abundance for the SC steelhead DPS. The potential lethal take of up to 4 SC steelhead, which would come from a natural population since no hatchery stocks currently exists for this DPS, is fewer than the total number of natural juvenile or sub-adult CCC coho that may be killed as a result of the proposed action (20 or 8, respectively), which constituted less than 1% of natural juvenile or sub-adult CCC coho abundance. With respect to the S-CC steelhead DPS abundance, the similar loss of up to 4 juveniles or sub-adults from that DPS is also estimated to less than 1% of its abundance. While we cannot provide an estimate for SC steelhead abundance that may be lost as a result of the proposed action, we conclude that the relative level of impact is likely somewhat similar to the relative impacts on CCC coho or S-CC steelhead DPSs, which are less than 1% of the DPS abundance. For salmon and steelhead ESU/DPSs other than CCC coho (and possibly SC steelhead), the proposed activities may kill at most 0.77% of any natural or hatchery component. As a result, we expect the proposed project to lead to a decrease in abundance and productivity from the affected populations that represent very small fractions of the total population in the ocean.

Because the research would take place along the whole U.S. Pacific coast, no individual population is likely to experience a disproportionate amount of these losses. This conclusion applies specifically to the structure of populations within any given ESU or DPS, as it seems most likely that impacts would not be focused to individuals from any one freshwater origin given takes are expected to occur scattered throughout the ocean in the CCE. And again, the effects displayed above are inflated by the fact that much of the take would be in the form of sub-adults - a life stage that may have 25-50% more individuals than would the adult life stage for each species. Therefore, while the research may have a very small effect on the species' abundance and productivity, it would in all probability not affect structure or diversity at all. And because a portion of the research would affect hatchery fish, any effects to the structure and diversity of those fish would be of lesser concern.

An effect of the research that cannot be quantified is the conservation benefit to the species resulting from the research. The research projects that result in incidental take of listed salmonids are not designed to directly benefit those ESU/DPSs, but the proposed section 10(a)(1)(A) permitted research is designed to benefit listed salmonid. This research would benefit listed fish by informing comprehensive lifecycle models that incorporate both freshwater and marine conditions and recognize the relationship between the two habitats; it would also identify and predict sources of salmon mortality at sea and thereby help managers develop indices of salmonid survival in the marine environment.

2.7 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.

This consultation incorporates a vast project action area encompassing domestic and international ocean waters across the Western Hemisphere. During this consultation, NMFS searched for information on future State, tribal, local, or private actions that were reasonably certain to occur in the action area within the general timeframe of this proposed action, which is

5 years. Activities that may occur in this area will likely consist of state, Federal, or foreign government actions related to ocean use policy and management of public resources, such as fishing, oil exploration, or energy development projects. Changes in ocean use policies as a result of government action, especially on an international scale, are highly uncertain and may be subject to sudden changes as political and financial situations develop. Examples of actions that may occur include development of aquaculture projects; changes to state, Federal, foreign, and international fisheries which may alter fishing patterns or influence the bycatch of ESA-listed species; installation of hydrokinetic projects near areas where marine species are known to migrate or congregate; designation or modification of marine protected areas that include habitat or resources that are known to affect marine species; changes to vessel traffic, and coastal development which may also alter patterns of vessel traffic. However, none of these potential state, local, or private actions, can be anticipated with any reasonable certainty in the action area at this time. Even if some of the projects were developed with any certainty, the level of direct or indirect effects associated with most of these types of actions appear speculative at this point. Current and continuing non-Federal actions that may continue to occur in the action area and may be affecting ESA-listed marine mammals are addressed in the *Environmental Baseline* section. As a result, we are not aware of any cumulative effects other than those already described in the *Environmental Baseline* section.

2.8 Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (section 2.6) to the environmental baseline (section 2.5) and the cumulative effects (section 2.7), taking into account the status of the species and critical habitat (section 2.4), 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) reduce the value of designated or proposed critical habitat for the conservation of the species.

2.8.1 Sea Turtles

Based on the analysis of potential effects from the SWFSC research activities considered in this opinion, we determined that adverse effects from incidental capture or entanglement in research gears including survey trawls or longlines for ESA-listed sea turtles in the CCE and ETP are likely. We have considered potential disturbance from active acoustic and vessels, the potential for vessel strikes, and potential impacts from reduction of prey impacts as well, and determined that adverse effects from these factors are unlikely. We have considered that up to 2 individual sea turtles could be incidentally captured or entangled in any given year (1 in trawl gear and 1 in longline gear) throughout the full range of where the SWFSC conducts these activities, and these turtles could be of any age or sex in these respective populations. Based on the nature of SWFSC research operations and the use of mitigation measures and proper handling, we conclude the most likely outcome from any incidental captures or entanglements is that individual turtles will survive these encounters. As a result, we have concluded that that the proposed activities are not likely to have a detectable impact on any ESA-listed sea turtle populations in terms of their current abundance or future reproductive output potential, or population structure and diversity. When the effect of this proposed action is added to the status, environmental baseline, and cumulative effects of other activities, and the anticipated effects of climate change over the foreseeable future, there is no increase in the risks of extinction or impediments to recovery for any of these ESA-listed sea turtles species. Ultimately, because no measurable impacts to these species is anticipated, we conclude that the proposed action will not reduce the likelihood of survival and recovery of the following sea turtle species considered in this opinion: leatherback sea turtle; North Pacific loggerhead sea turtle; olive ridley sea turtle; and green sea turtle.

2.8.2 Marine Fish

2.8.2.1 Eulachon, Southern DPS

Based on the analysis of potential effects from the SWFSC research activities considered in this opinion, we determined that adverse effects from incidental capture in research survey trawls to Southern DPS Pacific eulachon are likely. We've considered potential disturbance from active acoustic and vessels, the potential for vessel strikes, and potential impacts from reduction of prey impacts as well, and determined that adverse effects from these factors are unlikely. As stated in section 2.6.2.2.1, there are likely many millions of fish in the Southern DPS population, at least within the coastal ocean range where SWFSC research activities will encounter eulachon. The loss of up to 25 of these individuals to removal in SWFSC research trawls each year, when added to the 1 million plus individuals taken as bycatch in other commercial fisheries and the millions directly harvested each year, is not expected to have any detectable impact on the total population. In general, the population dynamics of anadromous fish with relatively short life-spans such as eulachon (3-5 years) is heavily influenced by the environmental conditions experienced rearing in freshwater and the ocean. Neither short term nor long term population monitoring will be able to distinguish the relative effect of an additional 25 adults missing each year from the variable signals from environmental fluctuations. There is no reason to expect that the loss of up to an additional 25 adults in any given year is going to impact the spawning potential and output in a year of a total population that can be counted in many millions in a way that can be reasonably expected or detected.

The Southern DPS is made up of a number of spawning populations; however we expect it is unlikely that the SWFSC eulachon impacts could be focused upon any particular population given the transitory nature of the SWFSC research surveys. The SWFSC generally does not remain confined within small areas for extended periods of time such that it could be expected that eulachon bycatch would come from the same place all the time. It is not currently clear how eulachon distribute in the marine environment, during any particular year and/or over the long term, but we conclude that it is more likely impacts to eulachon will be spread out across the entire Southern DPS population, as opposed to being focused on any one spawning group. Even if during one particular year all eulachon that are removed from the population as a result of capture in the SWFSC research trawls belonged to one specific spawning group, it is unlikely that future eulachon bycatch will always be focused in the ocean on that spawning group. As a result, we do not expect any discernable impact to Southern DPS at the population level.

Although a recovery plan for Southern DPS eulachon has not been completed, we have some idea of the major threats that face this species. Although directed harvest and bycatch in commercial fisheries are acknowledged as threats to eulachon (measured on the order of millions of fish), concerns of potential impacts from changing environmental conditions and altered fresh water spawning and rearing habitat were considered very significant during the ESA-listing process (75 FR 13012). We have concluded that the proposed project will lead to a small but insignificant reduction in abundance or productivity of the Southern DPS of eulachon, but will not have any detectable effect on spatial structure or diversity of this species. When the effect of this proposed action is added to the status, environmental baseline, and cumulative effects of other activities, and the anticipated effects of climate change over the foreseeable future, there is no increase in the risks of extinction or impediments to recovery for this species. As a result, we conclude that the proposed action will not reduce the likelihood of survival and recovery of the Southern DPS of eulachon.

2.8.2.2 Scalloped Hammerhead – Eastern Pacific DPS

Based on the analysis of potential effects from the SWFSC research activities considered in this opinion, we determined that adverse effects from incidental capture in research survey longlines to the Eastern Pacific DPS of scalloped hammerheads are likely. We've considered potential disturbance from active acoustic and vessels, the potential for vessel strikes, and potential impacts from reduction of prey impacts as well, and determined that adverse effects from these factors are unlikely. As described above, there are likely tens of millions of scalloped hammerheads in Eastern Pacific DPS population. For a population in the millions, there is no reason to expect that the loss of up to one additional individual, male or female, juvenile or adult, in any given year is going to impact the reproductive potential and output in a year for a total population that can be counted in many millions in a way that can be reasonably expected detected. A recovery plan has not been developed for this species, but based on the factors used to support the ESA-listing decision we conclude at this time that the recovery plan is likely to focus on management of intentional harvest and fisheries bycatch across industrialized and artisanal fishing. While bycatch in SWFSC research surveys shares some similarity with the issue of international harvest and bycatch, the scales of these activities and impacts are not relatable or comparable in a meaningful way. We conclude that the impact of the anticipated extent of mortality resulting from SWFSC research will be an undetectable reduction in the total abundance and productivity of this species, and no detectable effect on spatial structure or diversity of this population. When the effect of this proposed action is added to the status, environmental baseline, and cumulative effects of other activities, and the anticipated effects of climate change over the foreseeable future, there is no increase in the risks of extinction or impediments to recovery for this species. As a result, we conclude that the proposed action will not result in a reduction in the likelihood of survival and recovery of Eastern Pacific DPS scalloped hammerhead sharks.

2.8.2.3 Salmonids

Based on the analysis of potential effects from the SWFSC research activities considered in this opinion, we determined that significant adverse effects from incidental and directed capture in research trawl surveys are likely.

The reasons we integrate the proposed take in the section 10 permit considered here with the incidental take and the take from other research authorizations (i.e., baseline take) are that they are similar in nature, and we have good information on what the effects are. Thus, it is possible to determine the overall effect of all research in the study on the species considered here. The following table includes the proposed take for the actions considered in this opinion, including both direct (section 10) and incidental (section 7), added to the research take that has already been authorized for the included species, against the estimated annual abundance, by life stage, for each species under consideration (Table 67).

Table 67. Total expected take of the ESA-listed species for scientific research and monitoring already approved, plus the activities covered in this biological opinion.

Salmonid ESU/DPS	Life Stage	Origin	Total Take + Baseline	Percent of Abundance	Total Mortality + Baseline	Percent of Abundance
Sacramento River winter-run Chinook	Juvenile	Natural	7,920	4.9	175	0.1
	Sub-adult	Natural	4	0.2	11	0.5
Central Valley spring-run Chinook	Juvenile	Natural	981,260	63.2	17,782	1.1
		Listed Hatchery Adipose Clip	6,732	0.3	1,358	0.1
	Sub-adult	Natural	3,192	42.8	80	1.1
		Listed Hatchery Adipose Clip	27,649	431.1	265	4.1
	Juvenile	Natural	347,839	26.8	3,746	0.3

California Coastal Chinook	Sub-adult	Natural	5,364	75.1	37	0.5
Snake River fall Chinook	Juvenile	Natural	1,763	0.3	79	0.0
	Sub-adult	Natural	435	3.0	9	0.1
Snake River spring/summer Chinook	Juvenile	Natural	1,389,144	95.5	12,478	0.9
		Listed Hatchery Adipose Clip	168,607	3.8	1,856	0.0
	Sub-adult	Natural	7,444	36.5	43	0.2
Lower Columbia River Chinook	Juvenile	Natural	2,221,425	16.7	19,306	0.1
	Sub-adult	Natural	830	6.1	15	0.1
		Listed Hatchery (Adipose Clip and Intact Adipose)	482	2.1	20	0.1
Upper Willamette River Chinook	Juvenile	Natural	72,074	4.0	1,192	0.1
	Sub-adult	Natural	167	1.5	7	0.1
Upper Columbia River spring Chinook	Juvenile	Natural	25,263	4.4	902	0.2
	Sub-adult	Natural	588	18.5	16	0.5
Puget Sound Chinook	Juvenile	Natural	404,916	17.3	11,449	0.5
	Sub-adult	Natural	813	4.5	50	0.3
Hood Canal summer-run chum	Juvenile	Natural	636,615	20.7	4,682	0.2
	Sub-adult	Natural	5,208	29.7	53	0.3
Columbia River chum	Juvenile	Natural	13,171	0.4	245	0.0
	Sub-adult	Natural	61	0.5	10	0.1
Central California Coast coho	Juvenile	Natural	124,950	137.9	2,662	2.9
		Listed Hatchery Intact Adipose	24,580	10.9	863	0.4
	Sub-adult	Natural	3,779	292.0	58	4.5
		Listed Hatchery Intact Adipose	12	3.7	5	1.5
Southern Oregon/Northern California Coast coho	Juvenile	Natural	126,647	12.3	1,690	0.2
		Listed Hatchery Intact Adipose	1,388	0.2	793	0.1
		Listed Hatchery Adipose Clip	101	0.1	24	0.0
	Sub-adult	Natural	159	1.6	38	0.4
		Listed Hatchery Intact Adipose	36	0.6	19	0.3
		Listed Hatchery Adipose Clip	21	1.4	3	0.2

Oregon Coast coho	Juvenile	Natural	701,176	5.2	15,085	0.1
	Sub-adult	Natural	15,423	8.0	173	0.1
Lower Columbia River coho	Juvenile	Natural	216,720	25.8	2,746	0.3
	Sub-adult	Natural	3,286	30.0	50	0.5
Snake River sockeye	Juvenile	Natural	10,575	68.0	514	3.3
	Sub-adult	Natural	162	11.8	8	0.6
Ozette Lake sockeye	Juvenile	Natural	30	0.0	7	0.0
	Sub-adult	Natural	13	0.8	8	0.5
Southern California steelhead	Juvenile	Natural	3928	N.A.	154	N.A
	Sub-adult	Natural	119	N.A.	4	N.A.
South-Central California steelhead	Juvenile	Natural	22,648	28.6	247	0.3
	Sub-adult	Natural	41	5.9	6	0.9
Central California Coast steelhead	Juvenile	Natural	194,592	119.7	4,484	2.8
		Listed Hatchery Adipose Clip	1,511	0.2	47	0.0
	Sub-adult	Natural	1,079	75.5	36	2.5
		Listed Hatchery Adipose Clip	9	0.2	9	0.2
California Central Valley steelhead	Juvenile	Natural	56,779	36.3	1,769	1.1
		Listed Hatchery Adipose Clip	20,420	1.3	808	0.1
	Sub-adult	Natural	3,499	254.7	104	7.6
		Listed Hatchery Adipose Clip	3,837	114.2	279	8.3
Northern California steelhead	Juvenile	Natural	284,515	58.4	2,559	0.5
	Sub-adult	Natural	3,337	77.9	18	0.4
Upper Columbia River steelhead	Juvenile	Natural	28,734	10.0	1,042	0.4
	Sub-adult	Natural	4	0.1	4	0.1
Snake River Basin steelhead	Juvenile	Natural	458,115	32.7	5,717	0.4
	Sub-adult	Natural	13,732	29.6	154	0.3
Lower Columbia River steelhead	Juvenile	Natural	67,561	15.1	1,399	0.3
	Sub-adult	Natural	2,923	26.3	36	0.3
Upper Willamette River steelhead	Juvenile	Natural	6,543	3.0	155	0.1
	Sub-adult	Natural	278	4.6	8	0.1
Middle Columbia River steelhead	Juvenile	Natural	128,789	23.8	2,308	0.4
	Sub-adult	Natural	4,132	17.1	44	0.2
Puget Sound steelhead	Juvenile	Natural	65,130	3.9	1,216	0.1
	Sub-adult	Natural	1,475	10.8	36	0.3

For the vast majority of the 28 salmonid ESU/DPSs potentially affected by this research, the lethal take proposed by the activities included in this opinion represents less than 1% of the estimated abundance - for a given origin and life stage - even when combined with the section 10(a)(1)(A) and 4(d) research take that has already been authorized. While the proposed lethal take for these species is low, it should be noted that, for a number of reasons, the displayed percentages are in reality almost certainly much smaller than even the small figures stated. First, the juvenile abundance estimates are deliberately designed to generate a conservative picture of abundance. Second, it is important to remember that estimates of lethal take for most of the proposed studies are purposefully inflated to account for potential accidental deaths and it is therefore very likely that fewer juveniles would be killed by the research than stated. In fact, for the vast majority of scientific research permits, history has shown that researchers generally take far fewer than the permitted number of fish every year. From 2009 through 2012, the percent of actual mortalities per approved mortalities is only 1.322% for all California scientific research and monitoring permits. 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 small, and 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, to some degree, 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. Therefore, for species that exhibit less than 1% mortality for each life stage/origin, no further discussion is warranted. Species that exhibit greater than 1% mortality for any life stage/origin are further addressed individually below.

Central Valley spring Chinook – CVS Chinook lethal take, when added to the baseline take, represents 1.1% of abundance for natural juveniles, 1.1% for natural sub-adults, and 4.1% for hatchery sub-adults. While this is less than 0.1% additional take for each of the three life stage/origin classes over the baseline (Table 67), the additional potential affect, while small, warrants further discussion. First, the largest percent mortality is for hatchery sub-adults, which are of less conservation value (ESA take prohibitions do not apply to hatchery fish with clipped adipose fins from threatened ESUs/DPSs such as CVS Chinook) and therefore lesser concern than are the natural population. Second, our research tracking system for the 4(d) Limit 7 program reveals that on average researchers only take about eight percent of the naturally produced juvenile CVS Chinook salmon they request and the actual (reported) mortality is only 10 percent of requested mortality. For naturally produced adult CVS Chinook salmon, researchers have only taken about 18% of the fish they request and there has only been one reported mortality in the last five years of reporting. This would mean that the actual effect is likely to be fractions of the numbers stated in Table 67 above.

Central California Coast Coho – CCC coho lethal take, when added to the baseline take, represents 2.9% of abundance for natural juveniles, 4.5% of abundance for natural sub-adults, and 1.5% of abundance for hatchery sub-adults. The largest component of this take that is from research proposed for this opinion is for the hatchery sub-adult life stage/origin (1.529%), however a substantial percentage is also contributed to the natural sub-adult life stage/origin (0.618%; Table 67). Though these take and mortality numbers may be high, looking at the actual usage of these numbers is insightful. As mentioned before, mortalities during salmon research in California is typically only a fraction of what has been permitted. For example, natural origin, Central California Coast coho adults have an approved mortality rate of 3.864% when all of the research mortalities are considered. However, from 2009 through 2012, only 0.980% of the approved mortality had been used. If the subsequent five years are similar to the previous four years, then we would expect a mortality rate of only 0.038% from research on this ESU.

Southern California steelhead – As described before, we do not have good abundance data for SC steelhead, so it is not possible to directly estimate the impact of the proposed action in terms of percentages of abundance that is affected for either the juvenile or sub-adult life stage. However, we can look at two other salmon populations for some possible crude comparisons to gauge how SC steelhead may be impacted. As discussed above, the natural population of CCC coho is subject to lethal take across research actions included as part of the proposed action and baseline totaling up to over 2,500 juveniles and 58 sub-adults. This is much greater than the total lethal take across the proposed action and baseline research that may be expected for SC steelhead, which is 154 juveniles and 4 sub-adults. For S-CC steelhead, natural juvenile and sub-adult morality (247 and 6, respectively) is expected to be less than 1%. While we cannot provide an estimate for SC steelhead abundance that may be lost as a result considering the total impacts of research activities that have been authorized or proposed, we conclude that the relative level of impact is likely less than CCC coho, and possibly relatively similar to S-CC steelhead.

Central California Coast Steelhead – CCC steelhead lethal take, when added to the baseline take, represents 2.8% of abundance for natural juveniles, and 2.5% of abundance for natural sub-adults. In both cases the contribution of percent lethal take by the activities in this opinion is less than 0.8% (Table 67). However, our research tracking system for the 4(d) Limit 7 program reveals that on average researchers only take about 21% of the naturally produced juvenile CCC steelhead they request and the actual (reported) mortality is only 10% of requested mortality. For naturally produced adult Central California Coast steelhead, researchers have only taken about seven percent of the fish they request and there has been no adult mortality in the last five years of reporting. This would mean that the actual effect is likely to be fractions of the numbers stated in Table 67 above.

California Central Valley Steelhead – CCV steelhead lethal take, when added to the baseline take, represents 1.1% for natural juveniles, 7.6% for natural sub-adults, and 8.3% for hatchery sub-adults. In all cases the contribution of percent lethal take by the activities in this opinion is less than 0.6% (Table 67). Our research tracking system for the 4(d) Limit 7 program reveals that on average researchers only take about 14% of the naturally produced juvenile CCV steelhead they request and the actual (reported) mortality is only 11% of requested mortality. For naturally produced adult CCV steelhead, researchers have only taken about 14% of the fish they request and there has only been two reported mortalities in the last five years of reporting. This would mean that the actual effect is likely to be fractions of the numbers stated in Table 67 above.

In summary, we conclude that the level of incidental and directed take of salmonids during SWFSC scientific research activities each year that has been proposed and considered in this opinion, particular in terms of potential mortality, represents a very small reduction in abundance that is not likely to significantly impact any ESA-listed salmonids over time. We also conclude that the diversity of ESA-listed salmonid populations will be not be affected by this limited amount of take that should be distributed across populations throughout salmonid ranges in the ocean. We have generally identified and considered the worst case scenario of potential mortality for each ESA-listed salmonid population considered in this opinion, where applicable, leading to the most conservative estimates of expected take. As described in the opinion, it is likely that capture and mortality totals for each ESA-listed salmonid population will be some fraction less than the conservative estimates generated in the opinion, as takes will likely be spread out across salmonid populations throughout the CCE. Generally speaking, most recovery plans for salmonids that have been completed or are under development focus on addressing major threats associated with impaired habitat functions, such as access to freshwater spawning and rearing habitats, water quality and availability, and/or sensible harvest strategies. These recovery plans generally call for enhanced research efforts to improve our understanding of salmonid ecology. Under this proposed action, information that can be used to contribute to the enhancement of management activities for ESA-listed salmonids is expected to be derived from both directed and incidental take during SWFSC research activities.

We have concluded that the proposed action will have a very small effect on the species' abundance and productivity, but will not affect population structure or diversity at all. When the effect of this proposed action is added to the status, environmental baseline, and cumulative effects of other activities, and the anticipated effects of climate change over the foreseeable future, there is no increase in the risks of extinction or impediments to recovery for any of these ESA-listed species. As a result, we conclude that the proposed action will not reduce the likelihood of survival and recovery of any of the 28 ESA-listed salmonids that may be affected by this proposed action.

2.9 Conclusion

After reviewing and analyzing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of: leatherback sea turtle; North Pacific loggerhead sea turtle; olive ridley sea turtle; green sea turtle; Southern Pacific eulachon; Eastern Pacific scalloped hammerhead shark; Sacramento River winter Chinook; Central Valley spring Chinook; California coastal Chinook; Snake River fall Chinook; Snake River spring/summer Chinook; Lower Columbia River Chinook; Upper Willamette River Chinook; Upper Columbia River spring Chinook; Puget Sound Chinook; Hood Canal summer run Chum; Columbia River Chum; Central California coastal coho; S. Oregon/N. California coastal coho; Oregon Coast coho; and Lower Columbia River coho; Snake River sockeye; Ozette Lake sockeye; Southern California steelhead; South-Central California steelhead; Central California Coast steelhead; California Central Valley steelhead; Northern California steelhead; Upper Columbia River steelhead; Snake River Basin steelhead; Lower Columbia River steelhead; Upper Willamette River steelhead; Middle Columbia River steelhead; or Puget Sound steelhead.

Critical habitat has been designated or proposed for many of these species; including most ESA-listed salmonids. However, the proposed action occurs exclusively in the coastal marine environment outside the boundaries of designated critical habitats for salmonids, Southern Pacific eulachon, and Southern Resident killer whales; therefore, no was further analyses were conducted for those designated critical habitats that lie exclusively within freshwater, estuarine, or marine environments completely outside the proposed action area. Potential effects on designated critical habitats in marine areas for ESA-listed marine mammals, fish, and invertebrates that overlap with the proposed action area were analyzed in section 2.2. After reviewing the proposed project and potential effects, we conclude that no designated critical habitats for any ESA-listed species are likely to be adversely affected by the proposed action.

2.10 Incidental Take Statement

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

2.10.1 Amount or Extent of Take

In the biological opinion, we determined that incidental takes through capture or entanglement would occur as a result of the proposed action as follows:

Table 68. Description of incidental take of ESA-listed sea turtles, eulachon and scalloped hammerheads expected each year through capture or entanglement in SWFSC research surveys. For sea turtles, the take each year could come from any of the ESA-listed sea turtles species referenced.

Species	Expected Take	Life Stage	Manner of Take	Final Disposition
Sea turtles	1	juvenile/adult	Captured in CCE trawl surveys	released alive
leatherback				
North Pacific loggerhead				
olive ridley				
green				
Sea turtles	1	juvenile/adult	Captured/entangled in CCE or ETP longline surveys	released alive
leatherback				
North Pacific loggerhead				
olive ridley				
green				
Southern DPS Pacific eulachon	1 kg or 25 individual s	juvenile/adult	Captured in CCE trawl surveys	100% mortality
Eastern Pacific DPS scalloped hammerhead	1	juvenile/adult	Captured/entangled in ETP longline surveys	mortality

For sea turtles, we expect that one sea turtle may be incidentally captured in SWFSC trawl research in the CCE each year, and that one sea turtle may be incidentally captured or entangled in longline surveys in the CCE or ETP each year. In total, up to two sea turtles may be incidentally captured or entangled by SWFSC research in any year. These take could occur with any of the four species listed above. We expect that sea turtles will be released alive and survive. We will use the Ryder et al. (2006) criteria to assess the cumulative likelihood that a sea turtle will die as a result of all longline interactions that occur during the course of this proposed action. For Southern DPS Pacific eulachon, we expect up 25 individuals, or 1 kg, of eulachon may be incidentally captured and killed in any year in SWFSC survey trawls in the CCE. For Eastern Pacific DPS scalloped hammerhead, we expect one individual may be incidentally captured or entangled and killed in any year during longline surveys in the ETP. We will assume that any scalloped hammerhead captured during SWFSC research comes from the Eastern Pacific DPS, unless or until genetic information suggests otherwise.

Table 69. Incidental take of ESA-listed salmon expected each year through capture in SWFSC trawl gear. All takes are assumed to lead to mortality. Totals reflect combinations of sub-adults and juveniles by species and/or ESU/DPS that are expected or considered possible, as described in section 2.6.1.1.4.

	sub-adult	juvenile	total
Chinook			**53**
Sacramento River winter-run	1	1	2
Central Valley spring-run	1	1	2
California Coastal	1	2	3
Snake River fall	1	1	2
Snake River spring/summer	1	1	2
Lower Columbia River	1	4	5
Upper Willamette River	1	2	3
Upper Columbia River spring	1	1	2
Puget Sound	1	2	3
chum			**5**
Hood Canal summer-run	5	5	5[1]
Columbia River	5	5	5[1]
coho			**51**
Central California Coastal	4	4	8
S. Oregon/N. California Coastal	15	15	29
Oregon Coast	15	15	30
Lower Columbia River	13	13	25
sockeye			**4**
Snake River	4	4	4[1]
Ozette Lake	4	4	4[1]
steelhead			**4**
Southern California	4	4	4[1]
South-Central California	4	4	4[1]
Central California Coast	4	4	4[1]
California Central Valley	4	4	4[1]
Northern California	4	4	4[1]
Upper Columbia River	4	4	4[1]
Snake River Basin	4	4	4[1]
Lower Columbia River	4	4	4[1]
Upper Willamette River	4	4	4[1]
Middle Columbia River	4	4	4[1]
Puget Sound	4	4	4[1]

[1] Total reflects the possibility that takes could be all sub-adult, all juvenile, or some combination of both.

For salmonids, we expect that a total of 53 Chinook, 5 chum, 51 coho, 4 sockeye, and 4 steelhead, will be incidentally captured and killed in SWFSC survey trawls in the CCE. If these totals are exceeded, then take will have occurred in excess of what has been considered in this opinion. The exact proportions of these totals that will be composed of these individual ESUs or DPSs, both ESA-listed and non-listed population, are uncertain and will not be known until genetic analyses are completed. Because there is uncertainty and the expectation that proportions of species totals that can be attributed to individual ESUs and DPSs are likely to vary significantly each year over time, we have described the maximum number of individuals we expect to be captured from each ESU/DPS in Table 69. For Chinook and coho, this means that the individual ESU take amounts that may be expected and listed in Table 69 would not necessarily add up to the total number of Chinook or coho that is expected. Genetic analyses will be used to determine if any of these specific ESUs are being taken in excess of what has been considered in this opinion.

For the section 10(a)(1)(A) research permit (19320), there is no incidental take at all. The reason for this is that all take contemplated for this permit would allow the permit holder to directly take the animals in question. The actions are considered to be direct take rather than incidental take because in every case the 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 directed take laid out in Table 3 and the effects section above (2.6). Those amounts - displayed in the various permits' effects analyses - constitute hard limits on both the amount and extent of directed take the permit holders would be allowed in a given year. This concept is also reflected in the reinitiation clause just below.

MMPA Letter of Authorization for SWFSC research and acoustic harassment

As part of the proposed action covered in this opinion, NMFS OPR is proposing Level A authorization of serious injury and mortality of non-listed marine mammals as a result of incidental capture or entanglement with the SWFSC survey gear, as well as Level B acoustic harassment under the MMPA of marine mammals resulting from SWFSC research activities and the use of active acoustic equipment aboard ship-based surveys (80 FR 8166). We have considered the impact of this proposed action and concluded that no adverse impacts to ESA-listed species are expected from the use of the acoustic equipment. Consequently, no incidental ESA take of ESA-listed marine mammals as a result of exposure to active acoustic sources used during SWFSC research activity is anticipated.

2.10.2 Effect of the Take

In the biological opinion, we determined that the amount or extent of anticipated take, coupled with other effects of the proposed action, is not likely to result in jeopardy to any of these species or destruction or adverse modification of any designated critical habitats.

2.10.3 Reasonable and Prudent Measures

"Reasonable and prudent measures" are nondiscretionary measures that are necessary or appropriate to minimize the impact of the amount or extent of incidental take (50 CFR 402.02).

1. The SWFSC shall minimize the amount of serious injury and or mortality among ESA-listed animals that are incidentally taken in any research survey.

2. The SWFSC shall monitor, document, and report all incidental take of protected species resulting from their survey.

2.10.4 Terms and Conditions

The terms and conditions described below are non-discretionary, and the SWFSC must comply with them in order to implement the reasonable and prudent measures (50 CFR 402.14). The SWFSC has a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this incidental take statement (50 CFR 402.14). If the entity to whom a term and condition is directed does not comply with the following terms and conditions, protective coverage for the proposed action would likely lapse.

1. The following terms and conditions implement reasonable and prudent measure 1:

1a. The SWFSC shall implement mitigation and avoidance measures described in section 1.3.4 of this opinion to avoid interactions with protected species, including those required in conjunction with the MMPA LOA authorization.

1b. The SWFSC shall implement measures to minimize the handling time and improve the survivability of all ESA-listed species incidentally captured or entangled in SWFSC research survey gear, allowing for biological sampling as appropriate.

1c. Chief Scientists and all staff responsible for overseeing implementation of minimization and avoidance measures for ESA-listed species and marine mammals, as well as safe handling of and scientific sample collection from these species, shall receive training on procedures and protocols, updated as deemed necessary by the SWFSC in consultation with WCR.

2. The following terms and conditions implement reasonable and prudent measure 2:

2a. The SWFSC shall monitor and record the incidental capture or entanglement of all ESA-listed species and marine mammals. An annual report summarizing the take of all ESA-listed species and marine mammals during the previous research season shall be provided by April 1st each year to the following address:

Chris Yates
NMFS West Coast Region Protected Resources Division
501 W. Ocean Blvd, Suite 4200
Long Beach, CA 90802

Information included in the reports provided to the WCR PRD must include: species name, number(s), size/weight/age class/gender (if applicable), and any available information on the date, location (latitude and longitude), and release condition associated with each take of all ESA-listed species, as well as pertinent details on the monitoring and mitigation measures in use at the time when takes occurred. The SWFSC may elect to use the annual report and reporting format required under the proposed MMPA LOA for marine mammals, augmented as necessary to fulfill the reporting requirement for ESA-listed species.

2b. Any takes of ESA-listed marine mammals or sea turtles, must be reported to the NMFS West Coast Region Stranding Coordinator, Justine Viezbicke, at 562-980-3230 or Justin.Viezbicke@noaa.gov, as soon as practicable. Under the proposed MMPA LOA, the SWFSC is required to report any take of all marine mammals and sea turtles to NMFS within 48 hours of returning to port through the Protected Species Incidental Take (PSIT) database. The SWFSC and OPR shall take steps necessary to ensure the WCR Marine Mammal and Sea Turtle Stranding Program is notified coincidentally with these reports, and that data and/or stranding forms are submitted to the WCR Stranding Coordinator in a timely fashion upon return to port.

2c. The SWFSC and OPR shall consult with the WCR PRD annually, or upon request as necessary, to review any new information regarding impacts to ESA-listed species from SWFSC research, any new science or commercial data related to ESA-listed species, any new or revised ESA-listing decisions, or any other relevant developments which have occurred in the last year that may be applicable to this proposed action. The proposed MMPA LOA requires OPR and the SWFSC to meet annually to discuss the monitoring reports, current science, and whether mitigation or monitoring modifications under the LOA are appropriate. The presence of the WCR PRD in that meeting can be used to satisfy this condition.

2.11 Conservation Recommendations

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Specifically, conservation recommendations are suggestions regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information (50 CFR 402.02).

1. Because so little is known about the marine distribution of many ESA-listed species throughout the proposed action area, the SWFSC should document all sightings and encounters of ESA-listed species that may contribute to the body of knowledge regarding their distribution in marine waters.

2. The SWFSC, in conjunction with the WCR and OPR, should evaluate development and implementation of additional mitigation and avoidance measures for ESA-listed species and other marine mammals, as well as potential modification of current measures, to minimize interactions with protected resources while maximizing the efficiency and performance of SWFSC research activities.

3. The SWFSC, in conjunction with WCR, should continue exploring and developing new approaches to improve the understanding of how ecosystem and climatic variables may affect the presence, abundance, and distribution of ESA-listed species and other protected resources.

2.12 Reinitiation of Consultation

This concludes formal consultation for Continued Prosecution of Fisheries Research Conducted and Funded by the Southwest Fisheries Science Center; Issuance of a Letter of Authorization under the Marine Mammal Protect Act for the Incidental Take of Marine Mammals Pursuant to those Research Activities; and Issuance of a Directed Scientific Research Permit under the Endangered Species Act.

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

With regard to the proposed section 10 permitted direct take, there is no incidental take anticipated, and the reinitiation trigger set out in (1) is not applicable. If any of the directed take amounts specified in this opinion's effects analysis section (2.6) 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.

As described earlier, we have concluded that the effects of acoustic on marine mammals to be insignificant and discountable, and no ESA take is authorized. If, during the course of research activities, observation of apparent behaviors or injuries that may be indicative that effects are significant, reinitiation of formal consultation will be required because the regulatory reinitiation triggers set out in (1), (2), and/or (3) with regard to acoustic impacts will have been met.

3. 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.

3.1 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 SWFSC, OPR, and NMFS WCR. Other interested users could include non-governmental organizations (NGOs) involved in monitoring NMFS research and policy activities, other scientific institutions that may also conduct research activities throughout the CCE, ETP, and Antarctic, and the large pool of stakeholders and the general public that may have specific interests in conservation of any of the 53 ESA-listed species and their critical habitats that are mentioned in this opinion. Individual copies of this opinion were provided to the SWFSC, OPR, and the Permits Team of the NMFS WCR PRD. This opinion will be posted on the Public Consultation Tracking System web site (https://pcts.nmfs.noaa.gov/pcts-web/homepage.pcts), and will be made available on the OPR and NMFS WCR websites. The format and naming adheres to conventional standards for style.

3.2 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.

3.3 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.

Best Available Information: This consultation and supporting documents use the best available information, as referenced in the References section. The analyses in this opinion 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.

4. REFERENCES

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APPENDIX 1. Summary description of SWFSC surveys conducted annually on NOAA vessels and NOAA-chartered vessels.

Survey Name	Survey Description	General Area of Operation	Season, Frequency, Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Number of Samples	Mitigation Measures
California Current Research Area								
Survey Using Trawl Gear								
Coastal Pelagic Species (CPS) Survey (aka Sardine Survey)	One or two ship survey. Results of survey inform the annual assessment of sardines and the corresponding harvest guideline. Consists of southern and northern portions conducted on two survey vessels. When possible, preference has been for a two-ship survey. The southern portion is done in conjunction with the spring or summer CalCOFI Survey. Protocols similar to CalCOFI with the addition of mid-water trawls conducted near the surface at night to sample adult sardines.	United States (U.S.) West Coast Exclusive Economic Zone (EEZ)	Annually or biennially, April-May or July-August 70 DAS (~35DAS/vessel)	NOAA ship, Charter vessel One or two ship survey	NETS Nordic 264 two-warp rope trawl	Towed near-surface, primarily at night Tow speed: 2-4 knots (kts) Duration: 30 min at intended depth	50 tows	Acoustic pingers, marine mammal excluder devices (MMEDs), limited visual monitoring (night trawl), “move-on” rule.
					Various plankton nets (Bongo, Pairovet, Manta)	Tow speed: 1.5-2.5 kts for Bongo and Manta; 0 for Pairovet Duration: 10-20 min	75 tows	
					Conductivity Temperature Depth (CTD) and rosette water sampler	Tow speed: 0 Duration: 20-120 min	75 casts	
					Continuous Underway Fish Egg Sampler (CUFES)		Continuous	
					Multi-frequency single-beam active acoustics	18, 38, 70, 120, 200 kilohertz (kHz)	Continuous	
					Multi-beam echosounder (Simrad ME70) and sonar (Simrad MS70)		Continuous	

Survey Name	Survey Description	General Area of Operation	Season, Frequency, Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Number of Samples	Mitigation Measures
Juvenile Rockfish Survey	Targets pelagic phase of juvenile rockfish with nighttime tows. Results of survey inform assessments of several rockfish populations and may soon be used in assessments of Central California salmon productivity.	West Coast EEZ	Annually, May-mid-June 45 DAS	NOAA ship, Charter vessel	Modified Cobb Midwater Trawl	Tow speed: 2 kts Duration: 15 min at intended depth	150 tows	Acoustic pingers, development of MMEDs, limited visual monitoring (night trawl), "move-on" rule.
					CTD profiler and rosette water sampler	Tow speed: 0 Duration: 5-120 min	~250 casts	
					Various plankton nets (Bongo and Tucker)	Tow speed: 1.5-2.5 kts Duration: 20-60 min	50 tows	
					Multi-frequency single-beam active acoustics	18, 38, 70, 120, 200, 333 kHz	Continuous	
Juvenile Salmon Survey	Measures ocean survival of juvenile salmon and produces early estimate of adult returns. Protocols include surface-water trawls, active acoustics, oceanographic and meteorological measurements. Tissue samples are collected for genetic analysis.	Central CA to southern OR	Annually, June and September 30 DAS total for two surveys	Charter vessel	NETS Nordic 264 two-warp rope trawl	Towed at 15-30 meters (m) deep during daytime Tow speed: 2-4 kts Duration: 30 min at intended depth	50 tows	Acoustic pingers, MMEDs, visual monitoring, "move-on" rule.
					CTD profiler and rosette water sampler	Tow speed: 0 Duration: 20-120 min	50 casts	
					Various plankton nets (Bongo and Tucker)	Tow speed: 1.5-2.5 kts Duration: 20-60 min	50 tows	
					Multi-frequency single-beam active acoustics	18, 38, 70, 120, 200, 333 kHz	Continuous	
Surveys Using Longline Gear								
Highly Migratory Species (HMS) Survey	This survey targets blue sharks, shortfin mako sharks, and other HMS as a basis for stock assessments and support for HMS Fishery Management Plans. Information is also obtained about their	Southern to central CA	Annually, June-July 30 DAS	NOAA ship, Charter vessel	Pelagic longline	Mainline length: 2-4 mile set at 30 ft deep for mako and blue sharks; 300 to 600 ft for swordfish.	60 sets	Visual monitoring, "move-on" rule, operational adjustments to avoid take. Use of circle hooks and finfish bait where possible to minimize sea turtle bycatch.

Survey Name	Survey Description	General Area of Operation	Season, Frequency, Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Number of Samples	Mitigation Measures
	biology, distribution, movements, stock structure and status, and potential vulnerability to fishing pressure. Surveys involve catching sharks on longline gear, measuring, attaching various tags, and releasing them alive.					Gangion length: 12 ft; 36 ft for swordfish Gangion spacing: 50-100 ft apart. Hook size and type: 9/0 J hooks for blue and mako sharks; 16/0 and 18/0 offset, stainless circle hooks for swordfish. Soak time: 2-4 hrs for most species, up to8 hrs for swordfish		
					CTD profiler and rosette water sampler	Tow speed: 0 Duration: 30 min	60 casts	
					Bongo plankton tows	Tow speed: 1.5 kts Duration: 20 min	60 tows	
					Multi-frequency single-beam active acoustics	18, 38, 70, 120, 200, 333 kHz	Continuous	
Reproductive Life History Analysis of Sablefish	This survey is conducted to collect adult sablefish for reproduction studies. Surveys involve catching sablefish on longline gear.	Central California (near Bodega Bay)	Monthly (One day per month), 30 DAS	Charter vessel	Small commercial bottom longline	75 hooks per line, baited with squid, set at depths of 360-450m	2-3 sets per trip	“move on” rule if a marine mammal is encountered
Thresher Shark Survey	This survey is conducted to support stock assessment and management of thresher sharks, which are subject to commercial and recreational fisheries. Surveys involve catching sharks on longline gear, measuring and taking	Southern CA Bight	Annually, September 20 DAS	Charter vessel	Anchored pelagic longline	Mainline length: 1-2 mile set at 12 ft deep Gangion length: 12 ft Gangion spacing: 50-100 ft apart. Hook size and type:13/0 offset	40 sets	Visual monitoring, “move-on” rule, operational adjustments to avoid take. Use of circle hooks and finfish bait to minimize sea turtle bycatch.

Survey Name	Survey Description	General Area of Operation	Season, Frequency, Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Number of Samples	Mitigation Measures
	tissue samples, attaching various tags, and releasing them alive.					circle hooks for thresher sharks Soak time: 2-4 hr		
					CTD profiler and rosette water sampler	Tow speed: 0 Duration: 30 min	40 casts	
					Bongo plankton tows	Tow speed: 1.5 kts Duration: 20 min	60 tows	
					Multi-frequency single-beam active acoustics	18, 38, 70, 120, 200, 333 kHz	Continuous	
Surveys Using Trawl and /or Longline Gear								
Habitat Surveys (swordfish and adult rockfish)	Surveys include adult rockfish EFH, co-use of habitat by swordfish and leatherback turtles.	California Current LME	Opportunistically as funds and ship time are available 50 DAS	NOAA ship and charter vessels	NETS Nordic 264 two-warp rope trawl	Towed near-surface at night Tow speed: 2-3 kts Duration: 30 min at intended depth	10 tows	Visual monitoring, "move-on" rule, acoustic pingers, and MMEDs
					Pelagic longline	Mainline length: 2-12 mile set at 600 feet deep depending on target species. Gangion length: 36 ft Gangion spacing: 50-100 ft apart Hook size and type:16/0 and 18/0 offset, stainless circle hooks for swordfish Soak time: up to 8 hr	20 sets	Visual monitoring, operational adjustments to avoid take. Use of circle hooks and finfish bait to minimize sea turtle bycatch.
					Bongo plankton tows	Tow speed: 1.5 kts Duration: 20 min	100 tows	

Survey Name	Survey Description	General Area of Operation	Season, Frequency, Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Number of Samples	Mitigation Measures
					CTD profiler and rosette water sampler	Tow speed: 0 Duration: 30 min	100 casts	
					Oozeki, IKMT, MOCNESS, Tucker nets	Tow speed: 2-3 kts Duration: 20-60 min	50 tows	
					Manned Submersible	1-3 hour dives	10 dives	
Surveys Using Other Gear								
California Cooperative Oceanic Fisheries Investigation (CalCOFI) **Winter, Spring, Summer and Fall Surveys**	CalCOFI is a partnership of NMFS, California Department of Fish and Game, and Scripps Institution of Oceanography. The survey series was started in 1949 to describe the pelagic ecology of the California Current and its influence on the population dynamics of west coast sardine stocks. Several hundred taxa of marine fishes and zooplankton are monitored along with aspects of their physical and biological environment. Sampling protocols include transects to assess the distribution and abundance of marine mammals and seabirds	San Diego to San Francisco	Four surveys annually in January-February, April, July and October 90 DAS total for four surveys	NOAA ships and University-National Oceanic Laboratory System fleet (Scripps Institution of Oceanography)	Various plankton nets (Bongo, Pairovet, Manta, PRPOOS)	Tow speed: 1.5-2.5 knots (kts) for Bongo and Manta; 0 for Pairovet Duration: 10-20 minutes (min)	75-113 stations per survey; 340 samples total	Visual Monitoring
					CTD profiler and rosette water sampler	Tow speed: 0 Duration: 20-120 min	340 casts total	
					Various small, towed, fine-mesh nets designed to sample larval and juvenile fish and small pelagic invertebrates (Matsuda-Oozeki-Hu trawl net [MOHT], Isaacs-Kidd Mid-water Trawl[IKMT], MOCNESS, Tucker)	Tow speed: 2-3 kts Duration: 20-60 min	35-85 tows total	
					CUFES		Continuous	
					Multi-frequency single-beam active acoustics	18, 38, 70, 120, 200 kHz	Continuous	

Survey Name	Survey Description	General Area of Operation	Season, Frequency, Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Number of Samples	Mitigation Measures
					Multi-beam echosounder (Simrad ME70) and sonar (Simrad MS70)		Continuous	
Collaborative Optical Acoustical Survey Technology (COAST) Survey	ROV and acoustic surveys of offshore banks designed to monitor recovery of rockfish. Conducted in collaboration with the charter boat fishing industry.	Southern and Central California	Opportunistically as funds and ship time are available 40 DAS	NOAA ship, Charter vessel	Multi-frequency single-beam active acoustics	18, 38, 70, 120, 200, 333 kHz	Continuous	
					Still and video camera images taken from an ROV			
Marine Mammal and Ecosystem Assessment Surveys	One or two ship surveys are conducted to assess all marine mammal species in west coast EEZ, or to focus on the distribution and ecology of a selected group of species. Sampling protocols include transects to assess the distribution and abundance of marine mammals, seabirds, and the status of the ecosystems that support them.	California Current Large Marine Ecosystem (LME)	Tri-annually (July - Dec) 60-120 DAS total for three surveys	NOAA ship One or two ship survey	Bongo plankton tows	Tow speed: 1.5 kts Duration: 20 min	60 tows	
					CTD profiler and rosette water sampler	Tow speed: 0 Duration: 30 min	40 casts	
					Oozeki, IKMT, MOCNESS, Tucker nets	Tow speed: 2-3 kts Duration: 20-60 min	60 tows	
					Expendable bathythermographs (XBTs)		80-240 units	
					Multi-frequency single-beam active acoustics	18, 38, 70, 120, 200, 333 kHz	Continuous	
Pacific Coast Ocean Observing System (PacOOS) Central CA	Extension of CalCOFI observation protocols to CalCOFI lines off Monterey Bay and San Francisco during summer and fall surveys when the CalCOFI sampling grid is confined to the Southern California Bight. Surveys conducted in conjunction with Monterey Bay	Central CA, fixed survey lines off Monterey and San Francisco Bays	Annually, July and October 6 DAS total for two surveys	Research Vessel (R/V) Point Sur	Various plankton nets (Bongo, California Vertical Egg Tow (CalVET), Pairovet, Manta)	Tow speed: 1.5-2.5 kts for Bongo and Manta; 0 for CalVET and Pairovet Duration: 10-20 min	40 tows	
					CTD profiler and rosette water sampler	Tow speed: 0 Duration: 20-120 min	40 casts	

Survey Name	Survey Description	General Area of Operation	Season, Frequency, Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Number of Samples	Mitigation Measures
	Aquarium Research Institute, UC Santa Cruz, and Navy Post-Graduate School							
PacOOS North CA	Extension of CalCOFI observation protocols to a sampling line off Eureka CA. Surveys conducted in conjunction with Humboldt State University.	Northern CA, fixed survey lines off Eureka	Monthly 12 DAS total for 12 surveys	R/V Coral Sea	Various plankton nets (Bongo, CalVET, Pairovet, Manta)	Tow speed: 1.5-2.5 kts for Bongo and Manta; 0 for CalVET and Pairovet Duration: 10-20 min	100 tows	
					CTD profiler and rosette water sampler	Tow speed: 0 Duration: 20-120 min	100 casts	
Swordfish Tagging using Deep-set Buoy Gear	Investigate the use of deep-set buoy gear to capture and tag swordfish without generating significant bycatch interactions	Southern California Bight	Annually for two years, June-November	PIER research vessel *R/V Malolo*, cooperative commercial fishing vessels	Modified swordfish buoy gear to target pelagic swordfish at depths of 250-400 meters during daylight hours	250-400 m mainline monofilament with a buoy flotation system and a 1-2 kilogram (kg) drop sinker. Two monofilament gangions would branch from the mainline at 250-400 m and would contain a crimped 14/0 circle hook baited with either squid or mackerel. A single set of gear consists of two baited hooks soaked on average for a 4 hour period.	300 - 600 sets per year	Minimize slack in the fishing line to maintain a vertical profile and use a high speed electric reel to reduce the time that baits are within the upper water column and minimize potential for marine mammal interactions. Use circle hooks to increase post-hooking survivorship of non-target species. Visually monitor all of the indicator buoys from the vessel. When an indicator flag rises, the buoy set would immediately be tended and the animal caught would either be released or tagged and released in order to increase post-hooking survivorship of all animals.

Survey Name	Survey Description	General Area of Operation	Season, Frequency, Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Number of Samples	Mitigation Measures
White Abalone Survey	Remotely Operated Vessel (ROV) surveys of endangered white abalone to monitor population recovery. Surveys confined to offshore banks, island and continental margins, 30-150 m. depth.	Southern CA Bight	Opportunistically as funds and ship time are available 25 DAS	Charter vessel	Still and video camera images taken from an ROV	Tether connecting ROV to the ship is 0.75 inches diameter Avg. speed: 0.5 kts Max. speed: 2.4 kts	100 transects/yr	Slow operating speed minimizes risk of striking a marine mammal. The tether is securely attached to a steel cable and down-weight to minimize slack and prevent loops that might lead to entanglement risk.
Eastern Tropical Pacific Research Area								
HMS Survey	New longline survey planned for the future to monitor HMS abundance and distribution	Eastern Tropical Pacific Ocean	Annually, June-July 30 DAS	NOAA ship, Charter vessel	Pelagic longline	Mainline length: 2-4 mile set 30 feet deep for mako and blue sharks; 300 to 600 feet deep for swordfish Gangion length: 10-15 ft Gangionspacing: 50-100 ft apart Hook size and type: 9/0 J hooks for blue and mako sharks; 16/0 and 18/0 offset, stainless circle hooks for swordfish. Soak time: 2-4 hr	60 sets	Visual monitoring, “move-on” rule, operational adjustments to avoid take. Use of circle hooks where possible and finfish bait to minimize sea turtle bycatch.

Survey Name	Survey Description	General Area of Operation	Season, Frequency, Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Number of Samples	Mitigation Measures
					Bongo plankton tows	Tow speed: 1.5 kts Duration: 20 min	60 tows	
					CTD profiler and rosette water sampler	Tow speed: 0 Duration: 20-120 min	60 casts	
					Multi-frequency single-beam active acoustics	18, 38, 70, 120, 200, 333kHz	Continuous	
Marine Mammal Surveys	Multi-year cetacean and ecosystem assessment study designed to monitor the recovery of several dolphin stocks that were depleted by the yellowfin tuna purse-seine fishery in the ETP Ocean. Sampling protocols include visual observations of marine mammals and seabirds.	Eastern Tropical Pacific Ocean	Tri-annually (Jul – Dec) 240 DAS total for three surveys	NOAA ships Two ship survey	Bongo plankton tows	Tow speed: 1.5 kts Duration: 20 min	500 tows	
					CTD profiler and rosette water sampler	Tow speed: 0 Duration: 30 min	500 casts	
					Oozeki, IKMT, MOCNESS, Tucker nets	Tow speed: 2-3 kts Duration: 20-60 min	50-125 tows	
					Multi-frequency single-beam active acoustics	18, 38, 70, 120, 200, 333 kHz	Continuous	
					XBTs		720 units	
Antarctic Research Area								
Antarctic Survey	Shipboard surveys monitor the abundance and distribution of krill for stock assessments and studies of the foraging ecology of land-breeding	Scotia Sea sector of the Southern Ocean, including the continental	Annually, January-March or Annually, July-October	Charter (R/V Yuzhmorgeolgiya, R/V Moana Wave, R/V Ocean Stalwart)	Oozeki, IKMT, MOCNESS, Tucker nets	Tow speed: 2-3 kts Duration: 20-60 min	200 tows	
					Multi-frequency active acoustics	38, 70, 120 and 200 kHz	Continuous	

Survey Name	Survey Description	General Area of Operation	Season, Frequency, Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Number of Samples	Mitigation Measures
	penguin and fur seal populations. Protocols include marine mammal and seabird observations. Every 2-3 years these protocols are augmented with a bottom trawl used to sample benthic invertebrates and fish. Results of the survey inform fish stock assessments and benthic habitat descriptions.	shelf adjacent to the Antarctic Peninsula, and the South Shetland, South Orkney, South Sandwich and South Georgia archipelagos	Bottom trawl conducted every 2-3 years 70 DAS		CTD profiler and rosette water sampler	Tow speed: 0 Duration: 45 min	200 casts	
					Video camera tows	Tow speed: <3 kts Duration: <65 min	25 tows	
					Two-warp NET Hard-Bottom Snapper Trawl	Tow speed: 2-3 kts Duration: 30 min	100 tows	