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

Endangered Species Act Section 7(a)(2) Biological Opinion and Conference on the Continued Prosecution of Fisheries Research Conducted and Funded by the Southwest Fisheries Science Center, Including Issuance of a Letter of Authorization under the Marine Mammal Protect Act for the Incidental Take of Marine Mammals Pursuant to those Research Activities

NMFS Consultation Number: WCRO-2020-01302
ARN 151422WCR2020PR00228

Action Agency: NOAA Southwest Fisheries Science Center

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, Mexico DPS (*Megaptera novaeangliae*)[2]	Threatened	No[1]	N.A.	No[1,4]	N.A.
Humpback whale, Central America DPS	Endangered	No[1]	N.A.	No[1,4]	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[1,5]	N.A.
Gray whale, western North Pacific population (*Eschrichtius robustus*)[2]	Endangered	No[1]	N.A.	N.A.	N.A.

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[1]	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[1]	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, East Pacific DPS (*Chelonia mydas*)[2]	Endangered/ Threatened	Yes	No	N.A.	N.A.
Hawksbill turtle (*Eretmochelys imbricate*)[2]	Endangered	No[1]	N.A.	N.A.	N.A.
Marine Fish					
Green sturgeon, Southern DPS (*Acipenser medirostris*)	Threatened	No[1]	N.A.	No[1]	N.A.
Pacific eulachon, Southern DPS (*Thaleichthys pacificus*)	Threatened	Yes	No	N.A.	N.A.
Gulf grouper (*Mycteroperca jordani*)	Endangered	No[1]	N.A.	N.A.	N.A.
Giant manta ray (*Manta birostris*)	Threatened	No[1]	N.A.	N.A.	N.A.
Scalloped hammerhead shark, Eastern Pacific DPS (*Sphyrna lewini*)[2]	Endangered	No[1]	N.A.	N.A.	N.A.
Oceanic whitetip shark (*Carchirinus lonigmanus*)	Threatened	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[1]	N.A.
Salmonids					
Sacramento River winter-run Chinook (*Oncorhynchus tshawytscha*)	Endangered	Yes	No	N.A.	N.A.
Central Valley spring-run Chinook	Threatened	Yes	No	N.A.	N.A.
California Coastal Chinook	Threatened	Yes	No	N.A.	N.A.
Snake River fall Chinook	Threatened	Yes	No	N.A.	N.A.
Snake River spring/summer Chinook	Threatened	Yes	No	N.A.	N.A.
Lower Columbia River Chinook	Threatened	Yes	No	N.A.	N.A.
Upper Willamette River Chinook	Threatened	Yes	No	N.A.	N.A.
Upper Columbia River spring Chinook	Endangered	Yes	No	N.A.	N.A.
Puget Sound Chinook	Threatened	Yes	No	N.A.	N.A.
Hood Canal summer run chum (*Oncorhynchus keta*)	Threatened	Yes	No	N.A.	N.A.
Columbia River chum	Threatened	Yes	No	N.A	N.A.
Central California Coast coho (*Oncorhynchus kistuch*)	Endangered	Yes	No	N.A.	N.A.
S. Oregon/N. California Coast coho	Threatened	Yes	No	N.A.	N.A.
Oregon Coast coho	Threatened	Yes	No	N.A.	N.A.
Lower Columbia River coho	Threatened	Yes	No	N.A.	N.A.
Snake River sockeye (*Oncorhynchus nerka*)	Endangered	Yes	No	N.A.	N.A.
Lake Ozette sockeye	Threatened	Yes	No	N.A.	N.A.
Southern California steelhead	Endangered	Yes	No	N.A.	N.A.

(*Oncorhynchus mykiss*)					
South-Central California Coast steelhead	Threatened	Yes	No	N.A.	N.A.
Central California Coast steelhead	Threatened	Yes	No	N.A.	N.A.
California Central Valley steelhead	Threatened	Yes	No	N.A.	N.A.
Northern California steelhead	Threatened	Yes	No	N.A.	N.A.
Upper Columbia River steelhead	Endangered	Yes	No	N.A.	N.A.
Snake River Basin steelhead	Threatened	Yes	No	N.A.	N.A.
Lower Columbia River steelhead	Threatened	Yes	No	N.A.	N.A.
Upper Willamette River steelhead	Threatened	Yes	No	N.A.	N.A.
Middle Columbia River steelhead	Threatened	Yes	No	N.A.	N.A.
Puget Sound steelhead	Threatened	Yes	No	N.A.	N.A.

1 Please refer to section 2.12 for the analysis of species and critical habitats 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 Critical habitat for the Mexico DPS and Central America DPS of humpback whales was proposed on October 9, 2019 (84 FR 54354).
5 Revision of designated critical habitat for Southern Resident killer whales was proposed on September 19, 2019 (84 FR 49214).

Consultatior ries Service, West Coast Region

Issued By:

Assistant Regional Administrator for Protected Resources

Date: December 10, 2020

TABLE OF CONTENTS

Contents

1. INTRODUCTION

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

1.1. Background

The National Marine Fisheries Service (NMFS) prepared the biological opinion (opinion) and incidental take statement (ITS) portions of this document in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973 (16 USC 1531 et seq.), and implementing regulations at 50 CFR 402, as amended.

We completed pre-dissemination review of this document using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (DQA) (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). The document will be available within two weeks at the NOAA Library Institutional Repository [https://repository.library.noaa.gov/welcome]. A complete record of this consultation is on file at the NMFS West Coast Region (WCR) Long Beach Office.

1.2. Consultation History

In 2015, NMFS WCR issued a biological opinion to the Southwest Fisheries Science Center (SWFSC) and to the NMFS Office of Protected Resources (OPR) on the Continued Prosecution of Fisheries Research Conducted and Funded by the Southwest Fisheries Science Center; Issuance of a Letter of Authorization (LOA) under the Marine Mammal Protection Act (MMPA) 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 2015a). This opinion was the product of a comprehensive environmental compliance effort by the SWFSC that included development of a Programmatic Environmental Assessment (PEA) prepared under the Environmental Policy Act (NEPA), as well as issuance of MMPA and Endangered Species Act (ESA) permits to the SWFSC to cover incidental and directed take of protected species in their research activities from 2015-2020, as needed at that time to achieve compliance across these statutes and mandates (and others).

During the last 5 years since that time, SWFSC has executed their research programs under the obligations and guidance provided through the compliance process, including the terms and conditions of the 2015 biological opinion and the mitigation and monitoring requirements of the MMPA LOA. Throughout this time period, SWFSC maintained contact with WCR staff on the ongoing progress of research activities, and monitoring of the incidental take of protected species along with measures being implemented to minimize the extent of impacts that may occur.

Specifically, SWFSC was in periodic contact with WCR staff regarding the extent of salmon bycatch that occurred in research surveys (Coastal Pelagic Species survey) starting in 2017. In response, SWFSC coordinated with WCR Protected Resource Division (PRD) on proper ways to document and respond to these events, emphasized proper salmon sampling during surveys, and established a Salmon Working Group to better understand the increased take of salmon in research surveys. This Salmon Working Group presented their findings in report titled *SWFSC Incidental Take of ESA Listed Salmonids From 2016-2018* (SWFSC 2019a). This, along with a memo to the record regarding the exceedance of authorized takes of salmon in SWFSC research activities (SWFSC 2019b), were provided to WCR during the lead-up to initiation of consultation for this proposed action.

Preparation by the SWFSC and coordination with WCR to renew the environmental compliance efforts for next 5 years of research activities following the initial environmental compliance process that concluded in 2015 began in spring and summer of 2019. Periodic phone calls and emails were exchanged regarding the expected timing and subjects of the process that would ultimately lead to initiation of ESA consultation on 5 years of research activities beginning in the fall of 2020. On November 14, 2019, staff from SWFSC, WCR, and consultants working to produce regulatory documents met to discuss the pending environmental compliance efforts, including needs for initiating formal consultation on ESA-listed species. On January 6, 2020, a similar suite of staff and consultants met to discuss progress on a draft biological assessment (BA) to support ESA section 7 consultation, as well as progress on a draft Supplemental Programmatic Environmental Assessment (SPEA) and draft application for an MMPA LOA. In general, the nature of the discussions were focused on coordinating the timelines for all these environmental compliance processes to conclude by the fall of 2020 as the previous MMPA

LOA and biological opinion are expiring, and on the information needed to initiate and complete ESA consultation. During these discussions, it was apparent that the proposed research plan over the next 5 years was generally similar to what had been proposed in 2015, with some key differences. Changes in the status of ESA-listed species and designated critical habitats were identified, and potential changes in the analysis of effects were also discussed. These discussion included consideration of proposed critical habitat designations currently under process and consideration by NMFS that may be affected by SWFSC research. Although consultation on proposed critical habitats may not have been required, WCR and SWFSC agreed to proceed with conference consultation on these proposed critical habitat designations to ensure a thorough consideration of them had been completed should these proposed designations be finalized during the course of the proposed action, and SWFSC included analysis of their impacts on them within the BA provided to WCR. Finally, discussion surrounding the need of the SWFSC to renew ESA permits issued in 2015 for the directed take of ESA-listed salmonids during research activities indicated their intentions to consider and pursue that matter with the WCR Permits Office separately from this consultation on incidental impacts to ESA-listed species. At the time of issuance of this biological opinion, no new permits for the directed take of salmon by SWFSC have been issued.

On April 20, 2020, we received a letter from SWFSC requesting formal consultation under section 7 ESA on the incidental impacts of their fisheries and ecosystem research activities proposed to occur from 2020-2025. Accompanying the April 20, 2020 letter, SWFSC also transmitted a BA that analyzes the potential incidental impacts of their proposed research activities on ESA-listed species and designated or proposed critical habitats. After reviewing the request, the contents of the BA, along with a draft SPEA and application for the MMPA LOA, staff from WCR met with SWFSC staff and consultants working to assist with preparation of the environmental compliance documentation to discuss the contents of the BA and other associated compliance documents, along with the upcoming process and expectations for completing formal consultation under the ESA. After reviewing the documentation that has been provided and discussions between staff from WCR and SWFSC clarifying presentation of the materials in the BA alongside other documentation that was provided, WCR transmitted a letter on May 22, 2020, to the SWFSC indicating that sufficient information had been provided to initiate formal consultation under the ESA, in accordance with 50 CFR 402.14, beginning with the April 20, 2020, consultation request submitted to WCR.

Throughout the summer of 2020, WCR staff remained in periodic contact with SWFSC and their consultants to exchange information and provide updates on the progress of all the environmental compliance elements as well as the development of the biological opinion. On July 28, 2020, WCR provided SWFSC a list of key information needs regarding the proposed action and potential effects via email. In combination with the absence of a proposed MMPA LOA issued by OPR at that time, which is a necessary leg of the complete proposed action (see below), the consultation was paused until all the necessary information was provided by SWFSC and OPR, and evaluated by WCR. Responses to requests to from WCR were provided via email and through conference calls, culminating with exchanges at the end of August, 2020.

In July, 2020, staff from WCR and OPR began coordination on the issuance of the proposed MMPA LOA, including transmittal of draft language of the proposed LOA under review to

WCR staff via email for initial incorporation into consideration of the proposed action and drafting of this biological opinion. On August 28, 2020, OPR published the proposed LOA for a 30 day comment period that included Level B harassment for a number of ESA-listed marine mammals in the California Current Ecosystem and Antarctica (85 FR 53606). No Level A injuries for ESA-listed marine mammals was proposed to be included in the MMPA. On August 31, 2020, OPR transmitted a request for formal consultation on the proposed issuance of the LOA to SWFSC.

Following issuance of the proposed MMPA LOA, receipt of the request from OPR for formal consultation, and ongoing exchanges with SWFSC regarding information needs, WCR resumed the consultation with the necessary information in hand on September 8, 2020.

1.3. Proposed Federal Action

Under the ESA, "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 two 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 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) and the Scotia Sea in the Southern Ocean off Antarctica.[1]
- 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 SWFSC research activities considered in this opinion, the adverse interaction noted in the last bullet above would be in the form of incidental take - under the MMPA for the marine mammals and the ESA for the other protected species.

[1] 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).

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. Taking of ESA-listed species or marine mammal in any research activity that is considered direct, intentional take must be authorized under section 10 of the ESA and/or section 104 of the MMPA through other processes.
- In addition to the research described in the PEA and SPEA that are considered in this opinion, scientists from the SWFSC regularly collaborate with scientists in other NMFS regions. 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 PEA, SPEA, 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). Historically, the Center conducted studies in the Eastern Tropical Pacific (ETP) Ocean, but none are planned for the period 2020-2025. 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.

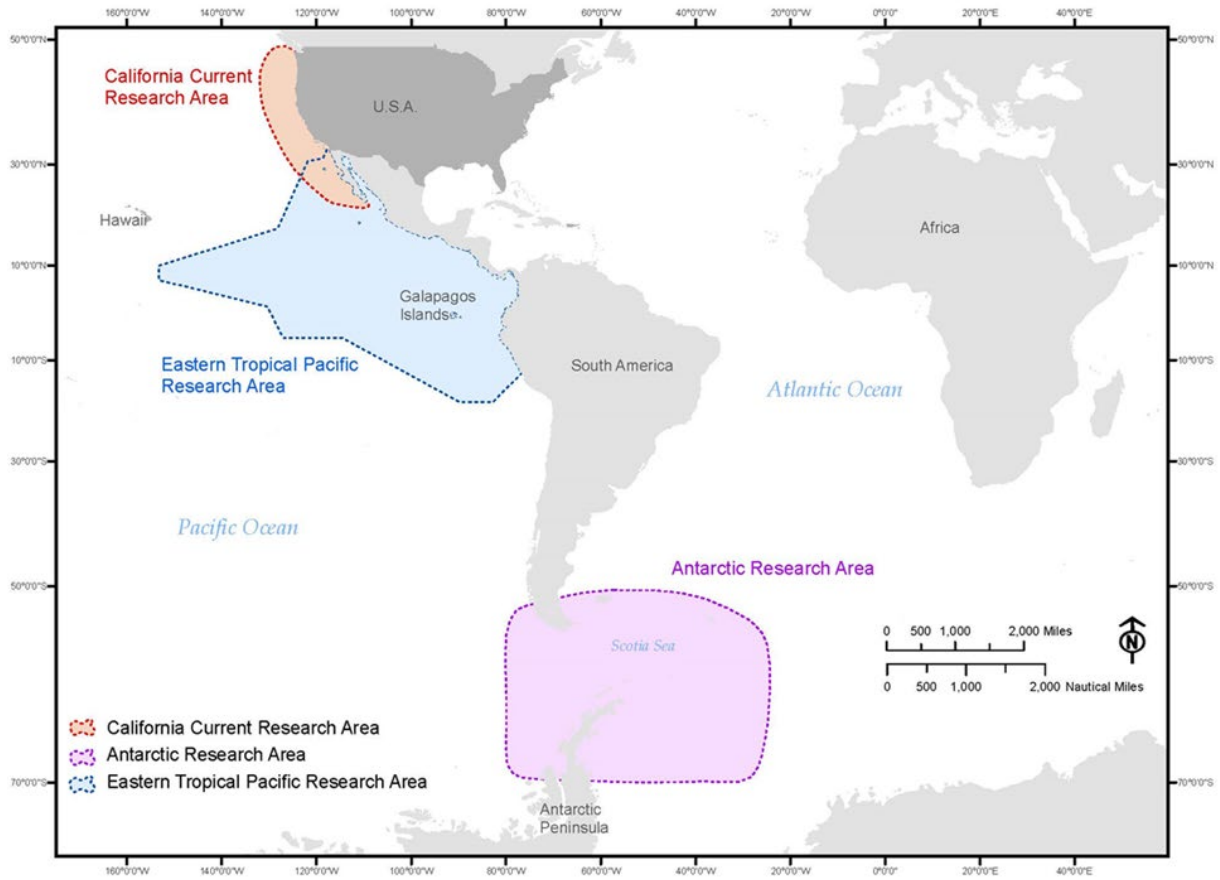

Figure 1. SWFSC research areas.

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 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. More information about each research activity can be found below in this section and in Appendix 1. Generally, future research planned for the period 2020-2025 includes all of the studies described in the 2015 biological opinion for the CCE and Antarctica (NMFS 2015a), plus additional surveys and technologies described and analyzed in the SPEA. As mentioned previously, no research activities are planned for the ETP as part of this proposed action.

Table 1. Summary of proposed SWFSC research 2020-2025.

	Proposed Action	Area of Operation	Seasonal Frequency	Gear Used	
Surveys Using Trawl Gear	Coastal Pelagic Species (CPS) Survey (Sardine Survey) including nearshore (depths between 20-50m)	Nearshore waters out to 120 miles from San Diego, CA to the northern extent of Vancouver Island, Canada	Annually or biennially. April-May or July-August. 70 Days at Sea (DAS) (~35 DAS per vessel); and June-September; DAS: 80 (nearshore study using an industry fishing vessel)	NETS Nordic 264; Various plankton nets; Conductivity Temperature Depth (CTD) and rosette water sampler; Continuous Underway Fish Egg Sampler (CUFES); Hook and Line/Handline; Multi-frequency single beam active acoustics (EK80, ME70, SX90)	50 tows, of which 3-4 tows occur at night; 75 tows 75 casts; Continuous Continuous
	Rockfish Recruitment and Ecosystem Assessment Survey - midwater trawls	CCE/ West Coast EEZ	Annually, May-mid June, 45 DAS	Modified Cobb; Isaacs Kidd CTD profiler and rosette water sampler; Bongo and tucker plankton nets;	150 tows 150 casts; 50 tows;

	Proposed Action	Area of Operation	Seasonal Frequency	Gear Used	Effort (No. of Tows or Casts)
				Multifrequency single beam active acoustics	Continuous
Purse Seine Surveys	Purse Seine Survey including nearshore areas	CCE	Summer- in order to shadow the Reuben Lasker during the CSP Survey; DAS: 60-70 (30–35 per vessel; one vessel in the northern area and one vessel in the southern area)	Purse seine Simrad Echosounder EK60	10-25 schools sampled after targeting with acoustics; ~50 samples will be retained per set; 3-7 transects/day, for total ~200 transects (100 per vessel) Day-night comparison surveys propose 4 sets/day (i.e., 2 daytime and 2 nighttime) over 5 days
Longline Surveys	Highly Migratory Species Surveys including new gear (deep-set buoy gear, troll and rod and reel) for any HMS species	Southern California Bight to Central CA	Annually, June to July, 30 DAS	Deep-set buoy gear; pelagic longline: Troll/rod and reel CTD profiler and rosette water sampler bongo plankton tows; Multi-frequency single-beam active acoustics	varying sets and numbers of hooks depending on species targeted; daytime sampling; up to 30days of effort; 60 casts; 60 tows; Continuous
Hook and Line and/or	Genetics Physiology and Aquaculture	CCE	2 years; November-June; 4 DAS	Hook and line (rod and reel)	12 live fish/year/species

	Proposed Action	Area of Operation	Seasonal Frequency	Gear Used	Effort (No. of Tows or Casts)
	Life History and Reproductive Ecology Investigations of Rockfish including new target species, Sebastes species, using hook and line or other gear.	CCE	Annually; Season is dependent on species targeted- therefore, monthly collection is possible; DAS: 10-15 over multiple 1-day trips; no current efforts are scheduled; potential projects could include sail drone and surveys in April-May-June-July, and micro-trolling[2] surveys in May-October	Hook and line (rod and reel)	Several hundred
	CA Current Ecosystem spring and summer surveys conducted with available ship time	CCE	Spring/summer; Frequency: with available ship time; ~120 DAS	Unmanned Systems	~46-50 transects
	White Abalone Study using Remotely Operated Vehicles (ROV)	CCE; Southern California Bight	Opportunistically as funds and ship time are available; ~25 DAS	ROV; still and video imaging cameras taken from the ROV	Continuous
	California Current Deep Sea Coral and Sponge Assessment	CCE	Summer/1 survey per year/ 14-21 DAS	ROV with attached underwater camera, UAS and towed camera systems	1 dive/day for each DAS
	Antarctic Living Marine Resources Program (FREEBYRD) using various types of autonomous underwater vehicles, such as gliders, deployed for longer periods and greater depths	Scotia Sea/AMLR; CCE (testing)	Annually 3-5 months; deployed in December and collected in March	Gliders	Data collected at predetermined intervals; Distance 1500-6000 km

	Antarctic Living Marine Resources Program (Seabirds) - Land-based surveys using Unmanned Systems and telemetry	Scotia Sea/AMLR	Cape Shirreff field camp from December - March each year, and occupy Copacabana field camp in January into early February each year	UAS, telemetry	
	Collaborative Optical Acoustical Survey Technology (COAST) Survey using unmanned systems	Southern and Central California	Opportunistically as funds and ship time are available (~40 DAS)	Mid-frequency single beam active acoustics; Still and video camera images taken from an ROV	Continuous; Continuous
	Ecosystem Based Fisheries Management and Stock Assessment including Monterey Bay or other regions within the California Current	CCE; possibly focus on Monterey Bay Area	Monthly for 2+ years; 12 DAS annually	UAS	
	California Cooperative Oceanic Fisheries Operations (CalCOFI) Winter, Spring, Summer and Fall Survey	CCE; San Diego to San Francisco	Four surveys annually. January to February, April, July, October. 90 DAS total for 4 surveys	Various plankton nets; CTD profiler and rosette water sampler; Small fine mesh nets; CUFES; Multi-frequency single-beam active acoustics; Hook and Line/Handline; Multi-beam echosounder	75-113 stations per survey; 340 samples total 340 casts total; 35-85 tows total; Continuous Continuous Continuous
	Juvenile Salmon Survey including trawl, micro-trolling[2] (hook and line) and	CCE	Annually, June and September, 30 DAS total for two surveys; Saildrone, surveys in April-May-June-July,	Nordic 264 trawl; CTD profiler and rosette water sampler; Hook and line (Micro-troll);	50 tows; 50 casts; 50 tows (of trolling lines);

	Proposed Action	Area of Operation	Seasonal Frequency	Gear Used	Effort (No. of Tows or Casts)
	unmanned systems		and micro-trolling[2] surveys in May-October	Multi-frequency single beam active acoustics; Unmanned systems	Continuous; Continuous
	Humboldt State University Cooperative Fisheries Oceanography Research Team: Trinidad Headlines	CCE	Monthly; 12 hour cruise duration	Plankton nets; CTD	11 plankton tows/cruise (6 vertical; 5 oblique)
	Pacific Coast Ocean Observing Program (Central California)	Central California including Monterey and San Francisco Bays	Annually, July and October; 6 DAS total for two surveys	CTD profiler and rosette water sampler	40 casts
	Pacific Coast Ocean Observing Program (Northern California)	Northern California including areas such as Eureka	Monthly; 12 DAS for a total of 12 surveys	Various plankton nets; CTD profiler and rosette water sampler	100 tows; 100 casts

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 (July-August) and extends from San Diego, CA, to the northern extent of Vancouver Island, Canada. 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.

Research is usually conducted in back to back surveys using the same ship. The survey typically requires about 80 survey days per year. As a modification to the previously analyzed CPS sardine survey, SWFSC proposes to sample nearshore areas whereas previous surveys have only been conducted in depths greater than 50 m. Two commercial purse seine vessels (PSV) are proposed to perform acoustic and biological surveys in conjunction with the NOAA ship Reuben Lasker along inshore portions of established transect lines to contribute additional information on the biomass of CPS species in waters previously un-surveyed. The validation of acoustic data and additional biological samples will enhance SWFSC's ability to improve its stock assessment for Pacific sardine and other CPS. Purse seines may also be used to conduct other surveys within the action area.

The protocol for the CPS survey includes deploying a NETS Nordic 264 two-warp rope trawl for 45-minute tows in the upper 10 m of the water column at 3 knots at night in order to sample CPS species. Additional protocols for this survey are similar to the CalCOFI surveys described below. The use of Unmanned Surface Vehicles (USVs), gliders and other unmanned systems

augment ship surveys and monitor nearshore waters for CPS where a ship cannot safely navigate. Additional opportunistic rod and reel/handline effort may be targeted toward HMS species during these surveys. The reasoning is that it presents a unique opportunity to collect samples from an area where HMS thrive during the times a year the surveys are in the offshore areas, which are otherwise difficult to sample with regularity. That gear will be consistent with gear used to target HMS described below.

CalCOFI Survey – Winter, Spring, Summer, and Fall

These surveys are conducted annually during January and February (winter), April (spring), July (summer), and October (fall). It extends from nearshore to offshore in the CCE from San Diego to San Francisco. It is usually conducted on a NOAA ship and requires about 90 total survey days.

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 use of a Continuous Underwater Fish Egg Sampler (CUFES), various plankton nets (Bongo, Pairovet, Manta, and PRPOOS), conductivity, temperature, and depth (CTD) sensors 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, and trawls for sampling mesopelagic organisms at selected stations. Additional opportunistic rod and reel/handline effort may be targeted toward HMS species during these surveys. The reasoning is that it presents a unique opportunity to collect samples from an area where HMS thrive during the 4 times a year the surveys are in the offshore areas, which are otherwise difficult to sample with regularity. That gear will be consistent with gear used to target HMS described below. See Appendix A *in* the PEA and the CalCOFI website http://www.calcofi.org/ for additional information.

Collaborative Optical Acoustical Survey Technology (COAST)

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. Protocols include the use of multi-frequency active acoustics and still and video camera observations using an ROV.

Pacific Coast Ocean Observing Program (PCOO) Central and Northern CA

These surveys are extensions of CalCOFI sampling protocols. The Central CA survey is conducted annually in July and October. It incorporates the plankton and oceanographic surveys of CalCOFI survey line 66, extending offshore from Monterey Bay, 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. The Northern CA survey is usually conducted on HSU R/V Coral Sea for one day a month off Eureka CA in conjunction with Humboldt State University. Protocols include the use of various plankton nets (Bongo,

California Vertical Egg Tow [CalVET], Manta, Pairvet), and CTDs with an array of vertically profiling instruments and bottles to collect water samples at discrete depths.

California Current Ecosystem Unmanned Systems in Water

Unmanned automated systems (UAS) are a new method of conducting surveys and complement current research objectives. The use of gliders, saildrones, and other unmanned systems will augment ship surveys and monitor waters where a ship cannot safely navigate. The projects will study migrating fish stocks, vertical migration and schooling behaviors. These surveys can occur throughout the CCE in the spring/summer with available ship time. Forty-six to 50 transects are expected to be sampled over about 120 days.

Purse Seine Survey

SWFSC will work with two purse seine vessels to collect acoustic data and CPS specimens in the nearshore areas to supplement sampling conducted by larger ships further offshore. This survey will be conducted along inshore portions of established transects by a commercial PSV in conjunction with a NOAA ship and the CPS survey. It is expected to occur over about 30 days a year for each of the two purse seine vessels. A Simrad EK 60/80 is used to identify schools of sardines, and then sample with 3-7 purse seine sets a day, up to ~100 sets over the course of a year for each purse seine vessel, or ~200 sets total. The purse seine will be used to collect about 50 fish samples from the identified schools. To conduct day-night comparative surveys, SWFSC may set approximately 4 times per day in a 24-hour period (each for 60 minutes) over about 5 days (i.e., minimum of 2 sets each during daytime and nighttime for a total of 20 sets). Acoustic transects may occur from the northernmost sampling location (approximately Cape Flattery, WA) to the vicinity of Eureka, California, and the vicinity of Bodega Bay, CA to the southernmost sampling location (approximately San Diego, CA) in the nearshore area approximately spaced 5 nmi apart, alternating direction (east-west and vice versa).

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 aboard a NOAA ship or charter vessel for a duration of approximately 25 survey days. The surveys are confined to offshore banks and island margins, 30-150 m depth, in the CCE, including the Southern California Bight (SCB). The average and maximum speed of the ROV is 0.5 and 2.4 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-weighed to minimize slack in the tether and to prevent loops that may lead to an entanglement risk.

Highly Migratory Species (HMS) Survey

This survey is conducted annually from June to July, extending from the SCB to central CA, targeting blue sharks, shortfin mako sharks, swordfish and other highly migratory species. The survey may be conducted on a NOAA ship or charter vessel, and requires about 30 survey days.

As a modification to the Highly Migratory Species (HMS) survey, SWFSC proposes to use additional hook and line gear (buoy gear and handline/troll) along with longline gear currently used to target HMS species.

Protocols include deployment of both shallow-set and deep-set pelagic longline at fixed stations with 2-8 hour soak times. 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.

SWFSC annually conducts the Swordfish tagging deep-set buoy gear (DSBG) survey from June-November in the SCB. The main objective is to investigate the use of DSBG to capture swordfish, and other HMS while minimizing bycatch of non-target species. Overall effort is about 300-600 annual sets. A description of deep-set buoy gear is provide in section 1.3.1.3.3, and is also provided in Appendix B of the SPEA. During trolling/rod and reel operations, tuna angler troll gear with artificial lures is used to target Pacific bluefin tuna, although live bait may be used as well in a large school if located.

Genetics/Physiology and Aquaculture

This study uses tagging and fish collection to study physiology and genetics in rockfish species. The study occurs four days annually over a two-year period. Recreational hook and line (rod and reel) gear is used to collect about 12 fish per year from small boats.

Rockfish Recruitment and Ecosystem Assessment (RREA) Survey

This survey is conducted annually from May to mid-June and extends from southern California to Washington. It targets the pelagic phase of juvenile rockfish or sablefish. Results of this survey inform assessments of several rockfish and sablefish populations. It is either conducted on a NOAA ship or a charter vessel requiring about 45 survey days. SWFSC proposes to collect life history and reproductive data on rockfish species whereas previous research focused on sablefish.

The protocols for this survey include using a Modified-Cobb mid-water trawl deployed for 15-minute tows at 2 knots during nighttime hours at 3-50 m depth. Protocols also include underway multifrequency single-beam active acoustics, IKMT, various plankton tows, and CTD profiles at fixed stations.

Juvenile Salmon Survey

This is a directed research survey that measures ocean survival of juvenile salmon (coho and Chinook) and produces early estimates of adult salmon returns. This survey is conducted annually in June and occasionally requires a second cruise in September. The study range extends from central California to southern Oregon and is a cooperative effort with Oregon State University, University of California Santa Cruz, University of California Davis, Monterey Bay Aquarium Research Institute, and Moss Landing Marine Laboratory. 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 45-minute tows at 15-30 m depth during daylight hours. Depending on vessel capabilities, additional operations may include multifrequency single-beam active acoustics for measuring biological and environmental conditions, and CTD profiles. This survey may also unmanned aircraft for collecting hydro-acoustic and physical oceanographic data.

The Juvenile Salmon Survey may also include the use of micro-trolling (hook and line) sampling in combination with unmanned aircraft to collect hydro-acoustic and physical oceanographic data.

Life History and Reproductive Ecology Investigations of Rockfish

This cooperative survey focuses on reproductive life history analysis of rockfish and is conducted monthly each year in the California Current Ecosystem. The primary objective of the survey is to collect adult rockfish for reproductive studies using rod and reel gear, and may include microtrolling. Gear may be deployed several hundred times over the course of the season.

California Current Deep Sea Coral and Sponge Assessment

This survey employs an ROV with attached underwater camera, AUVs and other towed camera systems to study fishes, deep sea corals and sponges. It is a cooperative project with other agencies and research groups. One survey lasting about 14 days is conducted each summer, with one dive for each DAS.

Humboldt State University Cooperative Fisheries Oceanography Research Team: Trinidad Headlines

This is a cross-shelf observation study taking place during a 12-hr cruise once every month. A glider, plankton nets, and CTD are used. A total of 11 plankton tows (6 vertical, 5 oblique) are deployed.

Ecosystem-Based Fisheries Management and Stock Assessment Surveys

Assessment studies conducted by ERD using unmanned systems and COAST survey conducted by FRD are planned in future years. The focus of these surveys to provide data on forage fisheries that may have been missed by the ship-borne surveys. They are usually conducted one day a month for 12 months and may use both a fixed-wing and rotorcraft UAS for regular monthly surveys of the CCE with a focus on Monterey Bay using established track lines.

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

Antarctic Living Marine Resources Program (FREEBYRD and Seabirds)

The U.S. AMLR Program has developed a new oceanographic program that relies on autonomous underwater vehicles (i.e., long-range hybrid gliders) to measure the hydrography and productivity in the western Antarctic Peninsula and to obtain acoustic estimates of krill biomass/trends in lieu of chartering research vessels. This allows for broader temporal and spatial coverage than was previously possible using ship-based at-sea surveys. Gliders are to be deployed for three to four months at a time to sample depths from the surface to 1000 m, allowing for broader temporal and spatial coverage than has been previously possible using at-sea surveys. Gliders "fly" a programmed trajectory along the west shelf of the Antarctic Peninsula region and in the Bransfield Strait, critical areas for the krill fishery and for krill-dependent predators, and collect data using various glider-mounted sensors. Gliders would also collect data using various attached sensors.

1.3.1.3 Gear Used During SWFSC Research

Appendix A of the PEA and SPEA provide full descriptions of sampling gear used during SWFSC research.

1.3.1.3.1 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.

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 in order to set management goals for the coastwide U.S. sardine fishery. The Nordic 264 is also used in salmon 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 45 minutes at a time at a speed of 2-4 knots.

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.

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 frame trawl with a 5 m^2 mouth area used for quantitative sampling of larval and juvenile pelagic fishes (Figure A-3 *in* PEA). 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. 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. 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.

1.3.1.3.2 Other Nets

Purse Seine

Purse seining targets near-surface schools of fish by deploying the seine skiff attached to one end of the net. The larger vessel then attempts to surround the school and close up with the skiff. A typical purse seine vessel (50 to 80 feet in length) and skiff. The two ends of the net are then brought aboard the larger vessel and a slip line running through the bottom of the net is cinched, which creates a “purse” or bowl (closed at the bottom and open at the top) containing the fish. Sometimes the skiff is used to pull the larger vessel or portions of the net to keep the bowl from collapsing. The float line (at the top of the net) is then brought in the larger vessel in order to make the bowl smaller and concentrate the fish. Ultimately a pump is submerged in the net and the fish are brought aboard as part of a slurry – hence the name "wet fish."

Purse seining based on NOAA-SWFSC and Washington Department of Fish and Wildlife protocols to allow dip-netting of fish from the seine for sample processing onboard is planned for the period 2020–2025. As an example, a seine net 230 fathoms in length, 2800 meshes deep, with a mesh size of 11/16 in. may be used for this research. Complementary echosounder, sonar, and purse-seine sampling along nearshore areas during surveys conducted by the ship, Lasker, may occur over a period of approximately 30 days.

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 PEA). 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 PEA). 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.

1.3.1.3.3 Hook and Line Gear

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 4 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 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. The typical bait used is whole mackerel or market squid.

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 HMS longline surveys, soak times are expected to last from 2-8 hours, depending on the sampling target species

Swordfish deep-set buoy gear

Swordfish deep-set buoy gear is used to capture and tag swordfish 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 of 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. 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).

The gear is set at a target depth below the thermocline (Figure A-5 *in* PEA), 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.

Other Hook and Line Gear (Microtrolling, rod and reel, troll)

The Juvenile Salmon Survey may also include the use of micro-trolling (hook and line) sampling to capture juvenile salmon. Similar to typical trolling, a line is fished from the side of the boat with a series of hooks at regular depth intervals. Hooks include flashers that attract salmon. The primary difference between micro-trolling and typical trolling is the size of the hooks and the speed of the boat towing the hooks, which are smaller and slower with micro-trolling. This technique incurs very low hooking mortalities such that we can use it to return fish after we obtain morphometric measurements, genetic samples, and scales to age.

Rockfish and other surveys using rod and reel gear includes use of shrimp flies, often baited with squid, on braided spectra 20-40 lb test lines, depending on the depth of water and weight needed. For tuna trolls, the gear will include the use of angler rod and reel or handlines, with tackle/line that is 80 lbs or greater, and barbed or unbarbed artificial tuna lures.

1.3.1.3.4 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.

The SWFSC also proposes to use unmanned automated systems (UAS) which may include both in-air and underwater autonomous unmanned vehicles devices. The use of gliders, saildrones, and other UASs augment ship surveys and monitor nearshore waters where a ship cannot safely navigate. UAS may be fixed wing units, rotary with vertical take-off and landing (VTOL) capabilities or hybrid fixed-wing VTOL platforms. Payload components (cameras, other sensors, collection plates, etc.) mounted on the unmanned platforms vary based on research objectives. Many of the UAS that can be used are extraordinarily quiet with sound levels equivalent to a whisper (less than 5 dB) at 30 m; these UAS operate almost silently, resulting in minimal to no disturbance to animals. UAS may be launched from survey vessels or shore and fly at altitudes ranging from 60 - 400 ft to assess and photograph target species and environmental conditions. As additional information becomes available on the potential effects of using UAS, the altitude authorized for marine research may continue to be adjusted on a case-by-case basis in close coordination with NMFS.

1.3.1.4 Active Acoustic Sources used by the SWFSC

High frequency transient sound sources operated by the SWFSC are used for environmental and remote-object sensing in the marine environment. They include various echosounders (e.g., multibeam systems), scientific sonar systems, positional sonars (e.g., net sounders for determining trawl position), and environmental sensors (e.g., current profilers). The specific acoustic sources used in SWFSC active acoustic surveys, are described in PEA and in section 6.3 of the MMPA LOA. Most of these sources involve relatively high frequency, directional, and brief repeated signals tuned to provide sufficient focus and resolution on specific objects. Table 2 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 2. Operating characteristics of active acoustic sources operated from SWFSC research vessels.

Active Acoustic System	Operating Frequencies	Maximum Source Level (dB)	Single Ping Duration (ms) and Repetition Rate (Hz)	Orientation/ Directionality	Nominal Beam Width
Simrad EK500, EK60 and EK80 narrow beam echosounders	18, *38, 70, 120, 200*, 333 kHz[1]	226[2]	Variable; most common settings are 1 ms and 0.5 Hz	Downward looking	7°
Simrad ME70 multibeam echosounder	70–120 kHz	205	0.06–5 ms; 1–4 Hz	Primarily Downward looking	130°
Simrad MS70 multibeam sonar	75–112 kHz	206	2–10 ms; 1–2 Hz	Primarily side-looking	60°
Simrad SX90 narrow beam sonar	20–30 kHz	219	Variable	Omnidirectional	4-5° (variable for tilt angles from 0-45° from horizontal)
Teledyne RD Instruments ADCP Ocean Surveyor	75 kHz	224	0.2 Hz	Downward looking	30°
Simrad ITI Catch Monitoring System	27–33 kHz	214	0.05–0.5 Hz	Downward looking	40°
Simrad FS70 Third Wire Net Sonde	120 kHz	Unknown, maximum transmit power is 1 kilowatt	Variable	Downward looking	40°

Active Acoustic System	Operating Frequencies	Maximum Source Level (dB)	Single Ping Duration (ms) and Repetition Rate (Hz)	Orientation/ Directionality	Nominal Beam Width
Autonomous Underwater Vehicles	**100–5,000Hz**	**124**	**N/A**	**Omnidirectional**	**N/A**
Unmanned Aerial Systems	**600–6,000 Hz[3]**	**91–102 dB (@5-10m altitude)[4]**	**N/A**	**Omnidirectional**	**N/A**

[1]Primary frequencies italicized.
[2]Source level values for the EK80 configured with different transducers ranged between 226 and 212 dB re 1 µPa at 1 m (Macaulay 2018).
[3]Intaratep et al. (2016) reported that an unloaded motor spectrum of a quadcopter indicates that the motors noise contributes to the overall noise signature of the drone in the mid-frequency range (600-6000 Hz).
[4]The specific equipment for which these results are reported is only an example for reference. The specific model of an unmanned aerial vehicle used by SWFSC may vary.

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.

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 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.

Single-Frequency Omnidirectional Sonar (Simrad XS90)

Single-frequency omni-directional sonar is used to prevent interference by vessels and operate between frequencies of 20 to 30 kHz. Systems such as the SX90 used by SWFSC can provide omnidirectional imaging around the source with three different vertical beam widths available (single or dual vertical view and 180° tiltable)

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 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 and Antarctic over the course of five years, on August 28, 2020 (85 FR 53606). The LOA would be effective for a period of five years from the date of issuance, which is expected to occur during the fall of 2020. 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 MMPA LOA application and/or 85 FR 53606 for complete description of estimation process; also summarized in section 2.12.1.3). No ESA-listed marine mammals are expected to be injured by SWFSC research activities, and no MMPA Level A 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[2] under the MMPA. Table 3 below describes the extent of Level B harassment for ESA-listed marine mammals by survey area in the proposed LOA (see 85 FR 53606 for a complete description of the MMPA acoustic harassment estimation process; summarized in section 2.12.1.3).

Table 3. Total number of incidents[3] 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 (Mexico DPS	21
Humpback whale (Central America DPS)	2
Sei whale	10
Fin whale	124
Blue whale	18
Sperm whale	96
Killer whale (Southern Resident DPS)[4]	13
Guadalupe fur seal	313

[2] 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."

[3] 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.

[4] The annual take number is for killer whales generically and is more likely to affect the non-ESA-listed Eastern North Pacific Offshore and West Coast Transient stocks, but takes could occur for the ESA-listed Southern Resident stock during times when whales may be foraging on the coasts of California, Oregon, or Washington (OPR consultation request).

Antarctica[5]	
Fin whale	57
Sperm whale	5

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 1.3.3. Reporting requirements of the LOA are also reflected, as necessary, in the Terms and Conditions (section 2.10) of this opinion.

1.3.3. Proposed Mitigation Measures

The proposed mitigation measures for SWFSC research activities are described in Chapter 2 and Table 2-3 in the SPEA, the PEA, and in the proposed MMPA LOA. In brief, we identify and summarize key mitigation measures as follows:

1.3.3.1 Trawl Surveys

Monitoring Methods

Marine mammal watches will be initiated 15 minutes prior to arrival on station to determine if these species are near the proposed trawl set location. Either dedicated observers, the Officer on Deck (OOD), Chief Scientist (CS), and/or crew standing watch will visually scan for marine mammals during all daytime operations. Marine mammal watches will be conducted using any binocular or monocular sighting instrument, with a means to estimate distance to infringing protected species during daytime, and the best available means of observation during nighttime observations. This typically occurs during transit leading up to arrival at the sampling station because of another mitigation measure intended to reduce the risk of attracting curious marine mammals, immediate deployment of trawl gear upon arriving at station. However, in some cases it may be necessary to conduct a bongo plankton tow prior to deploying trawl gear. In these cases, the visual watch will continue until trawl gear is ready to be deployed.

Operational Procedures

If marine mammals or other protected species are sighted within 1 nm of the planned set location in the 15 minutes before setting the gear, the vessel will transit to a different section of the sampling area to maintain a minimum set distance of 1 nm (aka “Move-On” Rule). An exception to this protocol is for baleen whales; baleen whales are commonly observed within the 1 nm distance from SWFSC trawl sampling locations but have never been observed to be attracted to SWFSC research activity and have never interacted with SWFSC research gear. If after moving on, protected species remain within the 1 nm exclusion zone, the CS or watch leader may decide to move again or to skip the station. However, SWFSC acknowledges that the effectiveness of visual monitoring may be limited depending on weather and lighting conditions, and it may not always be possible to conduct visual observations out to 1nm. If protected species

[5] There are acoustic harassment takes of humpback whales by SWFSC research activities anticipated in Antarctica, but these whales are expected to belong to unlisted DPSs of humpback whales that commonly occur in this area.

are observed within 1 nm of the vessel, the most appropriate response to avoid interaction with the gear is determined through the use of professional judgment of the CS or officer on watch. The CS or watch leader will determine the best strategy to avoid potential takes of marine mammals based on the species encountered, their numbers and behavior, position and vector relative to the vessel, and other factors. In any case, no gear will be deployed if marine mammals or other protected species other than baleen whales have been sighted within 1 nm of the planned set location during the 15-minute watch period. In many cases, trawl operations will be the first activity undertaken upon arrival at a new station, in order to reduce the opportunity to attract marine mammals to the vessel. However, in some cases it will be necessary to conduct plankton tows prior to deploying trawl gear in order to avoid trawling through extremely high densities of jellies and similar taxa that are numerous enough to severely damage trawl gear.

Once the trawl net is in the water, the OOD, CS, and/or crew standing watch will continue to monitor the waters around the vessel and maintain a lookout for marine mammal presence as far away as environmental conditions allow. If marine mammals are sighted before the gear is fully retrieved, the most appropriate response to avoid incidental take will be determined by the professional judgment of the CS, watch leader, OOD and other experienced crew as necessary. If trawling operations have been suspended because of the presence of marine mammals, the vessel will resume trawl operations (when practicable) only when the mammals have not been sighted within 1 nm of the planned set location.

Tow Duration

Standard tow durations of not more than 45 minutes at the target depth have been implemented, excluding deployment and retrieval time (which may require an additional 30 minutes depending on depth), to reduce the likelihood of attracting and incidentally taking marine mammals and other protected species. These short tow durations decrease the opportunity for curious marine mammals to find the vessel and investigate. Trawl tow distances are less than 3 nm, which should minimize the likelihood of attracting and incidentally taking marine mammals. Typical tow distances are 1-2 nm, depending on the survey and trawl speed.

Marine Mammal Excluder Devices

The NETS Nordic 264 trawl gear will be fitted with marine mammal excluder devices (MMEDs) to allow marine mammals caught during trawling operations an opportunity to escape. These devices enable target species to pass through a grid or mesh barrier and into the codend while preventing the passage of marine mammals, which are ejected out through an escape opening or swim back out of the mouth of the net. Modified Cobb trawls are considerably smaller than Nordic rope trawls, are fished at slower speeds, and have a different shape and functionality than the Nordic 264 trawl. SWFSC will continue to test modifications to MMEDs for use in Modified Cobb trawl gear, but will not mandate their use during all tows at this time.

Acoustic Pinger Devices

Acoustic pingers are underwater sound emitting devices that are designed to decrease the probability of entanglement or unintended capture of marine mammals. Acoustic pingers have

been shown to effectively deter several species of small cetaceans from becoming entangled in gillnets and driftnets (e.g., no observed catches of beaked whales after pingers implemented reported in Carretta and Barlow 2011; 50% reduction in common dolphin entanglement reported in Barlow and Cameron 2003). While their effectiveness has not been tested on trawls, pingers are believed to represent a mitigation measure worth pursuing given their effectiveness in other gears. Pingers will be deployed during all trawl operations and all types of trawl nets. Two to four pingers will be placed along the footrope and/or headrope to discourage marine mammal interactions.

SWFSC uses the Netguard 70 kHz dolphin pinger manufactured by Future Oceans and the Rockfish Recruitment and Ecosystem Assessment Survey uses the DDD-03H pinger manufactured by STM Products. 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. Maximum sound pressure level of 176 dB rms referenced to 1 μPa at 1 m at 30-80 kHz.

Speed Limits and Course Alterations

The vessel's speed during active sampling will rarely exceed 5 knots. Typical speeds during trawling are 2-4 knots. Transit speeds vary from 6-14 knots, but average 10 knots. As noted above, if marine mammals are sighted 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 standing watch or dedicated marine mammal observer that sights marine mammals that may intersect with the vessel course will immediately communicate their presence to the bridge for appropriate course alteration or speed reduction as possible to avoid incidental collisions.

1.3.3.2 Longline Gear

Visual surveillance by OOD, CS, and Crew

Longline surveys are conducted aboard smaller vessels and with fewer crew than trawl surveys but the pre-set monitoring procedures for longline gear are the same as described for trawl gear. No longline sets are made if marine mammals or other protected species have been seen within 1nm of the planned set location during the past 15 minutes, the move-on rule is implemented if these taxa are present, and the CS, watch leader, and OOD uses professional judgment to minimize the risk to protected species from potential gear interactions.

The only exception is when California sea lions are sighted during the watch period prior to setting longline gear. For this species only, longline gear may be set if a group of 5 or fewer animals is sighted within 1 nm of the planned set location; when groups of more than 5 sea lions are sighted within 1 nm of the sampling station, deployment of gear would be suspended. This exception has been defined considering the rarity of past interactions between this gear and California sea lions and in order to make this mitigation measure practicable to implement. Without it, given the density of California sea lions in the areas where longline surveys are conducted, the SWFSC believes implementing the move-on rule for a single animal would preclude sampling in some areas and introduce significant bias into survey results. Groups of

five California sea lions or greater is believed to represent a trigger for the move-on rule that would allow sampling in areas where target species can be caught without increasing the number of interactions between marine mammals and research longline gear.

Operational Procedures

SWFSC longline protocols specifically prohibit chumming (releasing additional bait to attract target species to the gear). However, spent bait may be discarded during gear retrieval while gear is still in the water. If protected species are detected while longline gear is in the water, the CS, watch leader and OOD exercise similar judgments and discretion to avoid incidental take of these taxa with longline gear as described for trawl gear. The species, number, and behavior of the marine mammals are considered along with the status of the ship and gear, weather and sea conditions, and crew safety factors. The CS, watch leader and OOD will use 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 other protected species, 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 marine mammals, resumption of setting will not begin until they have not been observed within 1 nm of the set location. If marine mammals are detected during retrieval operations and are considered to be at risk, haul-back may be postponed until the CS, watch leader or OOD determines that it is safe to proceed.

1.3.3.3 Purse Seines

Visual monitoring and operational protocols for purse seine surveys are similar to those described previously for trawl surveys, with a focus on visual observation in the survey area and avoidance of marine mammals that may be at risk of interaction with survey vessels or gear. The crew will keep watch for marine mammals before and during a set. If any killer whales, dolphins, or porpoises are observed within approximately 500 m of the purse seine survey location, the set will be delayed. If any dolphins or porpoises are observed in the net, the net will be immediately opened to let the animals go. Pinnipeds may be attracted to fish caught in purse seine gear but are known to jump in and out of the net without entanglement. If pinnipeds are in the immediate area where the net is to be set, the set is delayed until the animals move out of the area or the station is abandoned. However, if fewer than 5 pinnipeds are seen in the vicinity but do not appear to be in the direct way of the setting operation, the net may be set.

1.3.3.4 Other Sampling Gear

The SWFSC deploys a wide variety of gear to sample the marine environment during all of their research cruises, including plankton nets, oceanographic sampling devices, video cameras and ROV and unmanned system deployments. These types of gear are not considered to pose any risk to protected species and are therefore not subject to specific mitigation measures. However, the OOD 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.

Use of unmanned aerial vehicles (UAV) must comply with applicable FAA regulations. UAV deployments are only to be flown by an experienced operator. UAV flights will be within the line of sight in accordance with FAA regulations. UAV altitudes may range up to 400 ft depending on the method of use (i.e., flying transects or targeting specific species) or species involved. For pinnipeds, UAV flights will be at 100 – 200 ft depending on species (i.e., 100 ft for elephant seals and 200 ft for other species); in mixed aggregations, the most conservative altitude is used.

1.3.4. Handling and Disposition of Incidentally Captured Species

The proposed LOA describes the handling procedures for any marine mammals that may be incidentally captured or entangled by the SWFSC (85 FR 53606). 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 of the SWFSC's MMPA 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.

1.3.4.1 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.

1.3.4.2 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 of the SWFSC's MMPA 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.

1.3.4.3 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 Salmonids

During trawl surveys (except the juvenile salmon survey, which has its own protocols, 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 used in the juvenile salmon trawl 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.

During research survey tows where the incidental catch of salmon is relatively small (<50 fish), the sampling protocols spelled out in SPEA Appendix D indicate that all fish should be processed for length, weight, and a DNA fin clip. For survey tows with relatively large incidental catches of salmon (>50 fish), salmon may be subsampled as described in SPEA Appendix D. This includes an effort to subsample *at least* 50 fish using standard survey subsampling techniques.

During purse seine surveys, any adult salmon collected during sampling are immediately returned from the purse seine/dip net back into the water. Any juvenile salmon collected may be sampled similar to what is conducted during trawl surveys, although return to water of any juvenile salmon collected as quickly as possible is expected.

1.3.5. Other Activities

We considered, as required under the ESA, whether or not the proposed action would cause any other activities and determined that it would not. While SWFSC research activities contribute significantly to the management of marine resources across the globe, these are management activities that generally could and/or should be expected to occur with or without the contributions of SWFSC research. That these management activities are better informed through the research activity and products of the SWFSC likely reflect that direct or incidental impacts of these management activities on marine resources, including ESA-listed species, may likely be minimized and/or better understood as a result of SWFSC research activities.

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

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

SWFSC determined the proposed action is not likely to adversely affect the following ESA-listed species: blue whale (*Balaenoptera musculus*), fin whale (*Balaenoptera physalus*), Mexico DPS and Central America DPS of humpback whale (*Megaptera novaeangliae*), sei whale (*Balaenoptera borealis*), sperm whale (*Physeter macrocephalus*), Southern Resident DPS of killer whale (aka, Southern Residents; *Orcinus orca*), Western North Pacific DPS of gray whale

(*Eschrichtius robustus*), North Pacific right whale (*Eubalaena japonica*), Guadalupe fur seal (*Arctocephalus townsendi*), southern right whale (*Eubalaena australis*), hawksbill sea turtle (*Eretmochelys imbricate*), green sturgeon (*Acipenser medirostris*), Gulf grouper (*Mycteroperca jordani*), giant manta ray (*Manta birostris*), East Pacific DPS of scalloped hammerhead shark (*Sphyrna lewini*), oceanic whitetip shark (*Carchirinus lonigmanus*), white abalone (*Haliotis sorenseni*), and black abalone (*Haliotis cracherodii*).

SWFSC determined that the proposed action is also not likely to adversely affect the designated critical habitats of Steller sea lion (*Eumetopias jubatus*),[6] green sturgeon, or leatherback sea turtles. SWFSC also determined the proposed action was not likely to adversely affect proposed critical habitats of Southern Residents[7] and Mexico DPS and Central America DPS humpback whales.[8]

Our concurrence with these determinations is documented in the "Not Likely to Adversely Affect" Determinations section (Section 2.12).

2.1. Analytical Approach

This biological opinion includes both a jeopardy analysis. The jeopardy analysis relies upon the regulatory definition of "jeopardize the continued existence of" a listed species, which is "to engage in an action that reasonably 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 2019 regulations define effects of the action using the term "consequences" (50 CFR 402.02). As explained in the preamble to the regulations (84 FR 44977), that definition does not change the scope of our analysis and in this opinion we use the terms "effects" and "consequences" interchangeably.

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

- Evaluate the rangewide status of the species expected to be adversely affected by the proposed action.
- Evaluate the environmental baseline of the species.
- Evaluate the effects of the proposed action on species and their habitat using an exposure-response approach.
- Evaluate cumulative effects.
- In the integration and synthesis, add the effects of the action and cumulative effects to the environmental baseline, and, in light of the status of the species, analyze whether the

[6] The eastern DPS of Steller sea lion was delisted on November 4, 2013 (78 FR 66140); however their critical habitat remains designated.
[7] Revision of designated critical habitat to include ocean waters along the U.S. West Coast was proposed on September 19, 2019 (84 FR 49214).
[8] Critical habitat along the U.S. West Coast was proposed on October 9, 2019 (84 FR 54354).

proposed action is likely to directly or indirectly 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.

- If necessary, suggest a reasonable and prudent alternative to the proposed action.

In this biological opinion, we reviewed the results from previous execution of SWFSC research activities since the last biological opinion was issued in 2015, along with the historical data that was pulled together for the previous 2015 biological opinion, as needed. We also rely upon the description of anticipated impacts for new proposed SWFSC activities as described by in the BA, SPEA, MMPA LOA application, and the proposed MMPA LOA (85 FR 53606). We have reviewed the best available scientific and commercial data relevant to understanding the Status and Environmental Baseline of ESA-listed species that may be affected by SWFSC research in the CCE and Antarctica. Where needed, we draw from available information on bycatch of ESA-listed species in commercial fisheries that are most comparable to the research activities and gear used by SWFSC that may result in the bycatch of ESA-listed species.

2.2. Rangewide Status of the Species

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' "reproduction, numbers, or distribution" as described in 50 CFR 402.02.

Through consultation, the following species have been determined to likely be adversely affected as a result of incidental capture or entanglement with SWFSC survey gear during research activities conducted in the CCE and Antarctica in 2020-2025: leatherback sea turtle (*Dermochelys coriacea*); North Pacific DPS of loggerhead sea turtle (*Caretta caretta*); olive ridley sea turtle (*Lepidochelys olivacea*); East Pacific DPS of green sea turtle (*Chelonia mydas)*; Pacific eulachon (*Thaleichthys pacificus*; Southern 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 2.5, 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 2.12.

2.2.1. Sea Turtles

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. Based on climate change modeling efforts in the eastern tropical Pacific Ocean, for example, Saba et al. (2012) predicted that the Playa Grande (Costa Rica) sea turtle nesting populations would decline 7% per decade over the next 100 years. Changes in beach conditions are expected to be the primary driver of the decline, with hatchling success and emergence rates declining by 50-60% over the next 100 years in that area (Tomillo et al. 2012). Sea turtles are known to travel within specific isotherms and these could be affected by climate change and cause changes in their bioenergetics, thermoregulation, prey availability, and foraging success during the oceanic phase of their migration (Robinson et al. 2008; Saba et al. 2012). While the understanding of how climate change may impact sea turtles is building, there is still uncertainty and limitations surrounding the ability to make precise predictions about or quantify the threat of future effects of climate change on sea turtle populations (Hawkes et al. 2009).

We consider the ongoing implications of climate change as part of the status of ESA-listed species. Where necessary or appropriate, we consider whether impacts to species resulting from the proposed action could potentially influence the resiliency or adaptability of those species to deal with climate change that we believe is likely over the foreseeable future.

2.2.1.1 Leatherback Sea Turtles

A recovery plan for the U.S. Pacific populations of leatherbacks was completed nearly 20 years ago (NMFS and USFWS 1998a), and leatherbacks remain listed globally as an endangered species under the ESA (NMFS and USFWS 2020). In 2012, NMFS revised critical habitat for

leatherbacks to include additional areas within the Pacific Ocean (77 FR 4170). The proposed action occurs within Pacific leatherback critical habitat, and we analyze potential affects to designated leatherback critical habitat in section 2.12 of this Opinion.

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 1999; Benson et al. 2007, 2011). 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 to a lesser extent, 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). 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 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. 2007; Benson et al. 2011). The IUCN Red List conducted its most recent assessment of the West Pacific Ocean subpopulation in 2013 and listed it as "Critically Endangered" due in part to its continual decline in nesting, the continued threat due to fishing, and the low number of estimated nesting females.

<u>Population Status and Trends:</u> Leatherbacks occur throughout the world and populations and trends vary in different regions and nesting beaches. In 1980, the leatherback population was 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 we provide details on known populations 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 the Pacific leatherback is on the verge of extirpation (Spotila et al. 1996; Spotila et al. 2000). Recent estimates of the number of nesting females/year in Mexico and for Costa Rica were reported to be approximately 200 animals or less for each country per year (NMFS and USFWS 2013a). More recent estimates show a more positive increasing trend on the nesting beaches in Mexico with an estimated 280 females may have nested along the Pacific coast of Mexico during 2010-12 (Lopez et al. 2012). However, a more disturbing decline has been reported at Las Baulas, Costa Rica, with less than 30 females nesting in recent years (G. Schillinger, The Leatherback Trust, personal communication, 2016).

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. 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). 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). A decade ago, the nesting population was comprised of an estimated 2,700–4,500 breeding females (Dutton et al. 2007; Hitipeuw et al. 2007). 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). A recent NOAA funded, WWF-Indonesian assessment team identified a new leatherback nesting area in 2017 on three north coast beaches of Buru Island in Central Maluku (WWF 2018 as cited in NMFS and USFWS 2020). Initial monitoring of these beaches suggest that this 10.6 km stretch of shoreline supports the first substantial nesting population discovered outside of Papua, Indonesia in the last decade. Nesting activity appears to be year round with a primary summer nesting peak (May to July) and a secondary winter peak (December to February). During 2017, 203 nests were documented of which 114 were predated, and 16 were depredated (WWF 2018 as cited in NMFS and USFWS 2020).

The most recently available information on the number of nesting females in the Bird's Head region reflects a significant 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 an estimated 489 females nesting in 2011. Based on that information, the total number of adult females in the Bird's Head region was estimated to be 1,949 based on summer nests (April-September) (Talipatu et al. 2013; Van Houtan 2014). This represents about 75 percent of the nesting activity in the Western Pacific; therefore, NMFS estimated that there were approximately 2,600 nesting females in this population (NMFS 2014a).

In a 2017 biological opinion on the Proposed Implementation of a Program for the Issuance of Permits for Research and Enhancement Activities on Threatened and Endangered Sea Turtles Pursuant to Section 10(a) of the Endangered Species Act (NMFS 2017a), NMFS calculated an estimate number of annual nesting female western Pacific leatherbacks of 562 at the time based on data from Tapilatu et al (2013) and other concurrent data characterized in the 2013 Leatherback Sea Turtle Review (NMFS and USFWS 2013a). As discussed in that biological opinion, 562 is was estimate of the annual number of nesting female western Pacific leatherback sea turtles, not an estimate of the total number of nesting females in the subpopulation. As that biological opinion notes, leatherback females nest every one-to-seven years depending on foraging success and duration (NMFS 2017a). The number of annual nesting females described in the 2017 biological opinion represent only those turtles that remigrated to nest in a specific year and represents only a fraction of the total number of nesting females in the western Pacific leatherback sea turtle subpopulation. The 2013 Leatherback Sea Turtle Review acknowledged varying estimates of 1,775-4,500 total nesting female western Pacific leatherback sea turtles based on nest counts at the major nesting beaches (NMFS and USFWS 2013a).

Since 2012, monitoring effort at Jamursba-Medi and Wermon beaches has been somewhat variable and the overall nesting trend has continued to decline by 5% (NMFS 2019a). While there appears to be a slight upside to an oscillating trend in recent nesting activity, at the moment it is not affecting the long term trend and more years of data to understand what the upside in the oscillation means for the population (Jones et al. 2018; NMFS 2019a). An estimate of total nester abundance of females nesting between 2015 and 2017 (i.e., one remigration interval), is 723 females at Jamursba Medi and 554 females at Wermon (UNIPA unpublished data as cited in NMFS and USFWS 2020). Jones et al. (2018) estimated the current adult portion of the population is 1,851 (~1390 females). Most recently, Martin et al. (2020) generated three estimates of current abundance for the two index beaches in Indonesia which represent 75% of all nesting: (1) from median imputed nest counts, 790 Total Nesters (95% CI: 666–942), (2), from lower 95% imputed nest counts, 515 Total Nesters (95% CI: 425–634), and (3) from upper 95% imputed nest counts, 1224 (95% CI: 1052–1425). In total, NMFS recently estimated the total Western Pacific population is comprised of about 175,000 leatherback sea turtles; potentially ranging between 68,000 and 360,000 individuals (NMFS 2019a).

In a recent consultation completed on the Hawaii-based shallow-set longline fishery (NMFS 2019a), NMFS conducted analyses to estimate the growth rate for the Jamursba-Medi and Wermon portion of the Western Pacific leatherback population, along with the probabilities of this subpopulation reaching abundance thresholds within a 100 year projection period, and time in years (mean, median, & 95% credible interval) to reach the threshold for all runs that fall below the threshold (Jones et al. 2018). The results indicated the current mean growth rate (λ) is 0.949 (95% confidence interval 0.849 to 1.061), which suggest that most trajectories of this population can be expected to decrease in the coming years (NMFS 2019a). More recently, Martin et al. (2020) used a Bayesian state-space population growth model to estimate a declining trend for leatherbacks (−6.1% annually; 95% CI: −5.6% to −6.4%). Although human interactions are a major source of mortality for this declining population, there are indications that natural fluctuations in environmental and oceanic conditions could be significant influences on survival rates across various life stages or on reproductive rates (NMFS 2012a; Van Houtan 2011; Tomillo et al. 2012).

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., along with stable isotope analysis, all indicate or support that leatherbacks found off the U.S. West Coast are from the western Pacific nesting populations, specifically boreal summer nesters. The exact proportion of the western Pacific population that uses the U.S. West Coast is not known, but surveys in neritic waters off central and northern California estimate that, on average, approximately 180 leatherbacks (both males and females, subadults and adults) would be expected to be found in the action area (Benson et al. 2007). In recent years, surveys of leatherback abundance off the U.S. West Coast also have detected a decline, although it appears to be less than what has been documented back at the nesting beaches (Benson 2018). Given the relative size of the nesting populations, it is likely that the majority of the animals originate from the Jamursba-Medi nesting beaches, although some may come from the comparatively small number of summer nesters at Wermon in Papua Barat, Indonesia. Jamursba-Medi nesting population generally exhibits site fidelity to the central California foraging area, and it has been estimated that approximately 30 to 60 percent of Jamursba-Medi summer nesters may have

foraged in waters off California during some recent years (Benson et al. 2011; Seminoff et al. 2012).

Threats: The primary threats identified for leatherbacks are fishery bycatch and impacts at or adjacent to the nesting beaches, including nesting habitat (erosion, logging, elevated sand temperatures, human/animal encroachment), direct harvest and predation. In the western Pacific, leatherbacks are also subjected to traditional harvest, which was well documented in the 1980s and continues today. Traditional hunters from the Kei Islands continue to kill leatherbacks for consumption and ceremony. Recent surveys indicate that harvest continues with estimates of 431 takes over the past 8 years (53.9/yr), and at least 103 leatherbacks harvested in 2017 (WWF 2018 as cited in NMFS and USFWS 2020). 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. Off the U.S. West Coast, a large time/area closure was implemented in 2001 to protect Pacific leatherbacks by restricting the CA thresher shark/swordfish drift gillnet fishery, which significantly reduced bycatch of leatherbacks in that fishery. On the high seas, bycatch in longline fisheries is considered a major threat to leatherbacks (Lewison et al. 2004). 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).

There are interactions between leatherbacks and domestic longline fishing for tuna and swordfish based out of Hawaii. Under requirements established in 2004 to minimize sea turtle bycatch (69 FR 17329), vessel operators in the Hawaii-based shallow-set swordfish fishery must use large (sized 18/0 or larger) circle hooks with a maximum of 10 degrees offset and mackerel-type bait. From 2012-2017, the incidental take statement for the Hawaii-based shallow-set fishery was 26 leatherback sea turtles per year, which served as the "hard cap" for the fishery that requires closure of the entire fishery during any year if reached. Recently, the hard cap for leatherback sea turtle bycatch was reset to 16 per year, with the expectations that up to 16 may be caught and 3 may be killed each year and that vessels would be restricted to no more than 2 leatherbacks taken during any one trip (NMFS 2019a). Between 2004 and 2018, there were a total of 105 leatherback sea turtles captured in the fishery, with an estimated 21 leatherback sea turtles killed as a result (NMFS 2019a). In the deep-set longline tuna fishery based out of Hawaii, NMFS exempted the take (interactions or mortalities) of up to 72 interactions and 27 mortalities of leatherbacks over a 3-year period (NMFS 2014a). Based on observer data from 20012-2018 (over 20% observer coverage, on average), NMFS estimates that a total of 85 loggerheads were captured, including 36 mortalities (NMFS 2019a). Between 2006, when the observer program started in American Samoa, and 2018 the American Samoa longline fishery is estimated to have had 55 interactions, with 38 mortalities (NMFS 2019b).

Estimating the total number of sea turtle interactions in other Pacific fisheries that interact with the same sea turtle populations as U.S. fisheries is difficult because of low observer coverage and inconsistent reporting from international fleets. Lewison et al. (2004) estimated 1,000 – 3,200 leatherback 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), which would equate to 200

– 640 leatherbacks during that time period. 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. In 2015 a workshop was convened to analyze the effectiveness of sea turtle mitigation measures in the tuna RFMOs and 16 countries provided data on observed sea turtle interactions and gear configurations in the Western Central Pacific Ocean. Based on the information gathered there, 331 leatherback sea turtles reported with a total estimate of 6,620 leatherbacks caught in the region from 1989-2015 in these countries. Most recently, Peatman et al. (2018) estimated that 9,923 leatherbacks were captured in longline fisheries operating in the North Pacific from 2003-2017.

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 continues to occur at significant rates several orders of magnitude greater than what NMFS documents or anticipates in U.S. Pacific ocean fisheries.

In an attempt to develop a tool for managers to use locally (e.g. in an EEZ) to reduce threats in a particular area of interest, Curtis et al. (2015) developed biological "limit reference points" for western Pacific leatherback turtles in the U.S. West Coast EEZ, similar to a PBR approach calculated for marine mammal stocks. Depending on the model used and the various objectives sought (e.g. achievement of maximum net productivity, or no more than a 10% delay in the time for the population to rebuild) and incorporation of conservative assumptions accounting for broad uncertainty in abundance and productivity estimates, the limit reference point estimate for human-caused removals in the U.S. West Coast EEZ ranged from 0.8 to 7.7 leatherbacks over 5 years. Although these results are useful for consideration, NMFS is not currently using this approach to managing threats to sea turtles foraging within the U.S. EEZ pending further discussion of how this approach or other approaches relate to the standards of the ESA. We anticipate that the management tool presented by Curtis et al. (2015) and other approaches to managing threats to sea turtles will be subject to future discussion by scientific experts.

2.2.1.2 North Pacific DPS Loggerhead Sea Turtles

A recovery plan for the U.S. Pacific populations of loggerheads was completed nearly 20 years ago (NMFS and USFWS 1998b) when loggerheads were listed globally as a threatened species under the ESA. In 2011, a final rule was published describing ESA-listings for nine DPS of loggerhead sea turtles worldwide (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. Since the loggerhead listing was revised in 2011, a recovery plan for the North Pacific loggerhead DPS has not been completed. However, through a U.S. initiative, three countries (United States, Japan, and Mexico) have been developing a tri-national recovery plan (A. Gutierrez, NMFS, personal communication, 2017).

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. 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 many years before returning to their neritic foraging habitats (Pitman 1990; Bowen et al. 1995; Musick and Limpus 1997). Recent resident times of juvenile North Pacific loggerheads foraging at a known hotspot off Baja California were estimated at over 20 years, with turtles ranging in age from 3 to 24 years old (Tomaszewicz et al. 2015). 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).

In the western Pacific, the only major nesting beaches are in the southern part of Japan (Dodd 1988). 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). Researchers have identified other important juvenile turtle foraging areas off the coast of Baja California Sur, Mexico (Peckham et al. 2007; Conant et al. 2009). Loggerheads 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 (*Pleuroncodes planipes*) have been found in great numbers, attracting top predators such as tunas, whales and sea turtles, particularly loggerheads (Pitman 1990; Wingfield et al. 2011; Seminoff et al. 2014).

<u>Population Status and Trends:</u> 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). 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 over 50% percent of nesting occurs (Kamezaki et al. 2003; Jones et al. 2018). Census data from 12 of these 15 beaches provide composite information on longer term trends in the Japanese nesting assemblage. From this data, Kamezaki et al. (2003) concluded a substantial decline (50–90%) in the size of the annual loggerhead nesting population in Japan had occurred 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. Since that time, nesting has been variable, increasing and decreasing over time as is typical of sea turtle nesting trends. Nesting increased gradually to 5,167 nests in 2005 (Conant et al. 2009), peaked to 11,082 nests in 2008, declined and then has risen steadily to a record high of 15,396 nests in 2013 (Sea Turtle Association of Japan (STAJ) 2009, 2010, 2012; Y. Matsuzawa pers. comm. 2014). Nesting activity declined in 2014 to less than 10,000 nests, and again in 2015 with less than 5,000 nests laid, but has stabilized with a slight increase in 2016 (NMFS 2019a).

In terms of abundance, Van Houtan (2011) estimated the total number of adult nesting females in the population was 7,138 for the period 2008-2010. An abundance assessment using data available through 2013 was conducted by Casale and Matsuzawa (2015) as part of an IUCN Red

List assessment that estimated 8,100 nesting females in the population. More recently, Jones et al. (2018) used a model estimate of 3,632 females nesting in Yakushima, assumed to represent 52% of all nesting females in the population, to estimate the total number of North Pacific loggerhead nesting females at 6,984 (NMFS 2019a). Most recently, Martin et al. (2020) estimated that current loggerhead abundance was 4541 (95% CI: 4074–5063) for the all nesting females in in Yakushima. In total, Jones estimated that there are approximately 340,000 loggerhead sea turtles of all ages in the North Pacific population (Jones 2019 as cited in NMFS 2019a).

In a recent consultation completed on the Hawaii-based shallow-set longline fishery (NMFS 2019a), NMFS conducted analyses to estimate the growth rate for the Yakushima portion of the North Pacific loggerhead population, along with the probabilities of this subpopulation reaching abundance thresholds within a 100 year projection period, and time in years (mean, median, & 95% credible interval) to reach the threshold for all runs that fall below the threshold (Jones et al. 2018). The results indicated the current mean growth rate (λ) is 1.024 (95% confidence interval 0.897 to 1.168), which suggest that most trajectories of this subpopulation can be expected to increase slightly in the coming years (NMFS 2019a). Most recently, Martin et al. (2020) used a Bayesian state-space population growth model that estimated an increasing trend for loggerheads (2.3% annually; 95% CI: −11.1% to 15.6%)

As noted above, North Pacific loggerheads have been documented in high numbers off the central Pacific coast of Baja California, Mexico. Aerial surveys conducted from 2005 through 2007 in the Gulf of Ulloa, a known "hot spot," provided an estimated foraging population of over 43,000 juvenile loggerheads (Seminoff et al. 2014). NMFS conducted aerial surveys of the Southern California Bight in 2015 (a year when the sea surface temperatures were anomalously warm, and an El Niño was occurring) and estimated more than 70,000 loggerheads throughout the area (Eguchi et al. 2018), likely feeding on pelagic red crabs and pyrosomes, the turtle's preferred prey. Recent analysis of loggerhead sea turtle presence in the Southern California Bight suggests that loggerhead presence offshore of Southern California is tied not just to warm temperatures, but to persistently warm temperatures over a period of months such as what occurred during the recent large marine heatwave experienced by the Eastern North Pacific Ocean (Welch et al. 2019).

Recent efforts have examined potential relationships between significant climate/environmental variables and influences on turtle populations. Van Houtan and Halley (2011) identified correlations between loggerhead juvenile recruitment and breeding remigrations and two strong environmental influences: sea surface temperature and the Pacific Decadal Oscillation (PDO) index of ocean circulation. The mechanisms that could influence loggerhead survival at important stages may be relevant to understanding past nesting beach trends, and this is a promising avenue of research. However, there are many more anthropogenic and natural factors that may influence sea turtle populations and future trends, and a consideration of the differences in ocean basins, nesting assemblages, demographics, and habitat, among other variables, needs to be included in any characterization of status and trend of a particular population or DPS such as North Pacific loggerheads. Relating environmental variance into population dynamics is an important component in our attempts to understand the fate of long-lived and highly migratory marine species such as sea turtles. However, we cannot currently reliably predict the magnitude

of future climate change and its impacts on North Pacific loggerheads. In addition, as noted by Arendt et al. (2013), the Van Houtan and Halley (2011) paper proposed an alternative to a long-held paradigm that the survivorship of large juveniles and adult sea turtles is more predictive of population change than juvenile recruitment. Van Houtan and Halley (2011) suggested that cohort effects stemming from survival in the first year of life had a greater effect on population growth. Analyses conducted by Arendt et al. (2013) on climate forcing on annual nesting variability of loggerheads in the Northwest Atlantic Ocean showed that trends in annual nest counts are more influenced by remigrants rather than neophytes, which contradicts in part the Van Houtan and Halley (2011) study. As summarized above, the North Pacific loggerhead nesting population has been increasing over the last couple of decades, including the most recent years (2010-current) not included in the Van Houtan and Halley (2011) analysis, which may be explained by conservation efforts on the nesting beaches, at the foraging grounds (e.g., Gulf of Ulloa, in Baja California, Mexico), and potentially realized reduction of threats from large-scale fisheries such as longlining.

At this time, uncertainty remains related to the North Pacific loggerhead nesting beach trend forecasts and correlations with climate indices related to the PDO, for example. The mechanisms that could influence loggerhead survival at important stages are logical, and this is a promising avenue of research. Relating environmental variance into population dynamics will be an important step in trying to understand the fate of marine species such as sea turtles. However, it is not possible to reliably predict the magnitude of future climate change and the impacts on loggerhead sea turtles. 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). Given this lack of available information and within the context of the scale of the proposed action, climate change related impacts are not considered significant.

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. Overall, the NMFS and USFWS 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).

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 2009; Conant et al. 2009). In Mexico, loggerhead mortality has been significantly reduced, particularly in a previously identified hotspot, where thousands of loggerheads may forage for many years until reaching maturity. In 2013, Mexico was notified that, unless it established a regulatory

program comparable in effectiveness to that of the United States, Mexico would receive a "negative certification" under section 403(a) of the Magnuson-Stevens Act. This notification was made as a result of documented evidence of hundreds of loggerheads found stranded or bycaught in coastal artisanal fisheries in the Gulf of Ulloa, off the Pacific coast of Baja California. As a result, in 2016, Mexico published new regulations, which established a reserve located in the loggerhead hotspot area. Within this reserve, the 2016 regulation sets a loggerhead turtle mortality limit for commercial fishing vessels of 90 turtles. If that 90 mortality threshold is met, Mexico would suspend gillnet fishing from May through August to protect loggerhead sea turtles. Restrictions on mesh size and soak time were also included to reduce mortalities. After reviewing the regulations, the United States was able to positively certify Mexico in September 2016 (Department of Commerce 2016). This restriction likely reduces loggerhead bycatch by an order of magnitude and addresses one of the primary threats identified in Conant et al. (2009).

There are interactions between North Pacific loggerheads and domestic longline fishing for tuna and swordfish based out of Hawaii. Under requirements established in 2004 to minimize sea turtle bycatch (69 FR 17329), vessel operators in the Hawaii-based shallow-set swordfish fishery must use large (sized 18/0 or larger) circle hooks with a maximum of 10 degrees offset and mackerel-type bait. From 2012-2017, the incidental take statement for the Hawaii-based shallow-set fishery was 34 loggerhead turtles per year, which served as the "hard cap" for the fishery that requires closure of the entire fishery during any year if reach. Recently, the hard cap for loggerhead sea turtle bycatch was removed, with the expectations that up to 36 may be caught and 6 may be killed each year and that vessels would be restricted to no more than 5 loggerheads taken during any one trip (NMFS 2019a). From 2004 to 2018, the Hawaii-based shallow-set fishery captured a total of 177 loggerheads (11.8/year) with 2 observed mortalities (NMFS 2019a).

In the deep-set longline tuna fishery based out of Hawaii, NMFS exempted the take (interactions or mortalities) of up to 18 North Pacific loggerheads over a 3-year period (NMFS 2014a). Based on observer data from 2012-2018 (over 20% observer coverage, on average), NMFS estimates that a total of 45 loggerheads were captured, including 30 mortalities (NMFS 2019a).

Estimating the total number of sea turtle interactions in other Pacific fisheries that interact with the same sea turtle populations as U.S. fisheries is difficult because of low observer coverage and inconsistent reporting from international fleets. Lewison et al. (2004) estimated 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), which would equate to between 520 and 1,200 loggerhead mortalities during the year assessed. 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. In 2015 a workshop was convened to analyze the effectiveness of sea turtle mitigation measures in the tuna RFMOs and 16 countries provided data on observed sea turtle interactions and gear configurations in the Western Central Pacific Ocean. Based on the information gathered there, 549 loggerhead sea turtles reported with a total estimate of 10,980 loggerheads caught in the region from 1989-2015 in these countries. Most

recently, Peatman et al. (2018) estimated that somewhere between 473-2941 loggerheads were captured in longline fisheries operating in the North Pacific from 2003-2017.

Between recent developments to reduce sea turtle bycatch in domestic fisheries that have been working their way into some international fisheries and the incomplete data sets and reporting that exists, 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, continues to occur at significant rates several orders of magnitude greater than what is being documented or anticipated in U.S. Pacific Ocean fisheries.

2.2.1.3 Olive Ridley Sea Turtles

A recovery plan for the U.S. Pacific populations of olive ridleys was completed nearly 20 years ago (NMFS and USFWS 1998c). A 5-year status review of olive ridley sea turtles was completed in 2014 (NMFS and USFWS 2014). Although the olive ridley sea 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 sea 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 sea 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).

<u>Population Status and Trends:</u> It is estimated that there are over 1 million female olive ridley sea turtles 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 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 (i.e., than the western Pacific population) to be affected by the proposed action, and that any affected turtles may have originated from the endangered Mexican breeding population. 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. In the 1950s through the 1970s, 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.

2.2.1.4 East Pacific DPS of Green Sea Turtles

In 2016, NMFS finalized new listings for 11 green sea turtle DPSs, including listing the East Pacific DPS as threatened (81 FR 20057). The East Pacific DPS includes turtles that nest on the coast of Mexico which were historically listed under the ESA as endangered. All of the green turtles DPSs were listed as threatened, with the exception of the Central South Pacific DPS, Central West Pacific DPS, and the Mediterranean DPS which were listed as endangered Seminoff et al. 2015).[9]

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. 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

[9] The 2015 biological status report that was used to support the recent listing activities (Seminoff et al. 2015) can be found at: http://www.nmfs.noaa.gov/pr/species/Status%20Reviews/green_turtle_sr_2015.pdf

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 originate from the eastern 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 1998d). Here, green turtles were widespread and abundant prior to commercial exploitation and uncontrolled subsistence harvest of nesters and eggs. Sporadic nesting occurs 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).

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 appears 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 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 especially given their presence in nearshore coastal and estuarine habitats.

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 (Van Houtan 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).

2.2.2. Marine Fish

Climate change is likely to play an increasingly important role in determining the abundance and distribution of ESA-listed fish 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. The largest hydrologic responses are expected to occur in basins with significant snow accumulation, where warming decreases snow pack, increases winter flows, and advances the timing of spring melt (Mote et al. 2014; Mote 2016). Rain-dominated watersheds and those with significant contributions from groundwater may be less sensitive to predicted changes in climate (Tague et al. 2013; Mote et al. 2014).

During the last century, average regional air temperatures in the Pacific Northwest increased by 1-1.4°F as an annual average, and up to 2°F in some seasons (based on average linear increase per decade; Abatzoglou et al. 2014; Kunkel et al. 2013). Warming is likely to continue during the next century as average temperatures are projected to increase another 3 to 10°F, with the largest increases predicted to occur in the summer (Mote et al. 2014). Decreases in summer precipitation of as much as 30% by the end of the century are consistently predicted across climate models (Mote et al. 2014). Precipitation is more likely to occur during October through March, less during summer months, and more winter precipitation will be rain than snow (ISAB 2007; Mote et al. 2013; Mote et al. 2014). Earlier snowmelt will cause lower stream flows in late spring, summer, and fall, and water temperatures will be warmer (ISAB 2007; Mote et al. 2014). Models consistently predict increases in the frequency of severe winter precipitation events (i.e., 20-year and 50-year events), in the western United States (Dominguez et al. 2012). The largest increases in winter flood frequency and magnitude are predicted in mixed rain-snow watersheds (Mote et al. 2014).

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

As more basins become rain-dominated and prone to more severe winter storms, higher winter stream flows may increase the risk that winter or spring floods in sensitive watersheds will damage spawning redds and wash away incubating eggs (Goode et al. 2013). Earlier peak stream flows will also alter migration timing for salmon smolts, and may flush some young salmon and steelhead from rivers to estuaries before they are physically mature, increasing stress and reducing smolt survival (McMahon and Hartman 1989; Lawson et al. 2004). In addition to changes in freshwater conditions, predicted changes for coastal waters in the Pacific Northwest as a result of climate change include increasing surface water temperature, increasing but highly variable acidity, and increasing storm frequency and magnitude (Mote et al. 2014). Elevated ocean temperatures already documented are highly likely to continue during the next century, with sea surface temperature projected to increase by 1.0-3.7oC (1.8-6.7oF) by the end of the century (IPCC 2014). Habitat loss, shifts in species' ranges and abundances, and altered marine food webs could have substantial consequences to anadromous, coastal, and marine species in the Pacific Northwest (Tillmann and Siemann 2011; Reeder et al. 2013).

In California, average summer air temperatures are expected to increase according to modeling of climate change impacts (Lindley et al. 2007). Heat waves are expected to occur more often,

and heat wave temperatures are likely to be higher (Hayhoe et al. 2004). Total precipitation in California may decline, critically dry years may increase (Lindley et al. 2007). Events of both extreme precipitation and intense aridity are projected for California, increasing climactic volatility throughout the state (Swain et al. 2018). Snow pack is a major contributor to stored and distributed water in the state (Diffenbaugh et al. 2015), but this important water source is becoming increasingly threatened. The Sierra Nevada snow pack is likely to decrease by as much as 70 to 90 percent by the end of this century under the highest emission scenarios modeled (CCCC 2006). California wildfires are expected to increase in frequency and magnitude, with 77% more area burned by 2099 under a high emission scenario model (Westerling 2018). Vegetative cover may also change, with decreases in evergreen conifer forest and increases in grasslands and mixed evergreen forests. The likely change in amount of rainfall in Northern and Central Coastal California streams under various warming scenarios is less certain, although as noted above, total rainfall across the state is expected to decline.

For the California North Coast, some models show large increases in precipitation (75 to 200 percent) while other models show decreases of 15 to 30 percent (Hayhoe et al. 2004). Many of these changes are likely to further degrade salmonid habitat by, for example, reducing stream flows during the summer and raising summer water temperatures (Williams et al. 2016). Estuaries may also experience changes detrimental to salmonids and green sturgeon. Estuarine productivity is likely to change based on alterations to freshwater flows, nutrient cycling, and sedimentation (Scavia et al. 2002). In marine environments, ecosystems and habitats important to subadult and adult green sturgeon and salmonids are likely to experience changes in temperatures, circulation and chemistry, and food supplies (Feely et al. 2004), which would be expected to negatively affect marine growth and survival of listed fish. The projections described above are for the mid- to late-21st Century. In shorter time frames, climate conditions not caused by the human addition of carbon dioxide to the atmosphere are more likely to predominate (Cox and Stephenson 2007).

Moreover, as atmospheric carbon emissions increase, increasing levels of carbon are absorbed by the oceans, changing the pH of the water. Acidification also impacts sensitive estuary habitats, where organic matter and nutrient inputs further reduce pH and produce conditions more corrosive than those in offshore waters (Feely et al. 2012; Sunda and Cai 2012). Global sea levels are expected to continue rising throughout this century, reaching likely predicted increases of 10-32 inches by 2081-2100 (IPCC 2014). These changes will likely result in increased erosion and more frequent and severe coastal flooding, and shifts in the composition of nearshore habitats (Tillmann and Siemann 2011; Reeder et al. 2013). Estuarine-dependent salmonids such as chum and Chinook salmon are predicted to be impacted by significant reductions in rearing habitat in some Pacific NorthWest Coastal areas (Glick et al. 2007). Historically, warm periods in the coastal Pacific Ocean have coincided with relatively low abundances of salmon and steelhead, while cooler ocean periods have coincided with relatively high abundances, and therefore these species are predicted to fare poorly in warming ocean conditions (Scheuerell and Williams 2005; Zabel et al. 2006). This is supported by the recent observation that anomalously warm sea surface temperatures off the coast of Washington from 2013 to 2016 resulted in poor coho and Chinook salmon body condition for juveniles caught in those waters (NWFSC 2015). Changes to estuarine and coastal conditions, as well as the timing of seasonal shifts in these

habitats, have the potential to impact a wide range of listed aquatic species (Tillmann and Siemann 2011; Reeder et al. 2013).

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

2.2.2.1 Southern DPS of Pacific Eulachon

On March 16, 2010, NMFS listed the SDPS of eulachon as a threatened species (75 FR 13012). This DPS encompasses all populations within the states of Washington, Oregon, and California and extends from the Skeena River in British Columbia south to the Mad River in Northern California (inclusive). 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. Core populations for this species include the Fraser River, Columbia River and (historically) the Klamath River. Within the conterminous United States, most eulachon production originates in the Columbia River basin, and the major and most consistent spawning runs return to the Columbia River mainstem and Cowlitz River. Adult eulachon have been found at several Washington and Oregon coastal locations, and they were previously common in Oregon's Umpqua River and the Klamath River in northern California. Runs occasionally occur in many other rivers and streams, but often erratically, appearing in some years, but not in others, and only rarely in some river systems (Hay and McCarter 2000; Willson et al. 2006; Gustafson et al. 2010). 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.

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

Prior to 2011, few direct estimates of eulachon abundance existed in the United States. Escapement counts and spawning stock biomass estimates are only available for a small number of systems. Catch statistics from commercial and First Nations fisheries are available for some systems in which no direct estimates of abundance are available. However, inferring population status or even trends from yearly catch statistic changes requires making certain assumptions that

are difficult to corroborate (e.g., assuming that harvest effort and efficiency are similar from year to year, assuming a consistent relationship among the harvested and total stock portion, and certain statistical assumptions, such as random sampling). Unfortunately, these assumptions cannot be verified—few fishery-independent sources of eulachon abundance data exist. However, the combination of catch records and anecdotal information indicates that there were large eulachon runs in the past and that eulachon populations have severely declined (Gustafson et al. 2010). As a result, eulachon numbers are at, or near, historically low levels throughout the range of the SDPS. Beginning in 2011, eulachon monitoring programs began in the Columbia River and other nearby rivers that estimate eulachon egg and larvae production to close this data gap.

Similar abundance declines have occurred in the Fraser River and in other coastal British Columbia rivers (Hay and McCarter 2000, Moody 2008). Over a three-generation span of 10 years (1999 to 2009), the overall Fraser River eulachon population biomass declined by nearly 97 percent (Gustafson et al. 2010). In 1999, the biomass estimates were 418 metric tons; by 2010, this number had dropped to 4 metric tons (NMFS 2018b). Abundance information is lacking for many coastal British Columbia subpopulations, but Gustafson et al. (2010) found that eulachon runs were universally larger in the past. Under the Species at Risk Act, Canada designated the Fraser River population as endangered in May 2011 due to a 98 percent decline in spawning stock biomass over the previous 10 years (COSEWIC 2011a). From 2013 through 2017, the Fraser River eulachon spawner population estimate is 1,968,688 adults[10] (NMFS 2018b).

The Columbia River and its tributaries support the largest known eulachon run in the SDPS. Although direct estimates of adult spawning stock abundance are limited, commercial fishery landing records begin in 1888 and continue as a nearly uninterrupted data set to 2010 (Gustafson et al. 2010). From approximately 1915 to 1992, historical commercial catch levels were typically more than 500 metric tons, occasionally exceeding 1,000 metric tons. In 1993, eulachon catch levels began to decline and averaged less than 5 metric tons from 2005 to 2008 (Gustafson et al. 2010). Beginning in 2011, WDFW and ODFW began to estimate eulachon abundance for the Columbia River watershed. Adopting methods that CDFO has used since 1995 to estimate the Fraser River eulachon spawning runs, researchers began estimating eulachon spawning runs for the Columbia River watershed. From 2013 through 2017, the average eulachon spawner estimate for the Columbia River and its tributaries is 32,968,415 eulachon spawning adults (NMFS 2018b; from unpublished NWFSC data).

In Northern California, no long-term eulachon monitoring programs exist. In the Klamath River, large eulachon spawning aggregations once occurred regularly, but eulachon abundance has declined substantially (Fry 1979; Moyle et al; 1995, Larson and Belchik 1998; Hamilton et al. 2005). Beacham et al. (2005) reported that marine sampling by trawl showed that eulachon from different rivers mix during their 2 to 3 years of pre-spawning life in offshore marine waters, but not thoroughly. Their samples from southern British Columbia comprised a mix of fish from multiple rivers, but they were dominated by fish from the Columbia and Fraser River

[10] Spawing population estimates can be found at: http://www.pac.dfo-mpo.gc.ca/science/species-especes/pelagic-pelagique/herring-hareng/herspawn/pages/river1-eng.html

populations. Using the available information, the combined spawner estimate from the Columbia and Fraser rivers is ~35 million eulachon.

Threats: NMFS completed a recovery plan for the SDPS of eulachon in September 2017 (NMFS 2017b). The blueprint for recovery covers eulachon that spawn in rivers from British Columbia's Nass River south to the Mad River in California. The NMFS Biological Review Team (BRT) that examined the status of eulachon categorized climate change impacts on ocean conditions as the most serious threat facing all four subpopulations of eulachon: Klamath River, Columbia River, Fraser River, and British Columbia coastal rivers south of the Nass River. Climate change impacts on freshwater habitat and eulachon bycatch in offshore shrimp fisheries were also ranked in the top four threats in all subpopulations of the SDPS (NMFS 2017b). Dams and water diversions in the Klamath and Columbia Rivers and predation in the Fraser River and British Columbia coastal rivers filled out the last of the top four threats (Gustafson et al. 2010). These threats, together with large declines in abundance, indicated to the BRT that eulachon was at moderate risk of extinction throughout all of its range (Gustafson et al. 2010).

2.2.3. 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).

A species' status thus is a function of how well its biological requirements are being met: the greater the degree to which the requirements are fulfilled, the better the species' status. Information on the status and distribution of all the species considered here can be found in a number of documents, but the most pertinent are the status review updates and recovery plans listed in Appendix 1 and in the specific species sections that follow. These documents and other relevant information may be found on the NOAA Fisheries West Coast Region website; the discussions they contain are summarized in the tables below. For the purposes of our later analysis, all the species considered here require functioning habitat and adequate spatial structure, abundance, productivity, and diversity to ensure their survival and recovery in the wild.

2.2.3.1 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.

2.2.3.1.1 Sacramento River Winter-run Chinook Salmon

Listed Hatchery Juvenile Releases – Only one artificial propagation program is considered to be part of the Sacramento River winter-run (SacR WR) Chinook salmon ESU (79 FR 20802) – the Livingston Stone National Fish Hatchery. Annual releases from the hatchery are limited to 200,000 juvenile SacR WR Chinook salmon (all adipose-clipped).

Adult spawners and expected outmigration – To estimate annual abundance for adult spawners (natural- and hatchery-origin) we calculate the average of five years of adult spawner counts (2013 through 2017) from surveys conducted by the California Department of Fish and Wildlife (CDFW 2018). The average total abundance (2013-2017) for SacR WR Chinook salmon is 2,442 adult spawners (Table 4).

Juvenile SacR WR Chinook salmon abundance estimates come from escapement data, the percentage of females in the population, and fecundity. Fecundity estimates for the ESU range

from 2,000 to 5,500 eggs per female, and the proportion of female spawners in most populations is approximately 40% of escapement. By applying a conservative fecundity estimate (2,000 eggs/female) to the expected female escapement (both natural-origin and hatchery-origin spawners – 977 females), the ESU is estimated to produce approximately 1.95 million eggs annually. The average survival rate in these studies was 10%, which corresponds with those reported by Healey (1991). With an estimated survival rate of 10%, the ESU should produce roughly 195,354 natural outmigrants annually (Table 4).

Table 4. Expected annual abundances of SacR WR Chinook salmon spawners and juvenile outmigrants (CDFW 2018).

Life Stage	Origin	Abundance
Adult	Natural	210
	Listed Hatchery Adipose Clip	2,232
Juvenile	Natural	195,354
	Listed Hatchery Adipose Clip	200,000

2.2.3.1.2 Central Valley Spring-run Chinook Salmon

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

Adult spawners and expected outmigration – To estimate annual abundance for adult spawners (natural- and hatchery-origin) we sum the five-year geometric means of adult spawner counts (2013 through 2017) from all populations with available survey data (CDFW 2018; Table 5). Historic spawning habitat on the Feather River is blocked by Oroville Dam, so all CVS Chinook salmon are returned to the hatchery (i.e., there is no naturally produced component of this population; Williams et al. 2016; CDFW 2018).

The California Department of Fish and Game (1998; now CDFW) published estimates in which average fecundity of spring-run Chinook salmon is 4,161 eggs per female. By applying the average fecundity of 4,161 eggs per female to the estimated 1,862 females returning (half of the most recent five-year average of spawners), and applying an estimated survival rate from egg to smolt of 10%, the Sacramento River basin portion of the ESU could produce roughly 775 thousand natural outmigrants annually.

Table 5. Expected annual abundances of CVS Chinook salmon spawners and juvenile outmigrants (CDFW 2018).

Life Stage	Origin	Abundance
Adult	Natural	3,727
	Listed Hatchery Adipose Clip	2,273

Juvenile	Natural	775,474
	Listed Hatchery Adipose Clip	2,169,329

2.2.3.1.3 California Coastal Chinook Salmon

Adult spawners and expected outmigration – Although there are limited population-level estimates of abundance for California Coastal (CC) Chinook salmon populations, the ESU abundance estimate is calculated by summing the average population abundances calculated from information available for the major watersheds in the ESU (Metheny and Duffy 2014, PFMC 2013, Ricker et al. 2014, Mattole Salmon Group 2011, Potter Valley Irrigation District Van Arsdale Fish Counts 2015, Sonoma Water - Chinook Salmon in the Russian River webpage; Table 6).

While we currently lack data on naturally produced juvenile CC Chinook salmon production, it is possible to make rough estimates of juvenile abundance from adult return data. Juvenile CC Chinook salmon population abundance estimates come from escapement data, the percentage of females in the population, and fecundity. Average fecundity for female CC Chinook salmon is not available. However, Healey and Heard (1984) indicates that average fecundity for Chinook salmon in the nearby Klamath River is 3,634 eggs for female. By applying an average fecundity of 3,634 eggs per female to the estimated 3,517 females returning (half of the average total number of spawners), and applying an estimated survival rate from egg to smolt of 10%, the ESU could produce roughly 1,278,078 natural outmigrants annually. There are currently no listed hatchery programs included in this ESU.

Table 6. Expected annual abundances of CC Chinook salmon spawners and juvenile outmigrants (Metheny and Duffy 2014, PFMC 2013, Ricker et al. 2014, Mattole Salmon Group 2011, Potter Valley Irrigation District - Van Arsdale Fish Counts webpage, Sonoma Water - Chinook Salmon in the Russian River webpage).

Life Stage	Origin	Abundance
Adult	Natural	7,034
Juvenile	Natural	1,278,078

2.2.3.1.4 Snake River Fall-run Chinook salmon

Listed Hatchery Juvenile Releases and Natural Juvenile Abundance – four artificial propagation programs were listed as part of the Snake River (SnkR) fall-run ESU (79 FR 20802). From 2015-2019, the geometric means for the releases from these hatcheries are 2,483,713 listed hatchery adipose clipped (LHAC) and 2,862,418 listed hatchery intact adipose (LHIA) SnkR fall Chinook annually (Zabel 2015, 2017a, 2017b, 2018, 2020). To estimate abundance of natural juvenile SnkR fall Chinook, we calculate the geometric means for outmigrating smolts over the past five years (2015-2019) by using annual abundance estimates provided by the NWFSC (Zabel 2015, 2017a, 2017b, 2018, 2020). For natural-origin juvenile SnkR fall Chinook, an estimated average of 692,819 juveniles outmigrated over the last five years.

Adult Abundance – To calculate the abundance figures for adult spawners (natural and hatchery), we calculate the geometric means of the last five years of adult returns as measured by dam counts. This is part of the tracking done for the Federal Columbia River Power System's Adaptive Management and Implementation Plan (AMIP 2020). The five-year geometric means (2015-2019) for SnkR fall Chinook salmon are 10,337 natural-origin, 12,508 LHAC, and 13,551 LHIA adults. The AMIP figures represent natural returns only. We calculate the hatchery returns by taking the wild return numbers and expanding them by the fractions of the wild vs. hatchery constituents found in the NWFSC outmigration estimate memos (above).

2.2.3.1.5 Snake River spring/summer Chinook

Listed Hatchery Juvenile Releases and Natural Juvenile Abundance – 11 artificial propagation programs were listed as part of the Snake River spring/summer (SnkR spr/sum) ESU (79 FR 20802). From 2014-2018, the geometric means for the releases from these hatcheries are 4,760,250 LHAC and 868,679 LHIA SnkR spr/sum Chinook annually (Zabel 2014, 2015, 2017a, 2017b, 2018). To estimate abundance of natural juvenile spr/sum Chinook, we calculate the geometric means for outmigrating smolts over the past five years for which we have data (2014-2018) by using annual abundance estimates provided by the NWFSC (Zabel 2014, 2015, 2017a, 2017b, 2018). For natural-origin juvenile SnkR spr/sum Chinook, an estimated average of 1,296,641 juveniles outmigrated over the five most recent years for which we have data.

Adult Abundance – To calculate the abundance figures for adult spawners (natural and hatchery), we calculate the geometric means of the last five years of adult returns as measured by dam counts. This is part of the tracking done for the Federal Columbia River Power System's Adaptive Management and Implementation Plan (AMIP 2020). The five-year geometric means (2014-2018) for SnkR spr/sum-run Chinook salmon are 12,798 natural-origin, 2,387 LHAC, and 421 LHIA adults. The AMIP figures represent natural returns only. We calculate the hatchery returns by taking the wild return numbers and expanding them by the fractions of the wild vs. hatchery constituents found in the NWFSC outmigration estimate memos (above)

2.2.3.1.6 Lower Columbia River Chinook

Listed Hatchery Juvenile Releases and Natural Juvenile Abundance – This ESU includes fifteen ESA-listed artificial propagation programs (79 FR 20802). Hatchery release estimates are used to calculate 5-year geometric means for annual LHIA and LHAC juvenile Lower Columbia River (LCR) Chinook salmon abundance (Zabel 2015, 2017a, 2017b, 2018, 2020; Table 7). To estimate abundance of natural-origin juvenile LCR Chinook salmon, we calculate the geometric mean for outmigrating smolts over the past five years (2015-2019) by using annual abundance estimates provided by the NWFSC (Zabel 2014, 2015, 2017a, 2017b, 2018, 2020, Table 7).

Adult Abundance – To calculate estimates of annual abundance for adult spawners (natural- and hatchery-origin) we calculate the geometric means of the last five years of adult returns as estimated by state agencies from spawning ground surveys, counts at established fish passage monitoring locations, and other routine monitoring (ODFW Corvallis Research Laboratory -

Oregon Adult Salmonid Inventory & Sampling Project; WDFW Chinook - General Information Page). The average abundance for LCR Chinook salmon populations is 68,063 adult spawners (Table 7).

Table 7. Expected annual abundances of LCR Chinook salmon spawners and juvenile outmigrants (ODFW Corvallis Research Laboratory - Oregon Adult Salmonid Inventory & Sampling Project; WDFW Chinook - General Information Page, Zabel 2015, 2017a, 2017b, 2018, 2020).

Life Stage	Origin	Abundance
Adult	Natural	29,469
	Listed Hatchery, Clipped and Intact	38,594
Juvenile	Natural	11,745,027
	Listed Hatchery Intact Adipose	962,458
	Listed Hatchery Adipose Clip	31,353,395

2.2.3.1.7 Upper Willamette River Chinook

Listed Hatchery Juvenile Releases – This ESU includes spring-run Chinook salmon from six artificial propagation programs (79 FR 20802). To estimate abundance of juvenile Upper Willamette River (UWR) Chinook salmon, we calculate the geometric mean for outmigrating smolts over the past five years (2015-2019) by using annual abundance estimates provided by the NWFSC (Zabel 2014, 2015, 2017a, 2017b, 2018; Table 8).

Adult spawners and expected outmigration – To estimate annual abundance for adult spawners (natural- and hatchery-origin) we calculate the geometric means of five years of adult returns (2013-2017) as estimated from Willamette Falls fish counts and Clackamas River post-fishery escapement counts (ODFW - Lower Willamette Fisheries and Willamette Falls Fish Counts). The total abundance of UWR Chinook salmon is estimated at 41,679 adult spawners (Table 8).

Table 8. Expected annual abundances of UWR Chinook salmon spawners and juvenile outmigrants (ODFW - Lower Willamette Fisheries and Willamette Falls Fish Counts, Zabel 2015, 2017a, 2017b, 2018, 2020).

Life Stage	Origin	Abundance
Adult	Natural	10,203
	Listed Hatchery, Clipped and Intact	31,476
Juvenile	Natural	1,211,863
	Listed Hatchery Intact Adipose	4,214
	Listed Hatchery Adipose Clip	4,709,045

2.2.3.1.8 Upper Columbia River spring Chinook

Listed Hatchery Juvenile Releases and Natural Juvenile Abundance – The Upper Colombia River (UCR) spring-run ESU includes Chinook salmon from six artificial propagation programs (79 FR 20802). From 2015-2019, the geometric means for the releases from these hatcheries

were 621,759 LHAC and 368,642 LHIA UCR spring-run Chinook salmon smolts annually (Zabel 2014, 2015, 2017a, 2017b, 2018). To estimate abundance of natural juvenile UCR spring-run Chinook salmon, we calculate the geometric means for outmigrating smolts over the past five years (2015-2019) by using annual abundance estimates provided by the NWFSC (Zabel 2015, 2017a, 2017b, 2018, 2020). For natural-origin juvenile UCR spring-run Chinook salmon, an estimated average of 468,820 juveniles outmigrated over the last five years (Table 9).

Adult Abundance – To calculate the abundance figures for adult spawners (natural and hatchery), we calculate the geometric means of the last five years of adult returns as measured by dam counts. This is part of the tracking done for the Federal Columbia River Power System's Adaptive Management and Implementation Plan (AMIP 2020). The most recent five-year geometric means (2014-2018) for UCR spring-run Chinook salmon are 2,872 natural-origin; 6,226 LHAC; and 3,364 LHIA adults (Table 9). The AMIP figures represent natural returns only. We calculate the hatchery returns by taking the wild return numbers and expanding them by the fractions of the wild vs. hatchery constituents found in the NWFSC outmigration estimate memos (above).

Table 9. Recent Five-Year Geometric Means for the Estimated Juvenile Outmigrations and Adult returns of UCR Chinook (Zabel 2015, 2017a, 2017b, 2018, 2020, AMIP 2020).

Life Stage	Origin	Outmigration/Return
Juvenile	Natural	468,820
Juvenile	LHAC	621,759
Juvenile	LHIA	368,642
Adult	Natural	2,872
Adult	LHAC	6,226
Adult	LHIA	3,364

2.2.3.1.9 Puget Sound Chinook

Listed Hatchery Juvenile Releases – Twenty-six artificial propagation programs are part of the species and are also listed (79 FR 20802; Table 10). Juvenile listed hatchery PS Chinook salmon abundance estimates come from the annual hatchery production goals and planned releases (WDFW 2020; Table 10). Hatchery production varies annually due to several factors including funding, equipment failures, human error, disease, and adult spawner availability. Funding uncertainties and the inability to predict equipment failures, human error, and disease suggest that production averages from previous years is not a reliable indication of future production. For these reasons, abundance is assumed to equal production goals. The combined hatchery production goal for listed PS Chinook salmon is 54,843,130 adipose-fin-clipped and non-clipped juvenile Chinook salmon.

Adult spawners and expected outmigration – The current abundance for adult PS Chinook salmon is calculated by summing the five-year geometric mean abundance estimates for all populations' natural- and hatchery-origin spawners (unpublished data, Mindy Rowse, NWFSC,

July 14, 2020; Table 10). No populations in this DPS are meeting their minimum viability abundance targets, and only three of 22 populations average greater than 20% of the minimum viability abundance target for natural-origin spawner abundance (all of which are in the Skagit River watershed).

Table 10. Expected annual abundances of PS Chinook salmon spawners and juvenile outmigrants (WDFW 2020, unpublished data from Mindy Rowse, NWFSC, July 14, 2020).

Life Stage	Origin	Abundance
Adult	Natural	21,486
	Listed Hatchery, Clipped and Intact	18,060
Juvenile	Natural[1]	3,163,652
	Listed Hatchery Intact Adipose	7,470,630
	Listed Hatchery Adipose Clip	47,372,500

[1] Expected number of outmigrants=Total spawners*40% proportion of females*2,000 eggs per female*10% survival rate from egg to outmigrant (Healey 1991; Beamer et al. 2000; Seiler et al. 2002, 2004, 2005; Volkhardt et al. 2005; Griffith et al. 2004)

Natural-origin juvenile PS Chinook salmon abundance estimates come from escapement data, the percentage of females in the population, and fecundity. Fecundity estimates for the ESU range from 2,000 to 5,500 eggs per female, and the proportion of female spawners in most populations is approximately 40% of escapement. By applying a conservative fecundity estimate (2,000 eggs/female) to the expected female escapement (both natural-origin and hatchery-origin spawners – 15,818 females), the ESU is estimated to produce approximately 31.6 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 3.16 million natural-origin outmigrants annually.

2.2.3.2 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.

2.2.3.2.1 Hood Canal Summer Chum

Listed Hatchery Juvenile Releases – Four artificial propagation programs were listed as part of the Hood Canal summer (HCS) chum ESU (79 FR 20802); however, only one program is currently active. The combined hatchery production goal for listed HCS chum salmon from Table 11 is 150,000 unmarked juvenile chum salmon.

Table 11. Expected 2019 Hood Canal summer-run juvenile chum salmon hatchery releases (WDFW 2020.

Subbasin	Artificial propagation program	Brood year	Run Timing	Clipped Adipose Fin	Intact Adipose Fin
Hood Canal	LLTK - Lilliwaup	2018	Summer	-	150,000
				-	**150,000**

Adult spawners and expected outmigration – The current average run size of 40,526 adult spawners (38,697 natural-origin and 1,829 hatchery-origin spawners; Table 12) 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, Mindy Rowse, NWFSC, Feb 2, 2017). From 2013 to 2017, Jimmycomelately Creek averaged 2,634 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 2,521 and 332, respectively, for the 2013-2017 period.

Table 12. Abundance of natural-origin and hatchery-origin HCS chum salmon spawners in escapements 2013-2017 (unpublished data, Mindy Rowse, NWFSC, Apr 12, 2019).

Population Name	Natural-origin Spawners[a]	Hatchery-origin Spawners[a]	% Hatchery Origin	Expected Number of Outmigrants[c]
Strait of Juan de Fuca Population				
Jimmycomelately Creek	2,634	406	13.35%	444,570
Salmon Creek	2,521	0	0.00%	368,728
Snow Creek	332	0	0.00%	48,511
Chimacum Creek	1,611	0	0.00%	235,549
Population Average[d]	7,098	406	5.41%	1,097,359
Hood Canal Population				
Big Quilcene River	11,472	0	0.00%	1,677,808
Little Quilcene River	900	0	0.00%	131,586
Big Beef Creek	34	0	0.00%	5,024
Dosewallips River	4,329	2	0.05%	633,424
Duckabush River	6,151	2	0.04%	899,993
Hamma Hamma River	3,718	0	0.00%	543,729
Anderson Creek	3	0	0.00%	374

Population Name	Natural-origin Spawners[a]	Hatchery-origin Spawners[a]	% Hatchery Origin	Expected Number of Outmigrants[c]
Dewatto River	159	0	0.00%	23,298
Lilliwaup Creek	784	960	55.03%	255,106
Skokomish River	489	395	44.68%	129,222
Tahuya River	1,869	64	3.33%	282,815
Union River	1,690	0	0.00%	247,125
Population Average[d]	31,599	1,423	4.31%	4,829,506
ESU Average	**38,697**	**1,829**	**4.51%**	**5,926,865**

[a] Five-year geometric mean of post fishery natural-origin spawners (2013-2017).
[b] Five-year geometric mean of post fishery hatchery-origin spawners (2013-2017).
[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 (2013-2017).

Escapement data, the percentage of females in the population, and fecundity can estimate juvenile HCS chum salmon abundance. ESU fecundity estimates average 2,500 eggs per female, and the proportion of female spawners is approximately 45% of escapement in most populations (WDFW/PNPTT 2000). By applying fecundity estimates to the expected escapement of females (both natural-origin and hatchery-origin spawners – 18,237 females), the ESU is estimated to produce approximately 45.6 million eggs annually. For HCS chum salmon, freshwater mortality rates are high with no more than 13% of the eggs expected to survive to the juvenile migrant stage (Quinn 2005). With an estimated survival rate of 13%, the ESU should produce roughly 5.93 million natural-origin outmigrants annually.

2.2.3.2.2 Columbia River Chum Salmon

Listed Hatchery Juvenile Releases and Natural Juvenile Abundance – Two artificial propagation programs were listed as part of the ESU (79 FR 20802). All the fish produced in these hatcheries have intact adipose fins. Hatchery release estimates are used to calculate 5-year geometric means for annual hatchery-origin juvenile CR chum salmon abundance (Zabel 2015, 2017a, 2017b, 2018, 2020; Table 13). To estimate abundance of natural-origin juvenile CR chum salmon, we calculate the geometric mean for outmigrating smolts over the past five years (2015-2019) by using annual abundance estimates provided by the NWFSC (Zabel 2015, 2017a, 2017b, 2018, 2020).

Adult Abundance – To estimate annual abundance for adult spawners (natural- and hatchery-origin) we calculate the geometric means of the last five years of adult returns as estimated by state agencies from spawning ground surveys, counts at established fish passage monitoring locations, and other routine monitoring (ODFW Corvallis Research Laboratory - Oregon Adult Salmonid Inventory & Sampling Project; WDFW Chinook - General Information Page). The average abundance for CR chum salmon populations is 11,070 adult spawners (Table 13).

Table 13. Expected annual abundances of CR chum salmon spawners and juvenile outmigrants (ODFW Corvallis Research Laboratory - Oregon Adult Salmonid Inventory & Sampling Project; WDFW Chinook - General Information Page; Zabel 2015, 2017a, 2017b, 2018, 2020).

Life Stage	Origin	Abundance
Adult	Natural	10,644
	Listed Hatchery Intact Adipose	426
Juvenile	Natural	6,626,218
	Listed Hatchery Intact Adipose	601,503

2.2.3.3 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. There are 4 ESA-listed ESUs of coho salmon that occur within SWFSC research areas: Central California Coast ESU, endangered; Southern Oregon & Northern California Coasts ESU, threatened; Oregon coast ESU, threatened; and Lower Columbia River ESU, threatened.

2.2.3.3.1 Central California Coast Coho

Listed Hatchery Juvenile Releases – The Central California Coast (CCC) coho salmon ESU includes three artificial propagation programs (79 FR 20802). The sum of expected annual releases from all three programs is used to estimate the abundance of hatchery-origin outmigrating juveniles (Sea Grant California - Hatchery Releases webpage, Monterey Bay Salmon & Trout Project webpage, NOAA Fisheries - Species in the Spotlight Action Plan Implementation Highlights webpage; Table 14).

Adult spawners and expected outmigration – To estimate annual abundance for adult spawners (natural- and hatchery-origin) we sum the geometric means of recent years of adult spawner counts from populations with available survey data (Williams et al. 2016, J. Jahn, pers. comm., July 2, 2013; Table 14).

While we currently lack data on how many natural juvenile coho salmon this ESU produces, it is possible to make rough estimates of juvenile abundance from adult return data. Sandercock (1991) published fecundity estimates for several coho salmon stocks; average fecundity ranged from 1,983 to 5,000 eggs per female. By applying a very conservative value of 2,000 eggs per

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

Table 14. Expected annual abundances of CCC coho salmon spawners and juvenile outmigrants (Sea Grant California - Hatchery Releases webpage, Monterey Bay Salmon & Trout Project webpage, NOAA Fisheries - Species in the Spotlight Action Plan Implementation Highlights webpage; Williams et al. 2016, J. Jahn, pers. comm., July 2, 2013).

Life Stage	Origin	Abundance
Adult	Natural	1,932
	Listed Hatchery Intact Adipose	327
Juvenile	Natural	158,130
	Listed Hatchery Intact Adipose	165,880

2.2.3.3.2 Southern Oregon/Northern California Coast Coho Salmon

Listed Hatchery Juvenile Releases – Three artificial propagation programs were listed as part of the ESU (79 FR 20802). Average hatchery release estimates are used to calculate means for annual hatchery-origin juvenile SONCC coho salmon abundance (ODFW 2011, CHSRG 2012).

Adult spawners and expected outmigration – Abundances of hatchery and natural-origin adult SONCC coho salmon spawners are estimated by summing the most recent three-year average counts from the Rogue, Trinity, and Klamath Rivers (ODFW Corvallis Research Laboratory - Oregon Adult Salmonid Inventory & Sampling Project, Kier et al 2015, CDFW 2012; Table 15). In the Shasta River (a tributary to the Klamath River) the proportion of hatchery adults is unknown, but assumed to be low. Annual returns in the Salmon River (also a Klamath River tributary) are assumed to be 50 a year, but are likely less (NMFS 2014b).

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 9,995 females returning (half of the average total number of spawners), approximately 28.8 million eggs may be expected to be produced annually. Nickelson (1998) found survival of coho salmon from egg to parr in Oregon coastal streams to be around seven percent. Thus, we approximate that this ESU produces about 2,013,593 juvenile SONCC coho salmon outmigrants annually (Table 15).

Table 15. Expected annual abundances of SONCC coho salmon spawners and juvenile outmigrants (ODFW Corvallis Research Laboratory - Oregon Adult Salmonid Inventory & Sampling Project, Kier et al 2015, CDFW 2012).

Life Stage	Origin	Abundance
Adult	Natural	9,065
	Listed Hatchery, Clipped and Intact	10,934
Juvenile	Natural	2,013,593
	Listed Hatchery Intact Adipose	575,000
	Listed Hatchery Adipose Clip	200,000

2.2.3.3.3 Oregon Coast Coho

Listed Hatchery Juvenile Releases – The Oregon Coast (OC) coho salmon ESU includes one artificial propagation program: the Cow Creek Hatchery Program (Oregon Department of Fish and Wildlife Stock #18) (79 FR 20802). The hatchery production goal is 60,000 adipose-fin-clipped yearling OC coho salmon (ODFW 2017).

Adult spawners and expected outmigration – The average abundance for OC coho salmon populations is 94,879 adult spawners (94,320 natural-origin and 559 hatchery-origin spawners; Table 16).

Table 16. Average abundance estimates for OC coho salmon natural- and hatchery-origin spawners (Sounhein et al. 2014, 2015, 2016, 2017, 2018).

Population Name	Natural-origin Spawners[a]	Hatchery-origin Spawners[a]	% Hatchery Origin	Expected Number of Outmigrants[b]
North Coast Stratum				
Necanicum River	1,139	5	0.42%	80,063
Nehalem River	7,073	11	0.16%	495,889
Tillamook Bay	4,771	19	0.39%	335,290
Nestucca River	2,320	2	0.09%	162,547
North Coast Dependents	602	3	0.49%	42,350
Mid-Coast Stratum				
Salmon River	924	9	0.98%	65,352
Siletz River	5,534	2	0.04%	387,545
Yaquina River	4,585	2	0.05%	321,141
Beaver Creek	1,634	1	0.09%	114,493
Alsea River	8,627	0	0.00%	603,904
Siuslaw River	12,994	0	0.00%	909,584
Mid Coast Dependents	1,190	7	0.56%	83,747
Lakes Stratum				
Siltcoos Lake	2,362	0	0.00%	165,333
Tahkenitch Lake	1,356	2	0.13%	95,077
Tenmile Lake	2,909	0	0.00%	203,660
Umpqua Stratum				
Lower Umpqua River	8,755	2	0.02%	612,987

Population Name	Natural-origin Spawners[a]	Hatchery-origin Spawners[a]	% Hatchery Origin	Expected Number of Outmigrants[b]
Middle Umpqua River	3,080	0	0.00%	215,578
North Umpqua River	2,320	191	7.59%	175,760
South Umpqua River	3,683	299	7.52%	278,743
Mid-South Coast Stratum				
Coos River	6,320	0	0.00%	442,407
Coquille River	10,781	3	0.03%	754,870
Floras Creek	1,154	0	0.00%	80,785
Sixes River	200	0	0.00%	14,029
Mid-South Coast Dependents	5	1	16.36%	428
ESU Average	**94,320**	**559**	**0.59%**	**6,641,564**

[a] Five-year geometric mean of post-fishery spawners (2013-2017).
[b] Expected number of outmigrants=Total spawners*50% proportion of females*2,000 eggs per female*7% survival rate from egg to outmigrant.

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 five-year geometric mean from 2013 through 2017 is estimated at 94,879 spawners (Table 16). 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 47,440 females returning (roughly half of 94,879) to this ESU, one may expect approximately 94.88 million eggs to be produced annually. Nickelson (1998) found survival of coho salmon from egg to parr in Oregon coastal streams to be around 7%. Thus, we can estimate that roughly the Oregon Coast ESU produces 6.64 million juvenile coho salmon annually.

2.2.3.3.4 Lower Columbia River Coho

Listed Hatchery Juvenile Releases and Natural Juvenile Abundance – The Lower Columbia River (LCR) coho salmon ESU includes 21 artificial propagation programs (79 FR 20802). Hatchery release estimates are used to calculate 5-year geometric means for annual LHIA and LHAC juvenile LCR coho salmon abundance (Zabel 2015, 2017a, 2017b, 2018, 2020; Table 17). To estimate abundance of natural-origin juvenile LCR coho salmon, we calculate the geometric mean for outmigrating smolts over the past five years (2015-2019) by using annual abundance estimates provided by the NWFSC (Zabel 2015, 2017a, 2017b, 2018, 2020, Table 17).

Adult Abundance – To estimate annual abundance for adult spawners (natural- and hatchery-origin) we calculate the geometric means of the last five years of adult returns as estimated by state agencies from spawning ground surveys, counts at established fish passage monitoring locations, and other routine monitoring (Lewis et al. 2009, 2010, 2011, 2012, 2014; Sounhein et al. 2014, 2015, 2016, 2017, 2018; WDFW Conservation - Coho salmon webpage). The average abundance for LCR coho salmon populations is 38,657 adult spawners (Table 17).

Table 17. Expected annual abundances of LCR coho salmon spawners and juvenile outmigrants (Lewis et al. 2009, 2010, 2011, 2012, 2014; Sounhein et al. 2014, 2015, 2016, 2017, 2018; WDFW Conservation - Coho salmon webpage, Zabel 2015, 2017a, 2017b, 2018, 2020).

Life Stage	Origin	Abundance
Adult	Natural	29,866
	Listed Hatchery, Clipped and Intact	8,791
Juvenile	Natural	661,468
	Listed Hatchery Intact Adipose	249,784
	Listed Hatchery Adipose Clip	7,287,647

2.2.3.4 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 SWFSC research areas however only two are listed under the ESA: Snake River ESU, endangered, and Ozette Lake ESU, threatened.

2.2.3.4.1 Snake River Sockeye

Listed Hatchery Juvenile Releases and Natural Juvenile Abundance – One artificial propagation program was listed as part of the Snake River (SnkR) sockeye salmon ESU – Redfish Lake Captive Broodstock Program (79 FR 20802). From 2015-2019, the geometric mean for the releases from this hatchery program was 242,610 LHAC fish (Zabel 2015, 2017a, 2017b, 2018, 2020). There were no LHIA SnkR sockeye because all the fish from the program are clipped. To estimate abundance of natural juvenile SnkR sockeye, we calculate the geometric means for outmigrating smolts over the past five years (2015-2019) by using annual abundance estimates provided by the NWFSC (Zabel 2015, 2017a, 2017b, 2018, 2020). For natural-origin juvenile SnkR sockeye, an estimated average of 19,181 juveniles outmigrated over the last five years.

Adult Abundance – To calculate the abundance figures for adult spawners (natural and hatchery), we calculate the geometric means of the last five years of adult returns as measured by dam counts. This is part of the tracking done for the Federal Columbia River Power System's Adaptive Management and Implementation Plan (AMIP 2020). The five-year geometric means (2014-2018) for SnkR sockeye salmon are 546 natural-origin and 4,004 LHAC adults. The AMIP figures represent natural returns only. We calculate the hatchery returns by taking the wild return numbers and expanding them by the fractions of the wild vs. hatchery outmigrants found in the NWFSC outmigration estimate memos (above).

2.2.4.4.2 Lake Ozette Sockeye

Listed Hatchery Juvenile Releases – Two artificial propagation programs were listed as part of the Lake Ozette (OL) sockeye salmon ESU – the Umbrella Creek and Big River Hatchery programs (79 FR 20802). For 2018, 305,000 hatchery OL sockeye salmon are expected to be released from the two hatcheries (Table 18).

Table 18. Expected 2019 Ozette Lake juvenile sockeye salmon hatchery releases (WDFW 2018).

Subbasin				
Hoh-Quillayute	Stony Creek	2018	45,750	137,250
	Umbrella Creek	2018	-	122,000

Adult spawners and expected outmigration – Numerous methods with varying degrees of accuracy have been used to estimate adult OL sockeye salmon abundance throughout the years. Up until 2011, counts were conducted at a river spanning weir that were conducted inconsistently, may have impeded fish movement, and increased predation related mortality (NMFS 2016a). To replace the weir counts, an Adaptive Resolution Imaging Sonar (ARIS) has since been used to estimate OL sockeye salmon abundance. Abundance has only been estimated once since 2011; and in 2017, the adult OL sockeye salmon escapement was estimated at 5,036 adults (hatchery and natural-origin combined (Denton 2018). Juvenile OL sockeye salmon 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 2,518 females), the ESU is estimated to produce approximately 7.68 million eggs annually. Analyzing data from 1991 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 1,037,787 natural outmigrants annually.

2.2.3.5 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 (Myrick and Cech 2005). Variability in the diurnal water temperature range is also important for the survivability and growth of salmonids (Busby et al. 1996).

There are eleven DPS of steelhead that may occur in SWFSC research areas: Southern California DPS, endangered; South-Central California Coast DPS, threatened; Central California Coast DPS, threatened; California Central Valley DPS, threatened; Northern California DPS, threatened; Upper Columbia River DPS, threatened; Snake River Basin DPS, threatened; Lower Columbia River DPS, threatened; Upper Willamette River DPS, threatened; Middle Columbia River DPS, threatened; and Puget Sound DPS, threatened.

2.2.3.5.1 Southern California Steelhead

At the time of listing, NMFS concluded that the Southern California (SC) steelhead DPS was in danger of extinction throughout all or a significant portion of its range, and listed it as endangered (62 FR 43937). There is no hatchery production in support of this DPS.

Very little data regarding abundances of SC 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. It is believed that population abundance trends can significantly vary based on yearly rainfall and storm events within the range of the SC steelhead DPS (Williams et al. 2011). Much of the data pertaining to the incidence of adult anadromous *O. mykiss* in the SC steelhead DPS is not appropriate to be used to generate abundance estimates. However, the annual presence and count of adult SC steelhead has been documented annually in a number of streams (Table 19).

Table 19. Total and mean observations of adult anadromous SC steelhead from 2005 to 2014. (Santa Ynez River Adaptive Management Committee 2009, United States Bureau of Reclamation 2011, Hovey and O'Brien 2013, Dagit et al. 2015, Casitas Municipal Water District (2005 through 2014), United Water Conservation District (2005 through 2014), Mark Capelli unpublished data, George Sutherland unpublished data, Resource Conservation District of the Santa Monica Mountains unpublished data, Mauricio Gomez unpublished data, Dave Katjaniak unpublished data)

System	Years	Observations	Observations
		Total	Mean Annual
Santa Ynez River	2005 - 2014	29	2.9
Ventua River	2006 - 2014	13	1.4
Santa Clara River	2005 - 2014	5	0.5
Goleta Slough	2005 - 2014	6	0.6
Mission Creek	2005 - 2014	18	1.8
Carpinteria Creek	2008	3	-
Conejo Creek	2013	1	-

System	Years	Observations	Observations
		Total	Mean Annual
Malibu Creek	2006 - 2014	23	2.6
Topanga Creek	2005 - 2014	8	0.8
Ballona Creek	2008	2	-
San Juan Creek	2005 - 2014	5	0.5
Santa Margarita Creek	2009	1	-
San Luis Rey River	2007	2	-
Las Penasquito Creek	2012	1	-
	Total	**117**	**11.1**

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

Given the lack of consistent monitoring data, low absolute numbers of observations, recognized potential for highly variable escapement from year to year, and the potential for *O. mykiss* phenotypic plasticity we do not consider these estimates suitable for estimating proportions of the DPS which may be affected by the research actions considered in this opinion. These available data are presented for context, however, only qualitative analysis of impacts of the proposed research activities will be performed for the Southern California steelhead DPS.

2.2.3.5.2 South-Central California Coast Steelhead

Adult spawners and expected outmigration – To estimate annual abundance for adult South-Central California Coast (SCCC) steelhead spawners (natural- and hatchery-origin) we sum the geometric means of recent years of adult spawner counts from populations with

available survey data (DW Alley & Associates 2012, Kraft et al. 2013, MPWMD fish counts and Los Padres Reservoir Fish Trap 2013, Allen and Riley 2012, Garrapata Creek Watershed Council 2006; San Luis Resource Conservation District 2012, City of San Luis Obispo 2006; Baglivio 2012; Stillwater Sciences et al. 2012; Table 20). There are no artificial propagation programs that are currently part of this DPS.

Both adult and juvenile abundance data are 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 20). 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 six and a half percent (Ward and Slaney 1993), the DPS should produce roughly 79,057 natural outmigrants annually (Table 20).

Table 20. Expected annual abundances of SCCC steelhead spawners and juvenile outmigrants (DW Alley & Associates 2012, Kraft et al. 2013, MPWMD fish counts and Los Padres Reservoir Fish Trap 2013, Allen and Riley 2012, Garrapata Creek Watershed Council 2006; San Luis Resource Conservation District 2012, City of San Luis Obispo 2006; Baglivio 2012; Stillwater Sciences et al. 2012)

Life Stage	Origin	Abundance
Adult	Natural	695
Juvenile	Natural	79,057

2.2.3.5.3 Central California Coast Steelhead

Listed Hatchery Juvenile Releases – The Central California Coast (CCC) steelhead DPS includes four artificial propagation programs (79 FR 20802). The sum of expected annual releases from all three programs is used to estimate the abundance of hatchery-origin outmigrating juveniles (J. Jahn, pers. comm., July 2, 2013; Table 21).

Adult spawners and expected outmigration – To estimate annual abundance for adult spawners (natural- and hatchery-origin) we sum the geometric means of recent years of adult spawner counts from populations with available survey data (Ettlinger et al. 2012, Jankovitz 2013, MMWD and GANDA 2010, Manning and Martini-Lamb (ed.) 2012, DW Alley & Associates 2012, Atkinson 2010, Williams et al. 2011, Koehler and Blank 2012, additional unpublished data provided by the NMFS SWFSC 2013; Table 21).

Data for both adult and juvenile abundance are limited for this DPS. While we currently lack data on naturally-produced juvenile CCC steelhead, it is possible to make rough estimates of juvenile abundance from the available adult return data. Juvenile CCC steelhead abundance estimates come from the escapement data (Table 21). All returnees to the hatcheries do not contribute to the natural population and are not used in this calculation. For the species,

fecundity estimates range from 3,500 to 12,000; and the male to female ratio averages 1:1 (Pauley et al. 1986). By applying a conservative fecundity estimate of 3,500 eggs to the expected escapement of females (half of the escapement of natural-origin spawners – 1,094 females), 3.8 million eggs are expected to be produced annually. In addition, hatchery managers could produce 648,841 listed hatchery juvenile CCC steelhead each year (Table 21). With an estimated survival rate of six and a half percent (Ward and Slaney 1993), the DPS should produce roughly 248,771 natural outmigrants annually (Table 21).

Table 21. Expected annual abundances of CCC steelhead spawners and juvenile outmigrants (Ettlinger et al. 2012, Jankovitz 2013, MMWD and GANDA 2010, Manning and Martini-Lamb (ed.) 2012, DW Alley & Associates 2012, Atkinson 2010, Williams et al. 2011, Koehler and Blank 2012, additional unpublished data provided by the NMFS SWFSC 2013; J. Jahn, pers. comm., July 2, 2013).

Life Stage	Origin	Abundance
Adult	Natural	2,187
	Listed Hatchery Adipose Clip	3,866
Juvenile	Natural	248,771
	Listed Hatchery Adipose Clip	648,891

2.2.3.5.4 California Central Valley Steelhead

Listed Hatchery Juvenile Releases – Four artificial propagation programs were listed as part of the California Central Valley (CCV) steelhead DPS (79 FR 20802). The sum of expected annual releases from all programs is used to estimate the abundance of hatchery-origin outmigrating juvenile CCV steelhead (California HSRG 2012; Table 22).

Adult spawners and expected outmigration – To estimate annual abundance for adult spawners (natural- and hatchery-origin) we sum the geometric means of recent years of adult spawner counts from populations with available survey data (CHSRG 2012, Hannon and Deason 2005, Teubert et al. 2011, additional unpublished data provided by the NMFS SWFSC; Table 22).

Both adult and juvenile abundance data are limited for this DPS. While we currently lack data on naturally produced juvenile CCV steelhead, it is possible to make rough estimates of juvenile abundance from the available adult return data. Juvenile CCV steelhead abundance estimates come from the escapement data for natural-origin adults (Table 22). For the species, fecundity estimates range from 3,500 to 12,000; and the male to female ratio averages 1:1 (Pauley et al. 1986). By applying a conservative fecundity estimate of 3,500 eggs to the expected escapement of females (half of the escapement of hatchery- and natural-origin spawners – 2,771 females), 9.7 million eggs are expected to be produced annually. With an estimated survival rate of six and a half percent (Ward and Slaney 1993), the DPS should produce roughly 630,403 naturally produced outmigrants annually (Table 22).

Table 22. Expected annual abundances of CCV steelhead spawners and juvenile outmigrants (CHSRG 2012, Hannon and Deason 2005, Teubert et al. 2011, additional unpublished data provided by the NMFS SWFSC).

Life Stage	Origin	Abundance
Adult	Natural	1,686
	Listed Hatchery Adipose Clip	3,856
Juvenile	Natural	630,403
	Listed Hatchery Adipose Clip	1,600,653

2.2.3.5.5 Northern California Steelhead

Adult spawners and expected outmigration – Abundances of adult Northern California (NC) steelhead are estimated by summing the geometric means of population spawner counts available from recent years of surveys (Gallagher and Wright 2009, 2011, and 2012; Gallagher et al. 2013, Mattole Salmon Group 2011, Duffy 2011, Counts at Van Arsdale Fisheries Station 2015, Harris and Thompson 2014, De Haven 2010, Metheny and Duffy 2014, Ricker et al. 2014, additional unpublished data provided by the NMFS SWFSC; Table 23).

Both adult and juvenile abundance data are limited for this DPS. While we currently lack data on naturally produced juvenile NC steelhead, it is possible to make rough estimates of juvenile abundance from the available adult return data. Juvenile NC steelhead abundance estimates come from the escapement data (Table 23). For the species, fecundity estimates range from 3,500 to 12,000; and the male to female ratio averages 1:1 (Pauley et al. 1986). By applying a conservative fecundity estimate of 3,500 eggs to the expected escapement of females (half of the escapement of spawners – 3,610 females), 12.6 million eggs are expected to be produced annually. With an estimated survival rate of six and a half percent (Ward and Slaney 1993), the DPS should produce roughly 821,389 natural outmigrants annually. There are not currently hatchery NC steelhead included in this DPS.

Table 23. Expected annual abundances of NC steelhead spawners and juvenile outmigrants (Gallagher and Wright 2009, 2011, and 2012; Gallagher et al. 2013, Mattole Salmon Group 2011, Duffy 2011, Counts at Van Arsdale Fisheries Station, Harris and Thompson 2014, De Haven 2010, Metheny and Duffy 2014, Ricker et al. 2014, additional unpublished data provided by the NMFS SWFSC).

Life Stage	Origin	Abundance
Adult	Natural	7,221
Juvenile	Natural	821,389

2.2.3.5.6 Upper Columbia River Steelhead

Listed Hatchery Juvenile Releases and Natural Juvenile Abundance – Six artificial propagation programs were listed as part of the Upper Columbia River (UCR) steelhead DPS (79 FR 20802).

Five-year geometric means for releases from these hatchery programs are used to estimate UCR steelhead abundances (Zabel 2015, 2017a, 2017b, 2018, 2020; Table 24). To estimate abundance of natural juvenile UCR steelhead, we calculate the geometric means for outmigrating smolts over the past five years (2015-2019) by using annual abundance estimates provided by the NWFSC (Zabel 2015, 2017a, 2017b, 2018, 2020).

Adult Abundance – To calculate the abundance figures for adult spawners (natural and hatchery), we calculate the geometric means of the last five years of adult returns as measured by dam counts (Table 24). This is part of the tracking done for the Federal Columbia River Power System's Adaptive Management and Implementation Plan (AMIP 2020). The AMIP figures represent natural returns only. We calculate the hatchery returns by taking the wild return numbers and expanding them by the fractions of the wild vs. hatchery constituents found in the NWFSC outmigration estimate memos (above).

Table 24. Expected annual abundances of UCR steelhead spawners and juvenile outmigrants (AMIP 2020, Zabel 2015, 2017a, 2017b, 2018, 2020).

Life Stage	Origin	Abundance
Adult	Natural	1,931
	Listed Hatchery Intact Adipose	1,163
	Listed Hatchery Adipose Clip	5,309
Juvenile	Natural	199,380
	Listed Hatchery Intact Adipose	138,601
	Listed Hatchery Adipose Clip	687,567

2.2.3.5.7 Snake River Basin Steelhead

Listed Hatchery Juvenile Releases and Natural Juvenile Abundance – six artificial propagation programs were listed as part of the Snake River (SnkR) basin DPS (79 FR 20802). From 2015-2019, the geometric means for the releases from these hatcheries are 3,300,152 LHAC and 705,490 LHIA SnkR basin steelhead annually (Zabel 2015, 2017a, 2017b, 2018, 2020). To estimate abundance of natural juvenile SnkR basin steelhead, we calculate the geometric means for outmigrating smolts over the past five years (2015-2019) by using annual abundance estimates provided by the NWFSC (Zabel 2015, 2017a, 2017b, 2018, 2020). For natural-origin juvenile SnkR basin steelhead, an estimated average of 798,341 juveniles outmigrated over the last five years.

Adult Abundance – To calculate the abundance figures for adult spawners (natural and hatchery), we calculate the geometric means of the last five years of adult returns as measured by dam counts. This is part of the tracking done for the Federal Columbia River Power System's Adaptive Management and Implementation Plan (AMIP 2020). The five-year geometric means (2014-2018) for SnkR basin steelhead are 10,547 natural-origin, 79,510 LHAC, and 16,137 LHIA adults. The AMIP figures represent natural returns only. We calculate the hatchery

returns by taking the wild return numbers and expanding them by the fractions of the wild vs. hatchery constituents found in the NWFSC outmigration estimate memos (above).

2.2.3.5.8 Lower Columbia River Steelhead

Listed Hatchery Juvenile Releases and Natural Juvenile Abundance – Seven artificial propagation programs were listed as part of the Lower Columbia River (LCR) steelhead DPS (79 FR 20802). Hatchery release estimates are used to calculate 5-year geometric means for annual LHIA and LHAC juvenile LCR steelhead abundance (Zabel 2015, 2017a, 2017b, 2018, 2020; Table 9). To estimate abundance of juvenile natural-origin LCR steelhead, we calculate the geometric mean for outmigrating smolts over the past five years (2015-2019) by using annual abundance estimates provided by the NWFSC (Zabel 2015, 2017a, 2017b, 2018, 2020; Table 25).

Adult Abundance – To estimate annual abundance for adult spawners (natural- and hatchery-origin) we calculate the geometric means of the last five years of adult returns as estimated by state agencies from spawning ground surveys, counts at established fish passage monitoring locations, and other routine monitoring (ODFW Corvallis Research Laboratory - Oregon Adult Salmonid Inventory & Sampling Project; WDFW Chinook - General Information Page). The average abundance for LCR steelhead salmon populations is 35,217 adult spawners (Table 25).

Table 25. Expected annual abundances of LCR steelhead spawners and juvenile outmigrants (ODFW Corvallis Research Laboratory - Oregon Adult Salmonid Inventory & Sampling Project; WDFW Chinook - General Information Page; Zabel 2015, 2017a, 2017b, 2018, 2020).

Life Stage	Origin	Abundance
Adult	Natural	12,920
	Listed Hatchery, Clipped and Intact	22,297
Juvenile	Natural	352,146
	Listed Hatchery Intact Adipose	9,138
	Listed Hatchery Adipose Clip	1,197,156

2.2.3.5.9 Upper Willamette River Steelhead

Listed Hatchery Juvenile Releases – There are no listed hatchery programs for this DPS. To estimate abundance of natural juvenile Upper Willamette River (UWR) steelhead, we calculate the geometric mean for outmigrating smolts over the past five years (2015-2019) by using annual abundance estimates provided by the NWFSC (Zabel 2015, 2017a, 2017b, 2018, 2020; Table 26).

Adult Abundance – To estimate annual abundance for adult spawners (natural- and hatchery-origin) we calculate the geometric means of five years of adult returns (2013/2014 through 2017/2018) as estimated from Willamette Falls fish counts and Clackamas River post-fishery escapement counts (ODFW - Lower Willamette Fisheries and Willamette Falls Fish Counts; Table 26).

Table 26. Expected annual abundances of UWR steelhead spawners and juvenile outmigrants (ODFW - Lower Willamette Fisheries and Willamette Falls Fish Counts, Zabel 2015, 2017a, 2017b, 2018, 2020).

Life Stage	Origin	Abundance
Adult	Natural	2,912
Juvenile	Natural	140,396

2.2.3.5.10 Middle Columbia River Steelhead

Listed Hatchery Juvenile Releases and Natural Juvenile Abundance – Seven artificial propagation programs were listed as part of the Middle Columbia River (MCR) steelhead DPS (79 FR 20802). Hatchery release estimates are used to calculate 5-year geometric means for annual LHIA and LHAC MCR steelhead abundance (Zabel 2015, 2017a, 2017b, 2018, 2020; Table 27). To estimate abundance of natural juvenile MCR steelhead, we calculate the geometric means for outmigrating smolts over the past five years (2015-2019) by using annual abundance estimates provided by the NWFSC (Zabel 2015, 2017a, 2017b, 2018, 2020).

Adult Abundance – To calculate the abundance figures for adult spawners (natural and hatchery, Table 27), we calculate the geometric means of the last five years of adult returns as measured by dam counts. This is part of the tracking done for the Federal Columbia River Power System's Adaptive Management and Implementation Plan (AMIP 2020). The AMIP figures represent natural returns only. We calculate the hatchery returns by taking the wild return numbers and expanding them by the fractions of the wild vs. hatchery constituents found in the NWFSC outmigration estimate memos (above).

Table 27. Expected annual abundances of MCR steelhead spawners and juvenile outmigrants (AMIP 2020, Zabel 2015, 2017a, 2017b, 2018, 2020).

Life Stage	Origin	Abundance
Adult	Natural	5,052
	Listed Hatchery Intact Adipose	112
	Listed Hatchery Adipose Clip	448
Juvenile	Natural	407,697
	Listed Hatchery Intact Adipose	110,469
	Listed Hatchery Adipose Clip	444,973

2.2.3.5.11 Puget Sound Steelhead

Listed Hatchery Juvenile Releases – Six artificial propagation programs were listed as part of the Puget Sound (PS) steelhead DPS (79 FR 20802; Table 28). For 2021, 222,500 hatchery steelhead (adipose clipped and unmarked) are expected to be released throughout the range of the PS steelhead DPS (WDFW 2020).

Adult spawners and expected outmigration – The current abundance for adult PS steelhead is calculated by summing the five-year geometric mean abundance estimates for all populations' spawners (natural-origin and hatchery-production combined, data accessed on June 30, 2020 from WDFW Steelhead - General Information Page; Table 28). Natural-origin juvenile PS steelhead abundance estimates are calculated from the escapement data (Table 28). For this species the 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 (9,728 females), 34.05 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 2.21 million natural-origin outmigrants annually.

Table 28. Expected annual abundances of PS steelhead spawners and juvenile outmigrants (WDFW 2020, data accessed on June 30, 2020 from WDFW Steelhead - General Information Page).

Life Stage	Origin	Abundance
Adult	Listed Hatchery and Natural Origin	19,456
Juvenile	Natural[1]	2,210,140
	Listed Hatchery Intact Adipose	112,500
	Listed Hatchery Adipose Clip	110,000

[1]Expected number of outmigrants=Total spawners*50% proportion of females (Pauley et al. 1986)*3,500 eggs per female (Pauley et al. 1986)*6.5% survival rate from egg to outmigrant (Ward and Slaney 1993).

2.3. Action Area

"Action area" means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02).

For this proposed action, the action area includes a vast amount of marine waters in the CCE along the U.S. West Coast including adjacent waters in Canada and Mexico, and in the Southern Ocean off Antarctica, as described by Figures 2 and 3. 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. As needed, more specific information about where specific research surveys may be expected to occur are provided as relevant to specific analyses.

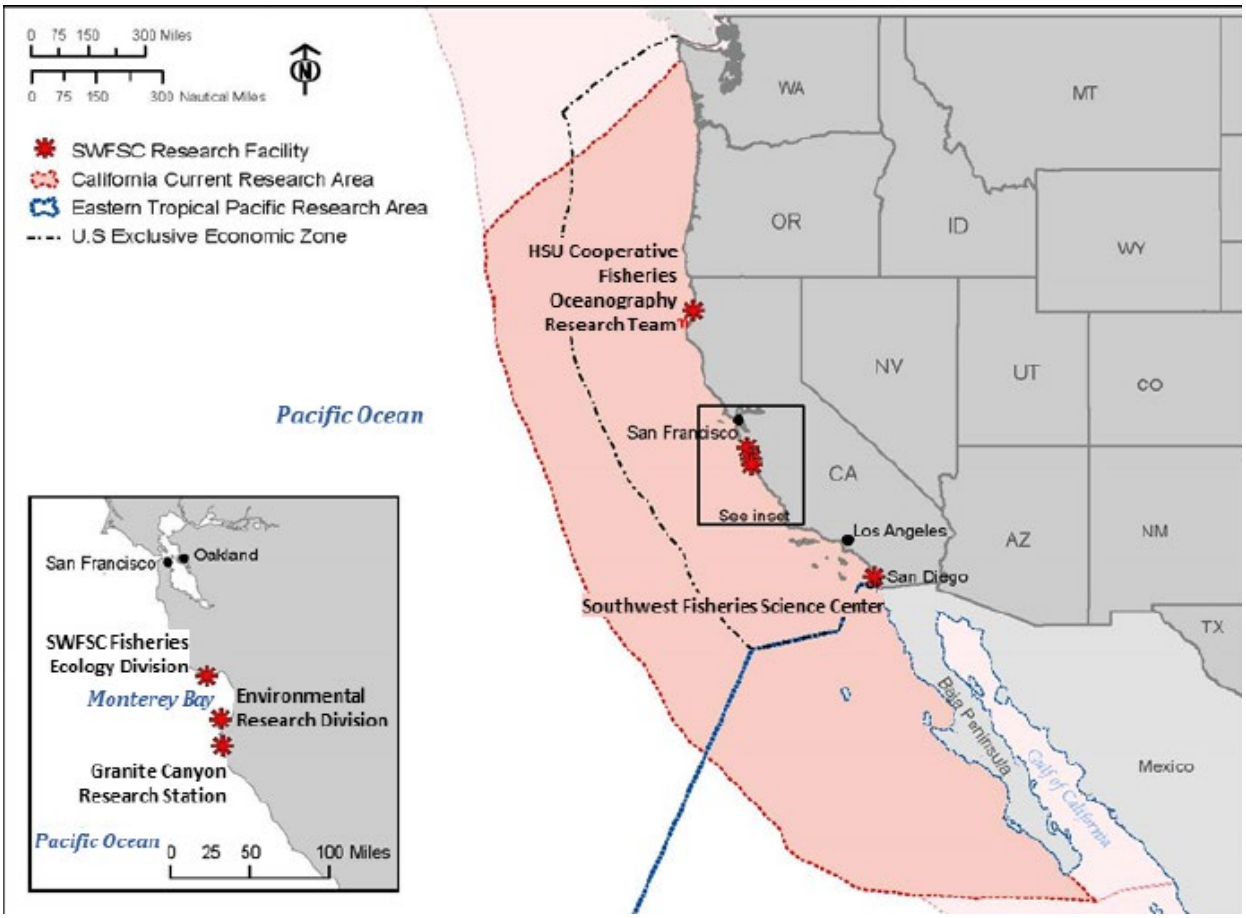

Figure 2. California Current Ecosystem (CCE) research area and research facilities.

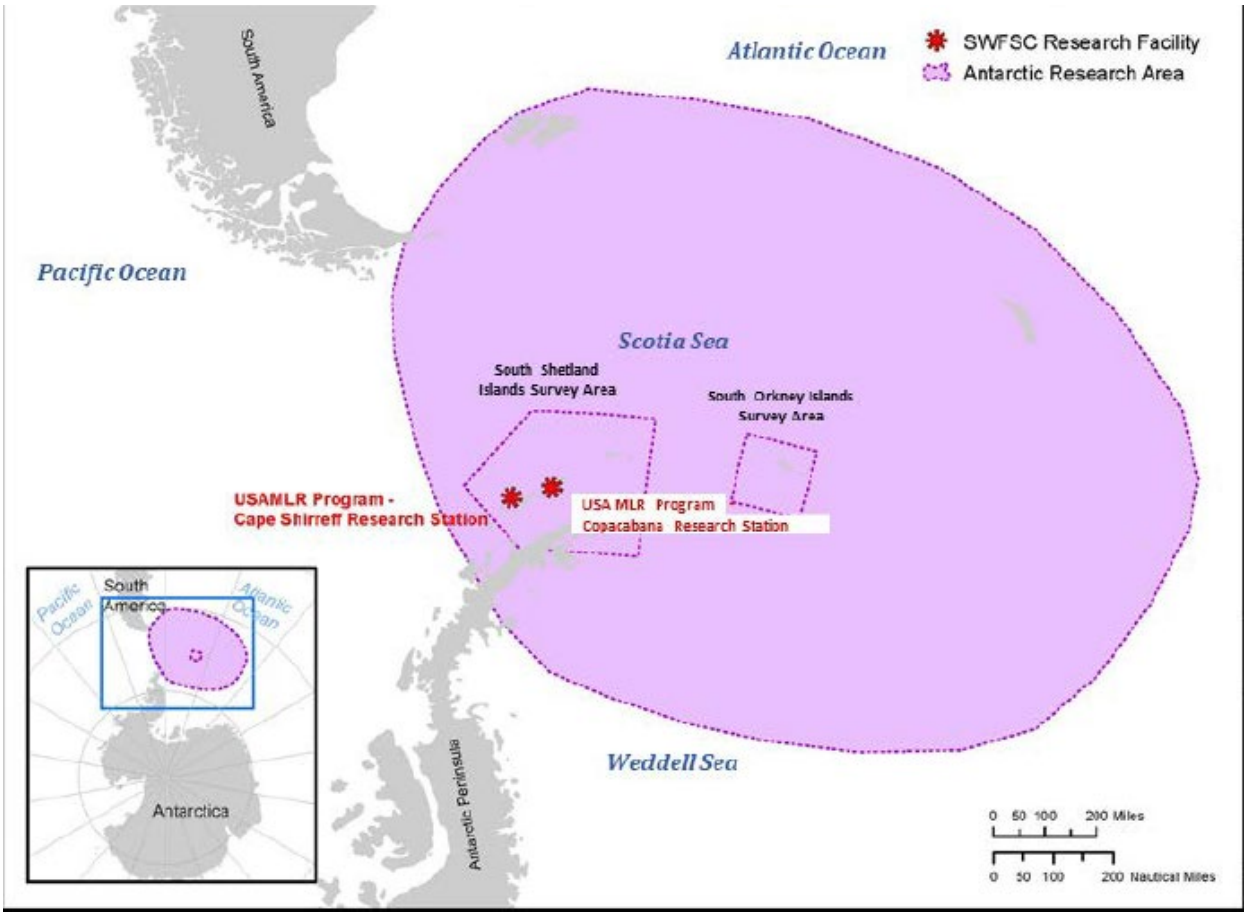

Figure 3. Antarctic research area and research facilities.

2.4. Environmental Baseline

The "environmental baseline" refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or designated critical habitat caused by the proposed action. 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 consultations, and the impact of State or private actions which are contemporaneous with the consultation in process. The consequences to listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 CFR 402.02).

2.4.1. Sea Turtles

As described above in the status section, leatherback, loggerhead, olive ridley, and green 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 where activities that affect sea turtles such as commercial and recreational fishing are conducted. Other impacts to ESA-listed sea

turtles that may occur while present along the U.S. West Coast include vessel collisions, scientific research, and entrainment in coastal power plants, and exposure to environmental changes or hazards. Because impacts on all four turtle species are similar, we look at the environmental baseline on all turtle species together, calling out differences among species as appropriate.

2.4.1.1 Fisheries Interactions

Along the West Coast of the U.S. in the California Current, the four sea turtle species considered in this biological opinion are occasionally reported and/or observed interacting with fishing gear, including pot/trap gear, recreational hook and line gear, and gillnets. All four species have been observed taken in the DGN fishery (NMFS 2013b; Carretta et al. 2019c), although sea turtle interactions are now considered rare events in this fishery since the Pacific Sea Turtle Conservation Areas have been put in place (NMFS 2013b). Since 2001 in the DGN fishery, two loggerheads have been observed taken and released alive (one in 2001 and one in 2006), and two leatherbacks have been observed taken and released alive (one in 2009 and one in 2012). Only one green and one olive ridley have been documented interacting with the DGN fishery (both in 1999).

In other commercial fisheries on the U.S. West Coast, sea turtle bycatch has only rarely been documented. In 2010, one leatherback was found entangled (dead) in sablefish trap gear fishing offshore of Fort Bragg (NMFS 2012c). Recently, one leatherback was found dead entangled in unidentified pot/trap gear in 2015 off central California, one leatherback was found entangled in Dungeness crab pot gear and released alive in 2016, and one leatherback was found dead entangled in rock crab pot gear (NMFS-WCR stranding database, unpublished). 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 2012c, 2013, 2016). 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 historically or recently, although observer coverage of these fisheries has been limited and irregular. Additional interactions between sea turtles and recreational fisheries are known to occur as well, especially green sea turtles in southern California (NMFS-WCR stranding database, unpublished).

2.4.1.2 HMS Experimental Fisheries Permits

In 2018 and 2019, NMFS SFD has consulted upon and/or issued 4 exempted fishery permits (EFPs) for HMS species recommended by the PFMC that may occur within the proposed action area. These EFPs include: Deep-Set Buoy Gear (DSBG) issued in 2018 (NMFS 2018c); Deep-Set Linked Buoy Gear (DSLBG) issued in 2018 (NMFS 2018d); Longline Gear (LL), including Deep-Set Longline Gear (DSLL) and Shallow-Set Longline Gear (SSLL), issued in 2019 (NMFS 2018e); and Deep-Set Shortline (DSSL) consulted on in 2019 (NMFS 2019c). Through consultation NMFS ultimately determined that ESA-listed species, including all ESA-listed species considered in this biological opinion, would not be adversely affected by 3 of these EFPs: DSBG, DSLBG, and DSSL. Through consultation, NMFS determined that the LL EFP

was likely to result in the take of ESA-listed sea turtles, including North Pacific DPS loggerhead, leatherback, and olive ridley sea turtles. Specifically, over the course of 2 years the LL EFP is expected to result in: as many as 2 loggerhead sea turtle entanglements, with 1 mortality; as many as 2 leatherback sea turtle entanglements, with 1 mortality; and no more than 1 olive ridley sea turtle entanglement and mortality (NMFS 2018c). The LL EFP was issued in April, 2019, and was set to expire after two years. On December 20, 2019, a federal court vacated the EFP, final EA, and biological opinion as a result of litigation on the issuance of the LL EFP. No SSLL or DSLL fishing activity has occurred within the West Coast EEZ under the EFP since the court's ruling, and both NMFS and the EFP permit applicants are considering options for how to proceed in the future.

2.4.1.3 Entrainment in Power Plants

In 2006, a biological opinion was completed and analyzed the effects of sea turtle entrainment in the two federally-regulated nuclear power plants located in California, the Diablo Canyon Power Plant found in San Luis Obispo County and the San Onofre Nuclear Generating Station found near San Clemente California (NMFS 2006a). While historically loggerheads, leatherbacks and olive ridleys were observed entrained in the power plants in very low numbers, since 2006, there have been only two reported entrainments, both in the San Onofre Nuclear Generating Station, one olive ridley (alive) in 2009, and one loggerhead (alive) in 2010. In addition, the San Onofre station began de-commissioning in 2014, although some cooling water is still drawn in to cool the reactors (D. Lawson, NMFS personal communication 2015). The incidental take statement covering both power plants estimates up to 6 loggerheads taken, 6 leatherbacks taken, and 6 olive ridleys taken (with two serious injuries each and two mortalities each for all three species) over a one year period (NMFS 2006a). There are other coastal power plants in California (non-nuclear) where sea turtle entrainment has occurred (typically green sea turtles). Although these facilities have all been required to install large organism excluder devices by the State of California (CASWRB 2010), occasional instances of green turtle entrainments (typically alive) continue to be reported.

2.4.1.4 Scientific Research

NMFS issues scientific research permits to allow research actions that involve take of sea turtles within the CCE. Currently there are 3 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 effects. But the risks of a sea turtle incurring an injury or mortality cannot be discounted as a result of directed research. Prior to completing a section 7 ESA consultation on the NWFSC's programmatic research program, one leatherback was found during a SWFSC scientific trawl net survey in 2011 and was released alive (NMFS 2015a). The section 7 ESA consultation on the NWFSC's programmatic research program was completed in 2016 and estimated one loggerhead taken annually, one leatherback taken annually, and one olive ridley taken annually (no mortalities) (NMFS 2016c).

2.4.1.5 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 sea turtles and leatherbacks are reported most often as stranded due to the impact by vessels strikes (Figure 7). 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 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. The recommended lane changes went into effect on June 1, 2013. NMFS completed section 7 consultation on the USCG's lane changes in February 2017 and concluded that there were no takes of leatherbacks anticipated and the proposed action was not likely to adversely affect hard-shelled turtles, including green, North Pacific loggerhead, and olive ridley sea turtles.

2.4.1.6 El Niño/Changing Climate

El Niño events occur with irregularity off the U.S. West Coast and are associated with anomalously warm water incursions. Sea turtles may be affected by El Niño event through a change in distribution or abundance of their preferred prey, which may result in a change in sea turtle distribution or behavior. These warm water events often bring more tropical marine species into normally temperate waters and therefore may affect the local ecosystem and normal predator-prey relationships. For example, North Pacific loggerheads have been encountered off the U.S. West Coast in large numbers during an El Niño. Loggerhead presence in the SCB was first documented in the CA drift gillnet fishery during the 1990s, when they were taken by the fishery during years associated with El Niño events (1992-93 and 1997-98). Anomalously warm waters bring pelagic red crabs, a preferred prey item of loggerheads and may have brought loggerheads into the area, although they have also been documented associating with pyrosomes during the 2014 incursion of warm water into the waters off California.

We considered the effect of climate change on sea turtles foraging in the action area and/or migrating to and from their nesting beaches or other areas of the Pacific Ocean. While climate change effects have been documented extensively on sea turtle nesting beaches, there is less information available effects of climate change on sea turtles specifically within in the action area. Generally we suspect that some sea turtle species may shift their distribution north as sea surface temperatures increase, which could bring them into more contact with human activities that occur off the U.S. West Coast. And the recent research described in Section 2.2.1 above suggest that the presence of loggerhead sea turtles should be expected to increase if warmer sea surface temperatures in the Southern California Bight occur and persist in the future (Eguchi et al. 2018; Welch et al. 2019).

2.4.1.7 Other Threats and Strandings

Strandings of sea turtles along the U.S. West Coast reflect in part the nature of interactions between sea turtles and human activities, as many strandings are associated with human causes. Sea turtles have been documented stranded off California (and Oregon and Washington, though in less frequent numbers) through their encounters with marine debris, either through ingesting debris or becoming entangled in the debris. Concentrations of plastic debris have been documented widely in the last decade, with the North Pacific Ocean showing similar patterns in other oceans, with plastics concentrating in the convergence zone of all five of the large subtropical gyres. Since the 1970s, the production of plastic has increased five-fold, with around 50% of it buoyant (summarized in Cozar et al. 2014). Studies documenting marine debris ingestion by sea turtles indicate impaired digestive capability, "floating syndrome," or reduced ability to swim, in addition to death (Casale et al. 2016). In addition, studies of marine debris ingestion in green turtles (Santos et al. 2015) and loggerheads (Casale et al. 2016) indicated that the potential for death is likely underestimated, as is the magnitude of the threat worldwide, particularly for highly migratory species. A recent study assessed the health of leatherbacks foraging off California and measured hematologic and plasma chemistry values. When these values were compared to nesting female leatherbacks in French Guiana and St. Croix, the foraging turtles were found to have elevated levels of cadmium, but Harris et al. (2011) note that biomagnification of trace elements via trophic transfer might be limited in this species due to their preference for cnidarian zooplankton. The authors note that hard-shelled turtles such as loggerheads, which have a more varied diet such as crustaceans and bivalves, have shown high levels of PCBs and DDE, when compared to more herbivorous consumers, such as green turtles. Domoic acid, which is a potent marine algal toxin that has been shown to cause neurologic disease in marine mammals and sea turtles was found in a stranded dead leatherback in 2008 (Harris et al. 2011). Other documented threats to sea turtles found off the U.S. West Coast include illness, gunshot wounds, and unknown illnesses (usually cold-stunning, particularly for olive ridleys). 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. This is especially true for leatherbacks, since they are often difficult to access and transport to a laboratory, given their size and rate of decomposition (Harris et al. 2011).

Figures 4 through 7 show the historical data on sea turtle strandings in California since 1975 (through late 2016), including information on trends, species, county, and known causes of strandings. There are fewer strandings of sea turtles in the Pacific Northwest, although they do occur and are documented. Strandings of olive ridleys increased in northern California and the Pacific Northwest since late 2014 (NMFS-WCR stranding data, unpublished), with most of them cold-stunned, likely following the warm water incursion associated with a strong El Niño, which occurred during that time period through the fall of 2016.

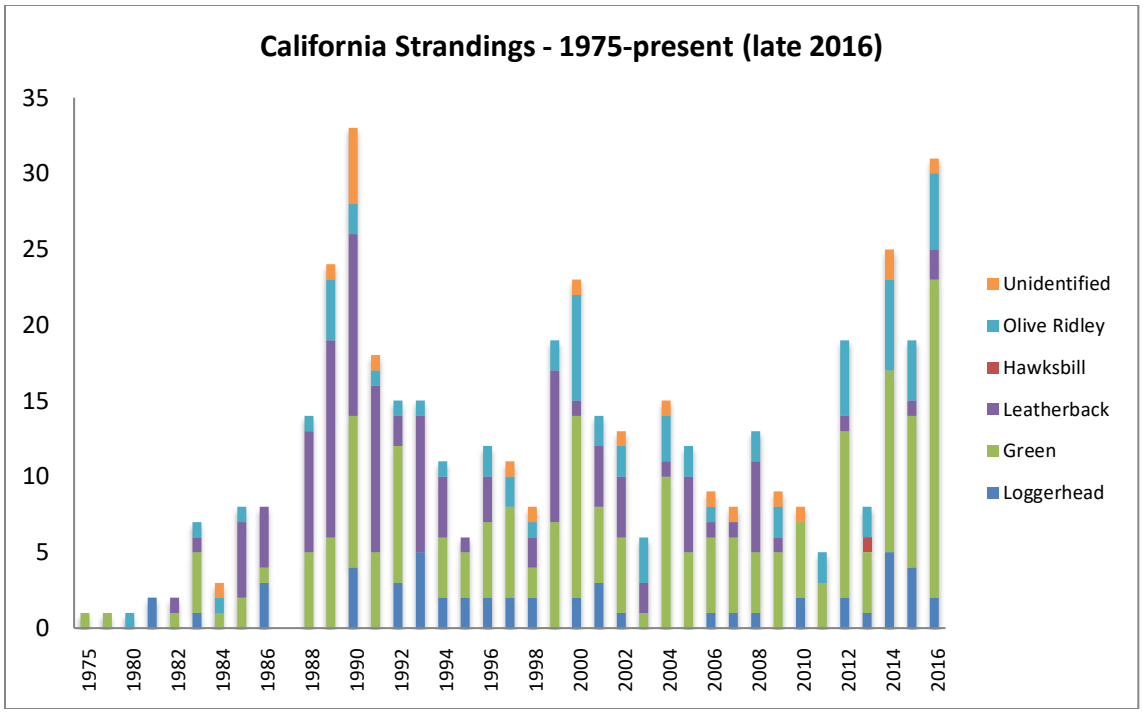

Figure 4. Sea turtle strandings in California, 1975 through late 2016 (R. LeRoux, NMFS-SWFSC, unpublished data).

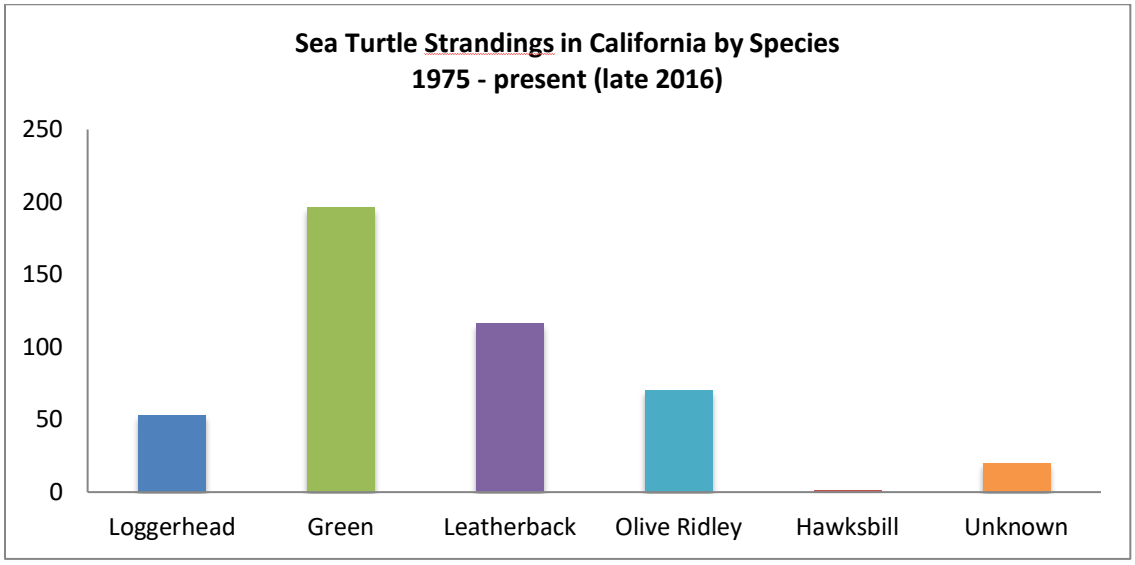

Figure 5. Sea turtle strandings in California, by species (R. LeRoux, NMFS-SWFSC, unpublished data).

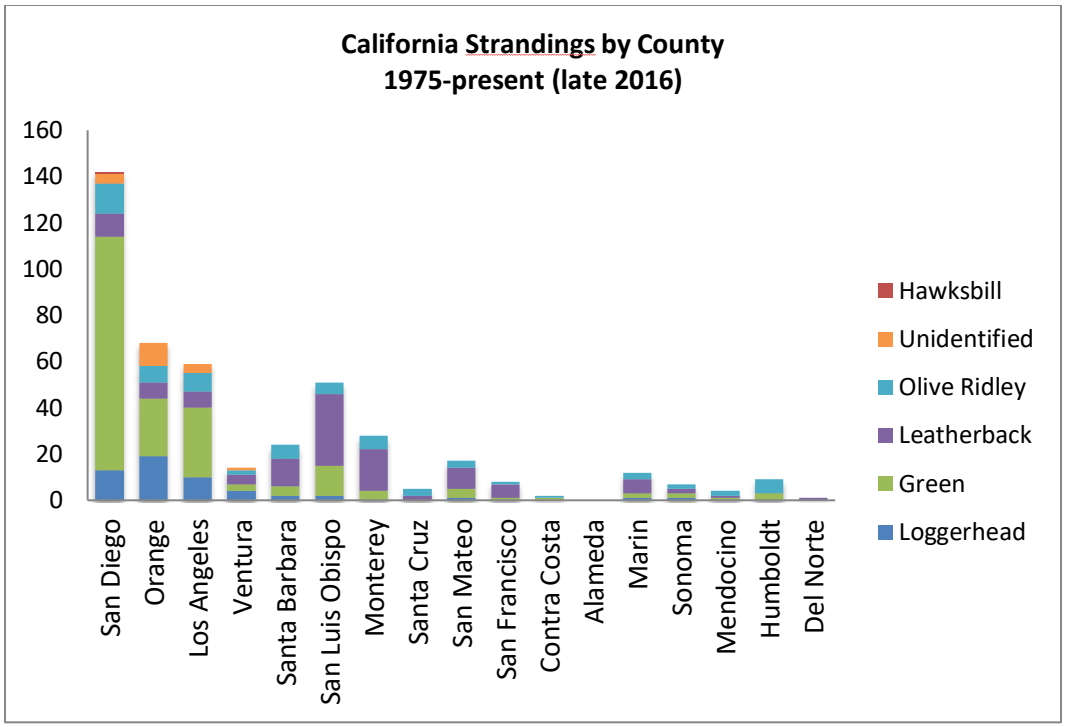

Figure 6. Sea turtle strandings by species and California county, 1975-present (late 2016) (R. Leroux, NMFS-SWFSC, unpublished data).

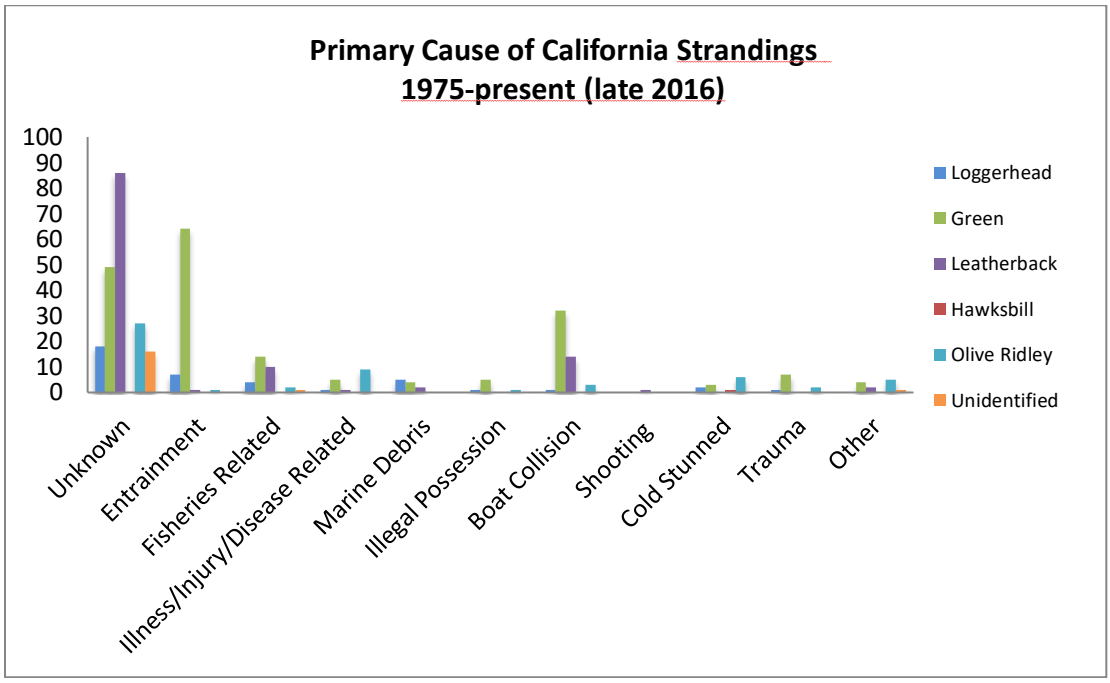

Figure 7. Known cause of sea turtle strandings in California (R. LeRoux, NMFS-SWFSC, unpublished data).

2.4.2. Southern DPS of Eulachon

2.4.2.1 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, and authorized state scientific research programs under ESA section 4(d). In total, there approximately 60 such permits and authorizations that include take of eulachon on the U.S. West Coast as of July, 2020.[11] Although eulachon take is not prohibited, the permit applicants have to cooperate 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 2012c). For 2018, NMFS authorized take of 36,473 juvenile and adult eulachon, 33,457 of which was lethal; and these numbers are expected to remain consistent (NMFS 2018b). While not all of these research activities occur specifically within the action area of this proposed project, many of these research activities do occur in marine waters that overlap with SWFSC research activities, and this summary reflects an accumulation of impacts that does influence the status of eulachon within the marine waters of the CCE.

2.4.2.2. Commercial and Recreational Harvest

In the past, commercial and recreational harvests likely contributed to eulachon decline. However, commercial and recreational harvests declined significantly, beginning in 1994 (see Section 2.2.2). From 2014-2016, the combined commercial, recreational, and tribal eulachon fisheries harvested 2.7 (2014), 3.5 (2015), and 1.6 (2016) million eulachon in the Columbia, Cowlitz, and Sandy Rivers (Gustafson et al. 2016).

2.4.2.2 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). For details on bycatch of eulachon in the pink shrimp fishery, see Section 2.2.2.

Eulachon bycatch in U.S. West Coast groundfish fisheries appears to be driven by both eulachon distribution and cyclic abundance. Evidence from some surveys (NWFSC-EW 2012) indicates that the latitudinal and longitudinal range of eulachon likely expands in years of high abundance, perhaps leading to an increase in bycatch. Based on the very low amount of eulachon bycatch in United States West Coast groundfish fisheries, either there is limited interaction with eulachon in these fisheries or most eulachon encounters result in fish escaping trawl nets or avoiding trawl gear altogether. However, not all eulachon avoid the groundfish fishery's trawl nets and thus are observed as bycatch. In 2012, NMFS estimated the extent of take of eulachon in the groundfish

[11] https://apps.nmfs.noaa.gov/search/search.cfm?src=S search that included eulachon and active permits.

fishery at 1,004 eulachon per year (NMFS 2012c). Observed bycatch in surrounding years (NMFS 2018b) exceeded that level: 2011 (1,621 eulachon), 2013 (5,113 eulachon), and 2014 (3,075 eulachon). Ultimately, NMFS concluded that the retained bycatch of the groundfish fishery amounted to no more than 0.02% of one portion of total eulachon abundance, and would have no appreciable effect on the diversity or distribution of the SDPS of eulachon (NMFS 2018b).

2.4.3. Salmonids

2.4.3.1 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.

2.4.3.1 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 2006b; NMFS 2010; NMFS 2017c). Most recently, in the West Coast groundfish fishery, NMFS estimated that bycatch in groundfish trawl fisheries were not expected to exceed 23,500 Chinook or 1034 coho per year, although some small increase in Chinook bycatch might occur.

2.4.3.2 Research Effects

Although not identified as a factor for decline or a threat preventing recovery, scientific research and monitoring activities have the potential to affect the species' survival and recovery by killing listed salmonids—whether intentionally or not. For the year 2019, NMFS issued numerous research section 10(a)(1)(A) scientific research permits allowing listed species to be taken and sometimes killed. NMFS has also issued numerous authorizations for state and tribal scientific research programs under ESA section 4(d). Table 29 displays the total take for the ongoing research authorized under ESA sections 4(d) and 10(a)(1)(A). While not all of these research activities occur specifically within the action area of this proposed project, some research activities do occur in marine waters that overlap with SWFSC research activities, and this summary reflects an accumulation of impacts that does influence the status of salmonids within the marine waters of the CCE.

Table 29. Total expected take of the ESA listed salmonids for scientific research and monitoring approved for 2019.

Species	Life Stage	Origin[a]	Total Take	Percent of ESU/DPS taken	Lethal Take	Percent of ESU/DPS killed
CC Chinook salmon	Adult	Natural	1,028	14.6147%	36	0.5118%
	Juvenile	Natural	307,003	24.0207%	3,932	0.3076%
CVS Chinook salmon	Adult	LHAC	740	32.5561%	256	11.2626%
		Natural	701	18.8087%	26	0.6976%
	Juvenile	LHAC	18,542	0.8547%	3,033	0.1398%
		Natural	873,548	112.6470%	16,830	2.1703%
LCR Chinook salmon[b]	Adult	LHAC	88	0.2280%	13	0.0337%
		LHIA	0		0	
		Natural	289	0.9807%	10	0.0339%
	Juvenile	LHAC	62,096	0.1890%	1,326	0.0040%
		LHIA	410	0.0383%	34	0.0032%
		Natural	819,245	6.9095%	11,323	0.0955%
PS Chinook salmon[b]	Adult	LHAC	1,620	16.3997%	125	0.8814%
		LHIA	929		12	

Species	Life Stage	Origin[a]	Total Take	Percent of ESU/DPS taken	Lethal Take	Percent of ESU/DPS killed
		Natural	958	4.2772%	39	0.1741%
	Juvenile	LHAC	138,699	0.3821%	10,580	0.0291%
		LHIA	40,527	0.5574%	2,513	0.0346%
		Natural	475,765	15.6745%	9,981	0.3288%
SacR winter-run Chinook salmon	Adult	LHAC	197	8.8262%	53	2.3746%
		Natural	275	130.9524%	15	7.1429%
	Juvenile	LHAC	11,552	5.7760%	1,471	0.7355%
		Natural	175,523	89.8487%	5,075	2.5978%
SnkR fall-run Chinook salmon	Adult	LHAC	241	2.1085%	15	0.1312%
		LHIA	202	1.6313%	3	0.0242%
		Natural	240	2.5408%	12	0.1270%
	Juvenile	LHAC	951	0.0361%	46	0.0017%
		LHIA	565	0.0198%	23	0.0008%
		Natural	2,303	0.3519%	89	0.0136%
SnkR spr/sum-run Chinook salmon	Adult	LHAC	1,029	43.1085%	19	0.7960%
		LHIA	618	146.7933%	7	1.6627%
		Natural	1,404	10.9705%	27	0.2110%
	Juvenile	LHAC	23,573	0.4952%	384	0.0081%
		LHIA	12,756	1.4684%	156	0.0180%
		Natural	519,711	40.0813%	6,149	0.4742%
UCR spring-run Chinook salmon	Adult	LHAC	12	0.1927%	4	0.0642%
		LHIA	0	0.0000%	0	0.0000%
		Natural	110	3.8301%	4	0.1393%
	Juvenile	LHAC	352	0.0577%	10	0.0016%
		LHIA	107	0.0336%	19	0.0060%
		Natural	2,057	0.4325%	57	0.0120%
UWR Chinook salmon[b]	Adult	LHAC	133	0.4225%	18	0.0572%
		LHIA	0		0	
		Natural	167	1.6368%	11	0.1078%
	Juvenile	LHAC	8,551	0.1641%	151	0.0029%
		LHIA	34	21.6561%	4	2.5478%
		Natural	42,666	3.3446%	822	0.0644%
CR chum salmon	Adult	LHIA	0	0.0000%	0	0.0000%
		Natural	14	0.1315%	4	0.0376%
	Juvenile	LHIA	550	0.0849%	6	0.0009%
		Natural	38,194	0.6553%	464	0.0080%
HCS chum salmon	Adult	LHIA	0	0.0000%	0	0.0000%
		Natural	1,999	5.1658%	32	0.0827%
	Juvenile	LHIA	135	0.0900%	3	0.0020%
		Natural	729,353	12.3059%	2,560	0.0432%
CCC coho salmon	Adult	LHAC	0	0.0000%	0	0.0000%
		Natural	2,126	110.0414%	38	1.9669%

Species	Life Stage	Origin[a]	Total Take	Percent of ESU/DPS taken	Lethal Take	Percent of ESU/DPS killed
	Juvenile	LHAC	25,486	15.3641%	858	0.5172%
		Natural	168,286	106.4226%	3,233	2.0445%
LCR coho salmon[b]	Adult	LHAC	339	3.8562%	38	0.4323%
		LHIA	0		0	
		Natural	601	2.0123%	12	0.0402%
	Juvenile	LHAC	54,058	0.7662%	990	0.0140%
		LHIA	627	0.2184%	11	0.0038%
		Natural	175,566	26.9530%	2,448	0.3758%
OC coho salmon	Adult	LHAC	10	1.7889%	4	0.7156%
		Natural	9,110	9.6586%	105	0.1113%
	Juvenile	LHAC	99	0.1650%	3	0.0050%
		Natural	556,873	8.3847%	12,228	0.1841%
SONCC coho salmon[b]	Adult	LHAC	590	19.2702%	14	0.2744%
		LHIA	1,517		16	
		Natural	1,510	16.6575%	28	0.3089%
	Juvenile	LHAC	8,551	4.2755%	108	0.0540%
		LHIA	266	0.0463%	266	0.0463%
		Natural	171,792	8.5316%	2,377	0.1180%
OL sockeye salmon[c]	Adult	LHAC	5	0.4567%	0	0.0794%
		LHIA	0		0	
		Natural	18		4	
	Juvenile	LHAC	31	0.0678%	3	0.0066%
		LHIA	0	0.0000%	0	0.0000%
		Natural	86	0.0083%	4	0.0004%
SnkR sockeye salmon	Adult	LHAC	3	0.0749%	0	0.0000%
		Natural	89	16.3004%	6	1.0989%
	Juvenile	LHAC	397	0.1934%	255	0.1242%
		Natural	7,539	38.0661%	401	2.0247%
LCR steelhead[b]	Adult	LHAC	71	0.3184%	4	0.0179%
		LHIA	0		0	
		Natural	2,147	16.6176%	22	0.1703%
	Juvenile	LHAC	40,731	3.2908%	584	0.0472%
		LHIA	0	0.0000%	0	0.0000%
		Natural	67,070	20.0867%	1,138	0.3408%
MCR steelhead	Adult	LHAC	920	155.4054%	12	2.0270%
		LHIA	39	26.3514%	1	0.6757%
		Natural	1,067	16.0066%	13	0.1950%
	Juvenile	LHAC	3,381	0.8456%	48	0.0120%
		LHIA	4,269	4.1933%	60	0.0589%
		Natural	119,023	28.6555%	2,408	0.5797%
PS steelhead[c]	Adult	LHAC	21	7.6788%	6	0.1916%
		LHIA	17		0	

Species	Life Stage	Origin[a]	Total Take	Percent of ESU/DPS taken	Lethal Take	Percent of ESU/DPS killed
		Natural	1,445		31	
	Juvenile	LHAC	4,247	3.8609%	86	0.0782%
		LHIA	835	0.7422%	16	0.0142%
		Natural	65,211	2.9683%	1,205	0.0548%
SnkR basin steelhead	Adult	LHAC	2,951	2.1247%	49	0.0353%
		LHIA	2,201	7.8086%	37	0.1313%
		Natural	8,381	45.4920%	109	0.5917%
	Juvenile	LHAC	28,003	0.8399%	358	0.0107%
		LHIA	22,323	3.4518%	247	0.0382%
		Natural	217,540	26.6142%	2,834	0.3467%
UCR steelhead	Adult	LHAC	9	0.0821%	2	0.0182%
		LHIA	0	0.0000%	0	0.0000%
		Natural	105	2.6329%	2	0.0502%
	Juvenile	LHAC	9,474	1.4293%	203	0.0306%
		LHIA	2,204	1.5298%	54	0.0375%
		Natural	17,727	10.4819%	361	0.2135%
UWR steelhead	Adult	Natural	220	7.5549%	6	0.2060%
	Juvenile	Natural	8,602	5.9778%	192	0.1334%
	Juvenile	Natural	350		350	
	Juvenile	Natural	64		15	

[a] LHAC=Listed Hatchery Adipose Clipped, LHIA = Listed Hatchery Intact Adipose.
[b] Abundances for adult hatchery salmonids are LHAC and LHIA combined.
[c] Abundances for all adult components are combined.
[d] Abundance for these species are only known for the adult life stage which is used to represent the entire DPS.

Actual take levels associated with these activities are almost certain to be a substantially lower than the permitted levels. There are three reasons for this. First, most researchers do not handle the full number of juveniles or adults they are allowed. That is, for the vast majority of scientific research permits, history has shown that researchers generally take far fewer salmonids than the allotted number of salmonids every year (20.45% of requested take and 14.74% of requested mortalities were used in ID, OR, and WA Section 10a1A permits from 2008 to 2017; NMFS West Coast Region Permit Office data). Over the past five years, (2014-2019) all section 10(a)(1)(A) permits active in California for ESA-listed steelhead and salmon resulted in only 8.8% of the requested handling (i.e., non-observation) take (489,389 of 5,575,092) and 3.6% of the requested mortalities (6,854 of 192,328; NMFS West Coast Permit Office data). Second, we purposefully inflate our take and mortality estimates for each proposed study to account for the effects of potential accidental deaths. Therefore it is very likely that far fewer fish, especially juveniles, would be killed under any given research project than the researchers are permitted. Third, for salmonids, many of the fish that may be affected would be in the smolt stage. These latter would simply be described as "juveniles," which means they may actually be yearlings, parr, or even fry: life stages represented by multiple spawning years and many more individuals than reach the smolt stage; perhaps as much as an order of magnitude more. Therefore, the estimates of percentages of ESUs/DPSs taken were derived by (a) conservatively estimating the

actual number of juveniles, (b) overestimating the number of fish likely to be killed, and (c) treating each dead juvenile fish as part of the same year class. Thus, the actual numbers of juvenile salmonids the research is likely to kill are undoubtedly smaller than the stated figures; probably on the order of 10% of the values given in the tables (NMFS West Coast Permit Office data).

2.4.3.3 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 1997; Chasco et al. 2017) and killer whales in the Pacific Northwest (see section 2.12.1.5; Osborne 1999; Hilborn et al. 2012). 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. 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.

2.5. Effects of the Action

Under the ESA, "effects of the action" are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (see 50 CFR 402.17). In our analysis, which describes the effects of the proposed action, we considered 50 CFR 402.17(a) and (b).

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 from SWFSC research activities: (1) incidental capture or entanglement in gear used for biological or oceanographic sampling; (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 or proposed 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 to complete the response and risk analysis for each ESA-listed entity.

Our analyses of how SWFSC research may affect ESA-listed species led us to determine that the 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 30 below identifies the ESA-listed species that may be adversely affected by each SWFSC research survey.

Table 30. 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
Purse Seine	
CPS (in nearshore areas)	eulachon; 28 species of salmonids
Longline	
Highly Migratory Species	4 species of sea turtles

Other Hook and Line	
HMS Deep-set Buoy Gear and Troll	none
Genetics/Physiology and Aquaculture	none
Life History and Reproductive Ecology of Rockfish	none
Juvenile Salmon Micro-trolling	none
Unmanned Systems	
California Current Ecosystem	none
White Abalone	none
California Current Deep Sea Coral and Sponge Assessment	none
Juvenile Salmon	none
Ecosystem-Based Fisheries Management and Stock Assessment	none
Antarctic LMR FREEBYRD	none
Antarctic LMR Seabirds	none
Multi-Gear Survey	
CalCOFI	none
COAST	none
PacOOS	none
Humboldt State Trinidad Headlines	none

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 2.12 to support those analyses as needed.

2.5.1. Exposure and Response

2.5.1.1 Capture or Entanglement

As described in the proposed action, the SWFSC conducts a number of surveys for various species of fish using trawls, purse seines, longlines and other hook and line gear, as well as oceanographic/environmental sampling using various other equipment such as bongo nets, egg sampler, video, current profilers, and CTDs, along with unmanned systems that may contain a variety of sensors, cameras, and other equipment that collects data. 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 biological 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, purse seines, and longlines. 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 PEA and SPEA, and this section of the opinion will focus on the potential effects of these gears. For the other types of gear (other hook and line gear, plankton and small-mesh towed nets, oceanographic sampling devices, video cameras, and unmanned system deployments), we have determined these do not likely pose any risk of incidental capture 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 other than salmon. 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 PEA, SPEA, 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, long beaked common dolphin (*Delphinus capensis*), northern right whale dolphins (*Lissodelphis borealis*), and northern fur seals (*Callorhinus ursinus*) (Table 4.2-7 *in* PEA; Tables 6-4 and 6-6 in MMPA LOA application). However, none of these marine mammals are listed under the ESA. In the development of their MMPA 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 biological opinion, we consider the likelihood of potential effects on ESA-listed marine mammal species arising from possible capture or entanglement in the "Not Likely to Adversely Affect" determinations, section 2.12.1.

2.5.1.1.1 Sea Turtles

Given the broad scope of SWFSC research activities occurring throughout the CCE, 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 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 near the coast could be spread out along the entire U.S. West Coast, and pelagic trawling for CPS is spread throughout the entire EEZ across the entire coast. Purse seines may be used in concert with the CPS trawl survey, deployed in nearshore waters from Washington down to Northern California. In summer, pelagic trawling and use of a purse seine 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. Hook and line surveys for rockfish and other groundfish species may be conducted off California throughout the entire year.

Despite the regular potential exposure of sea turtles to active fishing survey gear used by the SWFSC in the CCE, there has been only two 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.

In September, 2016, one green sea turtle was discovered to be tangled and hooked near Point Conception in Southern California at 34.4433°N, 120.35°W during an HMS pelagic longline survey targeting thresher shark. The monofilament mainline 2 miles in length with a 1000lb test and the 200 monofilament gangions were each 4 meters long. The longline was set at a depth of

about 6 meters and sardine and mackerel were used as bait. The sea turtle was pulled out of the water alive using the shark cradle. The leader was found to be wrapped once around the turtle's front left flipper and the barb of the 13/0 offset circle hook was partially embedded into the flipper. When the barb and leader line were removed from the turtle no blood was visible. During ther recovery and sampling, the turtle was very active and swam away vigorously after being released into the water. All required mitigation measures were followed during this set

Although the Juvenile Salmon Survey is the only trawl 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 the one SWFSC trawl bycatch 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. Similarly, we conclude the one recent sea turtle interaction with pelagic longline gear reflects the general risk of capture for sea turtles with any pelagic longline gear used in SWFSC research is a rare event possible at any time.

We also note that other hook and line research gear used by SWFSC may present some risk of incidental capture or entanglement of sea turtles. To date, no interactions between these SWFSC gears/surveys and sea turtles has occurred. In particular, we highlight that the SWFSC 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 experimental fishery research efforts involving buoy gear and concluded this research was not likely to adversely affect any ESA-listed species, including sea turtles (NMFS 2010b, 2014c, 2018c,d). In 2018, a loggerhead sea turtle was entangled in the buoy lines of a piece of deep-set buoy gear southwest of Anacapa Island in the SCB of a fisherman operating under in an experimental fishery permit (EFP) issued by the WCR (NMFS 2018c). Evaluation of that event determined that the configuration used was not typical or representative of how other commercial fishermen and researchers use this gear, and is considered analmolous. In the 2015 biological opinion on SWFSC research activities, we concluded that use of buoy gear by SWFSC research activities was not likely to interact with sea turtles. The available information suggests 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 research gear in the CCE has been, and 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 and longline 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 or longline gear can be classified as simply a 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 45 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* PEA). 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 (45 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. Given that only one sea turtle interaction with SWFSC longline gear has been documented, the possibility of encounter and subsequent hooking or entanglement remains a very small possibility.

In the 2015 biological opinion, we calculated possible bycatch rates for SWFSC research in the CCE or ETP with pelagic longlines based on available data on sea turtle bycatch using from Hawaii longline commercial fisheries. Although the gear used by SWFSC during research surveys is not directly comparable to commercial fisheries given the much smaller scale of effort associated with research surveys, at worst we estimated less than one sea turtle of any species would be caught by SWFSC longline research if the catch per unit effort (CPUE) of sea turtles were comparable (Table 55 in NMFS 2015a). The fact that the SWFSC did take only one sea turtle during the last 5 years of research surveys provides some evidence 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. 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, although in the CCE green turtles are known to be residents in the SCB and the most common sea turtle species that is documented stranded in coastal waters. Given the vast project action area and the wide distribution of all these sea turtles throughout the area, and the limited 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). 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.

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 limited 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. We note that the one green turtle that was captured was released alive with very minimal apparent injuries.

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 limited 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, which is far more likely to interact with sea turtles than deep-set gear, 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 1.3.4.2, 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 2006c). 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.

2.5.1.1.2 Southern DPS of Eulachon

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 (Gustafson et al. 2019). 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.

Historically, across all surveys, the average catch of eulachon each year is < 1 kg per year (PEA). 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. In order to be

conservative and for the sake of rounding small numbers, we assumed that up to 1 kg of eulachon, equivalent to about 25 fish based on an average weight of approximately 40 grams (NMFS 2013c), could be captured annually in SWFSC research trawls in the 2015 biological opinion on SWFSC research activies (NMFS 2015a). Since the 2015 biological opinion, eulachon eulachon have been incidentally caught during CPS surveys in 2016, 2017 and 2019, with SWFSC reporting 4, 28[12] and 58[13] takes, respectively. The juvenile rockfish survey in 2017 also incidentally caught one Pacific eulachon. The majority of these takes have occurred off the coat of Washington, but incidents of eulachon bycatch occurred from central Oregon up to off Vancouver Island, British Columbia (SWFSC survey data).

While bycatch of eulachon does not appear to be common or large in SWFSC research trawls, we expect it will periodically occur. During the most recent years of surveys, bycatch of eulachon was slightly higher than anticipated in 2015 at least in 2019 in terms of both numbers of individuals and total biomass. We note that the average size of eulachon captured in survey trawls has been smaller than previously assumed; about 16 grams and 25 grams in 2017 and 2019 respectively. Given that ~1.5 kg of eulachon bycatch occurred during one year, and following along the same general approach used in the last biological opinion to round up small numbers of eulachon bycatch conservatively, we will assume that up to 2 kg of eulachon could be incidentally captured during any year across all SWFSC trawl surveys in the CCE. Based on the recent history of SWFSC research, we assume that this could equate to as many as 91 fish based on the average weight of ~22 grams across recent survey years. While we anticipate the incidental capture of eulachon will occur primarily in CPS surveys, we acknowledge there is risk of capture in other surveys (e.g., juvenile rockfish). Although it is possible that eulachon bycatch in SWFSC could include individuals from unlisted eulachon populations, because SWFSC research activities occur in marine areas adjacent to the freshwater spawning habitats of Southern DPS eulachon, we conservatively assume that all of these eulachon incidentally captured during SWFSC research could belong to the Southern DPS.

The disposition of eulachon that have been incidentally captured in SWFSC trawls has not been reported in great detail previously. 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 (e.g., Suuronen et al. 1996, Broadhurst et al. 2006). During SWFSC research, tows are relatively short (45 minutes) and catches are not typically as large as compared to 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. In addition, 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.

Information from the recent Southern DPS eulachon status review (Gustafson et al. 2016), recovery plan (NMFS 2017b), and other available sources reviewed for this opinion do not

[12]Weight of one fish is missing – total weight of remaining 27 fish = 0.43 kg
[13]Total weight of 58 fish = 1.455 kg

indicate that eulachon catch/bycatch is commonly associated with purse seine fisheries for CPS along the U.S. West Coast (e.g., NMFS 2010), although the occassional bycatch of eulachon in CPS trawl surveys suggest that eulachon can co-occur with CPS species and vulnerable to bycatch in similar gear. The is no historical information from SWFSC surveys or readily apparent relavent surrogate information from some other source to inform any specific estimate of how many eulochon might be incidental captured during SWFSC purse seine surveys. Given the available information, we acknowledge that it may occur, but is not expected to be a large amount. As a result, we expect that the total estimate of eulachon bycatch anticpated from previous trawl surveys, up to ~ 2 kg or 91 individuals, will also encompass any limited incidental bycatch of eulachon in SWFSC purse seine survey sets.

Handling and Sampling

Because we assume that all eulachon will die as a result of incidental capture in survey trawls or purse seine sets, 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.

2.5.1.1.3 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. 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.

Trawl Bycatch

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 PEA and SPEA, as well as in the 2015 biological opinion and supplemental information provided by the SWFSC during this consultation. As described in the proposed action, the impacts as a result of directed scientific research on salmonids authorized under a section 10 ESA permit are not considered in this biological opinion.

In the 2015 biological opinion, the historical incidental bycatch of salmonids from SWFSC research trawls was used to project what might happen during the next 5 years. With this information, we estimated that as many as: 53 Chinook, 5 chum, 51 coho, 4 sockeye, and 4

steelhead, could be incidentally captured and killed annually in SWFSC survey trawls in the CCE. Using information about the distribution of salmonids in the CCE from fishery management tools and the results of directed research on salmonids in, we estimated the expected take of ESA-listed salmonids based on these expected totals for Chinook, chum, coho, sockeye, and steelhead (Table 31), based on assumption of the "worst case scenario" where all the incidental bycatch of a given salmonid species would occur in an area (either off CA or the PNW) where the relative abundance of each given ESA-listed ESU/DPS would be the greatest.

Table 31. Incidental take (all lead to mortality) of ESA-listed salmon expected each year through capture in SWFSC trawl gear in the 2015 biological opinion. Totals reflect combinations of sub-adults and juveniles by species and/or ESU/DPS that are expected or considered possible.

	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.

Since the 2015 biological opinion, SWFSC has continued to occasionally incidentally capture juvenile and sub-adult salmon during research cruises. Table 32 summarizes the incidental catch of salmon in SWFSC research from 2015-2019, as described in the SPEA and in annual reporting summaries provided to NMFS WCR. From August, 2015, through December, 2016, SWFSC incidentally caught 168 juvenile and sub-adult salmon in survey trawls. The spring and summer CPS survey nighttime trawls using the Nordic 264 net caught 167 salmon while the Rockfish Recruitment and Ecosystem Assessment survey using a modified Cobb net caught one salmon as bycatch. These takes were a combination of juvenile and adult salmon. In 2017, the SWFSC incidentally captured an estimated 1866 individual salmon in trawl nets during survey activities. The majority of salmon bycatch (1832) occurred during the California Current Ecosystem survey (including the CPS survey), and the rest (34) during the Rockfish Recruitment survey. All takes occurred during nighttime trawls and were a combination of juvenile and adult salmon. DNA was collected and analyzed from 173 Chinook incidentally captured. In 2018, SWFSC incidentally captured 610[14] individual salmon in trawl nets during survey activities. The majority of salmon bycatch (591) occurred during the CPS survey, and the remaining (19) during the Rockfish Recruitment survey. Of the 591 incidental captures that occurred during the CPS survey, 471 were sampled genetically. In 2019, SWFSC incidentally caught 320 salmon as bycatch during the CSP survey (309 fish) and the Rockfish Recruitment survey (11 Chinook salmon). Genetic analysis is currently underway for salmon incidentally captured during the CSP Survey, but was completed for the Rockfish survey salmon bycatch.

Table 32. Summary of the incidental bycatch of salmon in SWFSC trawl surveys from each year by species 2015*-2019.

	2015/2016*	2017	2018	2019
Chinook	37	173	276	11
chum	97	125	117	0
coho	44	15	151	0
sockeye	1	0	0	0
steelhead	4	3	15	0
unknown	0	1550	43	309
total	**183**	**1866**	**602**[16]	**320**

* Includes research activities from August 31, 2015, through December 2016.

Since the 2015 biological opinion, salmon bycatch in SWFSC survey trawls has been significantly higher than what was anticipated. Essentially every year the bycatch has exceeded total expectations for at least some species, and there have been years with large numbers of salmonid bycatch that is not attributed to any salmonid species. In response to these developments and coordination with WCR staff, SWFSC convened a Salmon Working Group composed of SWFSC expertise across several disciplines to review the salmon bycatch data and consider what factors may be influencing the surprising results. Ultimately, the group could not

[14] Of the 471 genetically sampled salmon from 2018 surveys, analysis confirmed that 6 of those were cutthroat trout (*O. clarkii*) and 2 pink salmon (*O. gorbuscha*) that are not ESA-listed species of salmonids.

identify any obvious causes of elevated incidental take, and did not identify or recommend any corrective sampling actions (SWFSC 2019b).

The location of incidental bycatch of salmon from 2015-2019 occurred in higher quantities from Oregon to Canada, with a smaller number of incidental takes occurring in off the California coast. The SPEA describes the general location where salmon were incidentally captured. Most salmon (94%) caught incidental to SWFSC trawl surveys 2015-2019 were caught north of the Oregon/California border, and 50% of all salmon (ESA-listed and non-listed populations) were caught in Canada. A majority of the total salmon caught in 2017 were incidentally captured in a single event off Vancouver Island on June 28, 2017, where 17.76 kg, or an estimated 1531 unidentified juvenile salmon, were incidentally caught in the CPS Survey's Nordic 264 trawl (SWFSC 2018 annual report). The largest number of salmon caught in California occurred in 2018 when 51 salmonids were caught, including 30 coho salmon, 3 Chinook salmon and 12 steelhead trout; the remaining six fish were not positively identified.

During most of the recent years, there has been a significant amount of salmon bycatch that has been categorized as unknown salmon (Table 32). In order to estimate what species these may belong to, we rely upon the relative proportion of salmon species that was identified visually or through genetics each year. Table 33 illustrates the proportions (%) of salmon species of SWFSC bycatch that was identified for recent years, along with an average proportion (%) over the time period not including 2019 where the genetic data has not yet been analyzed.

Table 33. Summary of the proportion of the incidental bycatch of salmon in SWFSC trawl surveys each year by species.

	2015/2016	2017	2018	2019	Average 2015-2018
Chinook	20.2%	54.7%	49.4%	100.0%	41.4%
chum	53.0%	39.6%	20.9%	0.0%	37.8%
coho	24.0%	4.7%	27.0%	0.0%	18.6%
sockeye	0.5%	0.0%	0.0%	0.0%	0.2%
steelhead	2.2%	0.9%	2.7%	0.0%	1.9%

With this information, we can estimate the total number of each species that may have been associated with salmon bycatch that was not identified from 2015-2019. Table 34 describes the allocation of unknown salmon bycatch each year using the proportions of known salmon bycatch each year from Table 33.

Table 34. Summary of the allocation of unknown incidental bycatch of salmon in SWFSC trawl surveys each year by species using the proportion of known salmon bycatch.

	2015/2016	2017	2018	2019
Chinook	0	849	21	128
chum	0	613	9	117
coho	0	74	12	57
sockeye	0	0	0	1
steelhead	0	15	1	6

Combining the summaries of identified salmon from Table 32, with the estimate totals allocated from the unknown salmon in Table 34, we can estimate how many salmon of each species were caught each year (Table 35).

Table 35. Summary of the total estimate of incidental bycatch of salmon by species each year in SWFSC trawl surveys from 2015-2019.

	2015/2016	2017	2018	2019
Chinook	37	1022	297	139
chum	97	738	126	117
coho	44	89	163	57
sockeye	1	0	0	1
steelhead	4	18	16	6

The recent history of salmon bycatch in SWFSC research trawls is significantly higher than what was anticipated in the 2015 biological opinion. As a result, we will assume the worst case scenario of salmon bycatch that approaches the highest levels seen recently during the last five years as the best indication of what we should reasonably expect to occur during the next five years of SWFSC trawl surveys. At this time, there is no obvious distinction between the amount or distribution of survey trawl effort that occurred during the last five years from what is expected to occur during the next five years. There was also no identification of a clear cause for the increased salmon bycatch observed during the last five years compared to surveys conducted prior to that can be exploited for minimizing salmon bycatch during the next five years of research. As a result, we use the information from Table 35 to estimate the maximum amount of salmon incidental capture that we expect across all SWFSC trawl surveys that are not engaged in directed salmonid research in any given year (Table 36).

Table 36. Maximum number of individuals that may be incidentally captured by SWFSC trawl surveys during any year.

	Total	Sub-adult	Juvenile
Chinook	1022	184	838
chum	738	133	605
coho	163	29	134
sockeye	1	1[1]	1[1]
steelhead	18	3	15

[1] It is possible that this individual could be either sub-adults or juveniles.

For information about the bycatch of salmon surveys from all recent SWFSC trawl surveys, we cannot readily distinguish between the proportion of individuals that were juveniles and sub-adults for each salmon species based on the information provided. However, the SPEA provides aggregated data on the information about the age class of all salmon bycatch in SWFSC survey trawls that was collected and readily available. During the last five years, the average annual ratio of juvenile salmon to sub-adult salmon documented has been 82% juvenile, and 18% sub-adult (data from Table 4-9 *in* SPEA). In the 2015 biological opinion, we relied upon other information from fisheries bycatch of salmon to estimate the anticipated proportions of bycatch in SWFSC trawl surveys that would be juvenile vs sub-adult. Given the increased bycatch in

recent years and the resulting data, we will now rely upon the age-class proportions from recent SWFSC bycatch to estimate the age-class proportions of future SWFSC bycatch over the next five years (Table 36). As a result, we expect that 82% of Chinook that may be incidentally captured by SWFSC research surveys over the next five years, or 838 individuals, will be juveniles, and that 18% (184 individuals) will be sub-adults. For chum, we expect 605 individuals that may be incidentally captured by SWFSC research surveys will be juveniles, and 133 will be sub-adult. For coho, we expect 134 individuals that may be incidentally captured by SWFSC research surveys will be juveniles, and 29 will be sub-adults. For sockeye, we assume that any individual that may be incidentally captured could be a juvenile or sub-adult. For steelhead, we expect 15 individuals that may be incidentally captured by SWFSC research surveys will be juveniles, and 3 will be sub-adults.

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 (up to 45 minutes), and the relatively small amount of total 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; NMFS 2015a biological opinion). 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, Shelton et al. 2019). 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 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.

During the last five years, SWFSC has been collecting DNA for identification of the origins of salmon incidentally captured in research trawls when possible. The SWFSC Molecular Ecology and Genetic Analysis (MEGA) Laboratory performed genetic stock identification (GSI) on incidentally captured salmon where DNA samples were available. Of the total salmon incidentally captured from 2015-2018, 938 (36%) were genotyped. Population origins identified included ESA-listed Chinook salmon from 6 different stocks: Snake River fall, Snake River spring-summer, Lower Columbia River, Upper Willamette River, Upper Columbia River spring, and Puget Sound, which include a combination of North and South Puget Sound stocks. Given that most of the bycatch of salmon in SWFSC research surveys during this time occurred in the northern part of the CCE as described above, it is not surprising that Chinook stocks that originate from freshwater systems in the Pacific Northwest were predominantly identified through GSI from sampled fish. In addition, GSI confirmed the incidental take of coho salmon from 3 ESA-listed ESUs: Oregon Coast, Lower Columbia River, and S. Oregon/N. California Coast. One ESA-listed steelhead (Northern California) was also identified from sampled fish. Using the results of GSI from sampled fish, SWFSC concluded that they had exceeding the incidental take of several specific ESA-listed Chinook and coho ESUs that was anticipated in the 2015 biological opinion, including: one ESA-listed ESU of chinook salmon in 2016 (Snake River fall), four ESA-listed ESUs of chinook salmon in 2017 (Snake River Fall, Lower Columbia River, Upper Willamette River and Puget Sound), and three ESA-listed ESUs of chinook salmon (Snake River Fall, Lower Columbia River, and Puget Sound), one subpopulation of coho salmon (S. Oregon/N. California Coast), and one subpopulation of Steelhead in 2018 (Northern California).

While we have some information about the general distributions of salmon in ocean, and some data about the origins of salmon captured in SWFSC research trawls recently, we do not have enough information to pinpoint exactly where and which salmon will be incidentally captured in SWFSC research survey trawls in the future. As described in the PEA and SPEA, salmon bycatch in SWFSC survey trawls can occur throughout the CCE where salmon and SWFSC trawl surveys may co-occur; effectively from Vancouver Island, British Columbia south to approximately 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 (in particular 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. Information collected from ocean salmon fisheries using GSI and other techniques also highlight how dynamic the stock composition may be within any given area, at least in terms of CPUE in fisheries, may be as the year progresses (e.g., Satterthwaite et al. 2014; Shelton et al. 2019). Given that salmon are not inherently distributed equally throughout the CCE, but the bycatch of salmon in SWFSC research trawls may occur throughout the CCE research area, we look to identify 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 three 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 that were used in the 2015 biological opinion. These data were originally used to support a permit for directed research on salmon in 2015; however, no update of this data was available for consideration in completion of this biological opinion. While some variation and/or changes in the relative stock composition of salmon in the ocean are expected over time, these data remain relevant as a general measure of the average relative distribution and abundance of salmon stock off California and southern Oregon until such an update becomes available. In the northern area (off northern Oregon and Washington), we use information describing the stock compositions of Chinook catch in marine waters off Oregon and Washington, based on information derived from the Fisheries Regulation Assessment Model (FRAM) used to help manage salmon ocean fisheries.[15] Looking at Chinook salmon catch compositions from the recreational salmon fishery off the coast of northern Oregon and Washington, the stock composition proportions presented here represent 10-year averages within the northern area as tabulated by FRAM. For coho, no updated fishery information from FRAM was available to support this biological opinion. Instead, we looked at the magnitude of coho returns along the Oregon Coast and the Columbia River to gauge the relative abundances of two two coho populations off northern Oregon and Washington (PFMC 2020). Looking at the relatively magnitude of coho returns, the stock compositions presented here represent the average percentage of coho return associated with each population from the combined total of both populations over the last 10 years. Table 37 illustrates the relative stock composition proportions for ESA-listed ESU in two different CCE areas based on these three data sources, as way to assess possible stock composition proportions of Chinook and coho incidentally captured in SWFSC research survey trawls.

Table 37. Stock compositions of Chinook and coho in SWFSC juvenile salmon surveys and recreational salmon fishery, used to represent possible stock composition proportions of salmon incidentally capture by SWFSC research survey trawls in southern and northern marine waters respectively.

	SWFC Salmon Survey (southern)	Pacific Northwest FRAM (northern)
ESA-listed Chinook		
Sacramento River winter	0.3%	0.0%
Central Valley spring	3.0%	0.0%
California coastal	4.0%	0.0%
Snake River fall	0.2%	6.8%
Snake River spring/summer	0.0%	0.0%
Lower Columbia River	0.3%	37.9%
Upper Willamette River	0.1%	0.6%

[15] The possible stock composition of salmon bycatch in SWFSC survey trawls presented here were derived by looking at the salmon 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. FRAM data were provided by NMFS WCR SFD on January 30, 2020. See Table 60 in NMFS 2015 biological opinion for more details about this type of information.

Upper Columbia River spring	0.1%	0.0%
Puget Sound	0.1%	4.0%
Non-listed Chinook		
Central Valley Fall/Late Fall	92.0%	2.6%
Non-listed Columbia River	0.0%	46.6%
ESA-listed coho		
Central California coastal	12.4%	0.0%
S. Oregon/N. California coastal	55.9%	0.0%
Oregon Coast	25.3%	35.2%
Lower Columbia River	6.5%	64.8%

In the 2015 biological opinion, we used the highest stock composition from either the southern or the northern area to characterize the worst case scenario in terms of potential composition of SWFSC salmon bycatch. This worst case scenario percentage was then used to estimate bycatch of each ESA-listed ESU of Chinook and coho. This approach was based on a general assumption that salmon bycatch of relatively small amounts could occur anywhere in the CCE. Since that time, there has been an increase in the amount of salmon bycatch in SWFSC survey trawls. As described above, most all of this salmon bycatch occurred in the northern area (94%), including ~50% of it in Canadian waters. Even though the underlying cause of the increased bycatch is not understand, we do know that the one particularly high bycatch event in 2017 was a driver of the overall results; that one tow resulted in ~50% of all salmon bycatch that occurred from 2015-2019. Based on these results, we conclude that higher salmon bycatch in SWFSC survey trawls, and specifically a high bycatch event, is more likely to occur in the northern part of the CCE study area. Considering there isn't a precise way to translate this conclusion into an estimate of how much SWFSC trawl survey bycatch may occur in each area, we will generally assume that at least one-half (50%) of SWFSC salmon bycatch would occur in the northern part. This means that a worst case scenario that involves salmon bycatch in the southern area would equate to no more than one-half (50%) of the total bycatch that may occur would occur in the southern area. Alternatively, it is also possible that all of the SWFSC salmon bycatch that may occur could occur in the northern area. From these two scenarios, we select the highest stock composition of Chinook and coho bycatch to use as our worst case scenario for maximum bycatch of each ESA-listed (and non-listed) ESU.

Table 38 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 1022 Chinook and 163 coho that we expect 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. 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 one

individual could be incidentally captured (either juvenile or adult). ESA-listed ESUs are generally composed of natural and hatchery individuals, and we generally assume that individuals that may be captured by SWFSC research surveys will reflect the general proportions of natural and hatchery origin fish that each population consists of.

Table 38. Estimated maximum number of sub-adult and juvenile Chinook and coho that may be incidentally captured each year by SWFSC trawl surveys, by ESA-listed ESU.

	Maximum Stock Composition Proportions	Stock Composition of SWFSC Incidental Capture – 184 Sub-adults and 838 Juveniles			
ESA-listed Chinook		**sub-adult**	**juvenile**	**sub-adult (rounded)**	**Juvenile (rounded)**
Sacramento River winter-run	0.3%	0.55	2.51	1	3
Central Valley spring-run	3.0%	5.52	25.14	6	26
California coastal	4.0%	7.36	33.52	8	34
Snake River fall	6.8%	12.51	56.98	13	57
Snake River spring/summer	0.0%	0	0	1[1]	1[1]
Lower Columbia River	37.9%	69.74	317.60	70	318
Upper Willamette River	0.6%	1.10	5.03	2	6
Upper Columbia River spring	0.1%	0.18	0.84	1	1
Puget Sound	4.0%	7.36	33.52	8	34
ESA-listed coho		**Stock Composition of SWFSC Incidental Capture – 29 Sub-adults and 134 Juveniles**			
Central California Coast	12.4%	3.60	16.62	4	17
S. Oregon/N. California Coast	55.9%	16.21	74.91	17	75
Oregon Coast	35.2%	10.21	47.17	11	48
Lower Columbia River	64.8%	18.79	86.83	19	87

[1] Total reflects the possibility that takes could be a sub-adult or juvenile.

For sockeye, chum, and steelhead, there is limited information available to help us determine the likely stock composition or population origin for any individuals that may be incidentally captured by SWFSC research survey trawls. While we acknowledge that the capture of these species during the last 5 years has largely occurred in northern areas, there are no models or information on the marine distributions of these species along the CCE, and we cannot eliminate

the possibility that individuals from any of these ESA-listed ESUs/DPSs can be captured anywhere in the CCE. In addition, both ESA-listed units of chum salmon originate from freshwater systems adjacent to the northern part of the CCE research area. As a result, we employ a similar methodology for sockeye, chum, and steelhead that we used for coho stock composition in the northern area above where we use the relative number of adults for each population unit (described in Table 47 below) to estimate the relative stock composition of each ESA-listed unit that may present anywhere in the CCE. With that information, we estimate how individuals from each ESA-listed ESU/DPS may be caught annually in SWFSC trawl surveys (Table 39).

Table 39. Estimated maximum number of sub-adult and juvenile chum, sockeye, and steelhead that may be incidentally captured each year by SWFSC trawl surveys, by ESA-listed ESU/DPS.

ESA-listed ESU	SWFSC Incidental Capture			
	Total	Stock Composition by Species	Sub-adult	Juvenile
Chum salmon	738	-	133	605
Hood Canal summer run chum	579	78.5%	104	475
Columbia River chum	159	21.5%	29	130
Sockeye salmon	1[1]		1[1]	1[1]
Snake River sockeye	1[1]		1[1]	1[1]
Ozette Lake sockeye	1[1]		1[1]	1[1]
Steelhead salmon	18		3	15
Southern California steelhead	1[2]	<0.1%	1[2]	1[2]
South-Central California steelhead	1[2]	0.4%	1[2]	1[2]
Central California Coast steelhead	1[2]	3.1%	1[2]	1[2]
California Central Valley steelhead	1[2]	2.8%	1[2]	1[2]
Northern California steelhead	1[2]	3.7%	1[2]	1[2]
Upper Columbia River steelhead	1[2]	4.3%	1[2]	1[2]
Snake River Basin steelhead	10	53.9%	2	8
Lower Columbia River steelhead	3	17.9%	1[2]	3
Upper Willamette River steelhead	1[2]	1.5%	1[2]	1[2]
Middle Columbia River steelhead	1[2]	2.8%	1[2]	1[2]
Puget Sound steelhead	2	9.8%	1[2]	2

[1] It is possible that this individual could be from either population, and either a sub-adult or juvenile.
[2] All totals are rounded up to at least 1 to acknowledge the risk of incidental bycatch, however small.

Purse Seine Bycatch

The proposed purse seine survey working in concert with the CPS survey represents an additional source of potential salmon bycatch in SWFSC survey efforts with very little historical information to draw from to characterize the potential effects. Generally, we know that salmon bycatch can and does occur in commercial purse seine fisheries for CPS. In a 2010 biological opinion on the West Coast CPS Fishery Management Plan (FMP), NMFS estimated that 0.06 salmon (individuals) are incidentally captured per metric ton of catch in CPS purse seine fishing

in the PNW, with 41% of the salmon bycatch being Chinook and 59% being coho (NMFS 2010). Although there has not been a long history of purse seine surveys by SWFSC, there has been some effort piloting this work in recent years. Data from a 2019 experimental effort presented to the PFMC to support an application for an Exempted Fishery Permit (EFP) to continue the industry initiated collaborative research project that represents work being proposed by SWFSC in this biological opinion indicate that limited salmon bycatch did occur in 2019 research, including Chinook and chum (PFMC 2019b). During 2019, a total of 4 Chinook and 2 chum salmon were incidentally collected during the sampling of the catch during the survey; all of which were juveniles according to the sample weights provided.

On April 21, 2020, the West Coast Pelagic Conservation Group (WCPCG) submitted an EFP application to NMFS requesting to directly harvest up to 5 mt of Pacific sardine from northern California through Washington (i.e., the northern area) as part of collaboration in partnership with the SWFSC research proposed in this biological opinion (i.e,, "purse seine survey") (85 FR 37433). Additionally, the SWFSC anticipates a similar extent of effort and identical sampling protocol with another purse seine vessel in the southern areas from Central California south to the Mexico border.

Based on the available information, it is unclear what the total catch of fish (and salmon) that may occur in the purse seine survey effort will be, as total catch is not something that was (apparently) documented during the previous work. In addition, the focus of the research has been only on the amount of catch that may be sampled/harvested during the survey, because only those fish are at risk of experiencing any injury and mortality. Generally, fish encircled by the purse seine remain unharmed as the school or aggregation of fish remain surrounded by net while dip net sampling occurs. After the samples are taken, the net is opened and the entire remaining catch is released unharmed (SWFSC email communication, August 21, 2020). As a result, we focus on expectations for the amount of salmon that may be injured or killed as a result of limited sampling from each and all purse seine sets that occur as part of the proposed action. While injury or mortality of sampled juvenile salmon is necessarily expected for all fish, we will conservatively assume that immediate or delayed mortality for all juvenile salmon that might be incidentally captured and sampled could occur.

In 2019, the 6 juvenile salmon collected from purse seine survey samples in the northern area came out of a total sample of 210 kg, or 0.21 metric tons (mt), of sampled catch. This equates to a salmon capture rate of ~30 (28.5) salmon per mt of catch. Using this rate, we estimate that up to ~150 juvenile salmon could be sampled and potentially injured or killed if the proposed research were to sample a full 5 mt of catch in the northern area, per the EFP that has been applied for.

In the southern area, available data from previous purse seine efforts indicate that the risk of salmon bycatch and sampling from proposed purse seine survey work is less than in the PNW. In the 2010 biological opinion on the CPS FMP, NMFS found that data from previous deployments of observers in the CPS purse seine fishery in California had not detected any salmon bycatch, and concluded that the bycatch of ESA-listed salmon in that area was unlikely based on this information. Data made available from limited pilot use of purse seines for SWFSC research in collaboration with the CPS survey in the southern area indicated that salmon

bycatch was not recorded during these studies, and was generally considered unlikely by SWFSC biologists (SWFSC email communication, August 21, 2020). As a result of this information, we conclude that salmon bycatch in purse seine surveys in the southern area is unlikely to occur, and will not be assumed or considered further in this biological opinion.

With respect to the ~150 juvenile salmon that may be incidentally captured and sampled in purse seine surveys in the northern area, we will assume that the relative proportion of each species, both the species of salmonid as well as the ESA-listed population of each species, matches with the same relative proportion of salmon bycatch in the SWFSC trawl surveys. While there may be differences in the nearshore distribution of salmonids where the purse seine survey may occur compared to the offshore areas of the trawl surveys, the few salmon that were documented from previous purse seine survey effort do not offer much of a sample to work with. Therefore, the expectations from SWFSC trawl surveys provide the best available information that we can rely upon until there is a more extensive record and accounting of salmon bycatch from future purse seine survey efforts.

Using the information from Table 36, we can calculate the relative proportion of juvenile salmonids that may constitute the ~150 juvenile salmon that may be incidentally captured and sampled in the purse seine survey. Table 40 describes the relative proportion of juvenile salmon bycatch in SWFSC trawl surveys, and the estimate of the composition of purse seine survey salmon bycatch, by species.

Table 40. Estimated proportion of juvenile salmon from SWFSC trawl surveys from Table 36, and the estimated species composition of the maximum annual juvenile salmon bycatch in SWFSC purse seine surveys.

	Juveniles in Trawl Surveys	Proportion	Juveniles in Purse Seine Surveys
Chinook	838	0.53	79
chum	605	0.38	57
coho	134	0.08	13
sockeye	1	0.00	1[1]
steelhead	15	0.01	1

[1] Rounding up to 1 from a low decimal number.

In order to estimate the individual stock composition of juvenile salmon bycatch in SWFSC purse seine surveys in the northern area, we rely upon the stock compositions for salmonids in the northern area from Table 37 for Chinook and coho, along with the same assumptions used for chum, sockeye, and steelhead populations, for estimating the possible stock composition of trawl survey salmon bycatch. Given the totals for each species in Table 40, we estimate the following possible ESA-listed stock composition for Chinook and salmon bycatch in the purse seine survey sets in Table 41.

Table 41. Estimated stock composition proportions and maximum number of juvenile Chinook and coho that may be incidentally captured each year by SWFSC purse seine surveys, by ESA-listed ESU.

	Pacific Northwest FRAM (northern)	**Stock Composition of SWFSC Incidental Capture in Purse Seines**
ESA-listed Chinook		**79 juvenile Chinook**
Sacramento River winter	0.0%	0
Central Valley spring	0.0%	0
California coastal	0.0%	0
Snake River fall	6.8%	5
Snake River spring/summer	0.0%	0
Lower Columbia River	37.9%	30
Upper Willamette River	0.6%	0
Upper Columbia River spring	0.0%	0
Puget Sound	4.0%	3
Non-listed Chinook		
Central Valley Fall/Late Fall	2.6%	2
Non-listed Columbia River	46.6%	37
ESA-listed coho		
Central California coastal	0.0%	0
S. Oregon/N. California coastal	0.0%	0
Oregon Coast	35.2%	20
Lower Columbia River	64.8%	37

For chum salmon, we use the same stock composition that we used above in Table 37 to estimate the number of juveniles from each ESU that may be incidentally captured by SWFSC research purse seine sets each year (78.5% Hood Canal summer run; 21.5% Columbia River). For sockeye and chum salmon, given that no more than one individual from each species is expected to be incidentally captured by SWFSC research purse seine sets each year, we assume that one individual that may be incidentally capture and sampled in purse seine surveys could belong to any ESA-listed DPS from each species.

Table 42. Estimated maximum number of juvenile chum, sockeye, and steelhead that may be incidentally captured by SWFSC purse seine surveys each year, by ESA-listed ESU/DPS.

ESA-listed ESU	**SWFSC Incidental Capture in Purse Seine**
	Juvenile
Hood Canal summer run chum	45

Columbia River chum	12
Snake River sockeye	1
Ozette Lake sockeye	1
Southern California steelhead	1
South-Central California steelhead	1
Central California Coast steelhead	1
California Central Valley steelhead	1
Northern California steelhead	1
Upper Columbia River steelhead	1
Snake River Basin steelhead	1
Lower Columbia River steelhead	1
Upper Willamette River steelhead	1
Middle Columbia River steelhead	1
Puget Sound steelhead	1

Total Salmon Bycatch in SWFSC Research Surveys

In order to aggregate the total amount of salmon bycatch that may occur in SWFSC research surveys, we combine the totals of maximum annual juvenile and sub-adult salmon bycatch from trawl surveys (Tables 38 and 39) with the maximum annual juvenile salmon bycatch that is sampled from purse seine surveys (Tables 41 and 42) in Table 43.

Table 43. Estimated maximum number of ESA-listed salmon by ESA-listed ESU/DPS captured each year in SWFSC trawl and purse seine surveys.

ESA-listed Chinook	**Total**	**Sub-adult**	**Juvenile**
Sacramento River winter-run	4	1	3
Central Valley spring-run	32	6	26
California coastal	42	8	34
Snake River fall	75	13	62
Snake River spring/summer	2	1	1
Lower Columbia River	418	70	348
Upper Willamette River	8	2	6
Upper Columbia River spring	2	1	1
Puget Sound	45	8	37
ESA-listed coho			0
Central California Coast	21	4	17
S. Oregon/N. California Coast	92	17	75
Oregon Coast	79	11	68

Lower Columbia River	143	19	124
ESA-listed chum			0
Hood Canal summer run chum	624	104	520
Columbia River chum	171	29	142
ESA-listed sockeye			
Snake River sockeye	2[1]	1[1]	2[1]
Ozette Lake sockeye	2[1]	1[1]	2[1]
ESA-listed steelhead			
Southern California steelhead	2[1]	1[1]	2[1]
South-Central California steelhead	2[1]	1[1]	2[1]
Central California Coast steelhead	2[1]	1[1]	2[1]
California Central Valley steelhead	2[1]	1[1]	2[1]
Northern California steelhead	2[1]	1[1]	2[1]
Upper Columbia River steelhead	2[2]	1[1]	2[1]
Snake River Basin steelhead	11	2	9
Lower Columbia River steelhead	4	1	3
Upper Willamette River steelhead	2[1]	1[1]	2[1]
Middle Columbia River steelhead	2[1]	1[1]	2[1]
Puget Sound steelhead	3[1]	1[1]	3

[1] Total reflects the possibility that some takes could include 1 sub-adult, or be all juveniles.

2.5.1.2 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).

2.5.1.2.1 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 (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 section 2.12 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 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.

2.5.1.2.2 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.

2.5.1.3 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 PEA, PEA, and MMPA LOA application, 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 for description of acoustic sources) in order to assess the potential injury or MMPA harassment of marine mammals as defined by the MMPA. 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 2.12.1.3). Because the analyses conducted by the SWFSC are most linked to impacts on marine mammals, section 2.12.1.3 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.

2.5.1.3.1 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 and 2.12.1.3 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 2.12.1.4 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.

2.5.1.3.2 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, Gulf grouper, giant manta ray, oceanic whitetip shark, 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 2.12.1.3 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.

2.5.1.4 Prey reductions

SWFSC research surveys, primarily use of trawl gear and purse seine, is expected to result 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 species such as HMS sharks or swordfish that are not likely to be common prey items for the ESA-listed species considered in this opinion. Table 44 below describes some historical information on 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 have been 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 44. Average annual catch of potential forage species for ESA-listed species from all surveys from 2007-2011 (PEA). 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

In the SPEA, SWFSC provided some specific updates on the removals of some prey species for marine mammals and other species where data was readily available from recent surveys. Table 45 shows CPS and Rockfish Recruitment and Ecosystem Assessment Survey removals of the three target species brought forward for analysis compared to spawning biomass (where available) and commercial and recreational landings. Table 46 shows that the biomass of prey species removed during surveys varies each year, but has decreased from 2016 likely due to reduced level of survey efforts. Note the biomass numbers in Table 46 do not include jellyfish, salps, dogfish, sharks, rays or other organisms taken in CPS surveys that are not considered potential prey species for marine mammals.

Table 45. Removals of Chinook, Pacific hake, and Pacific sardines during CPS and Rockfish Recruitment and Ecosystem Assessment Surveys in CCE from 2017-2019 (SPEA).

Target Species	CPS Survey			Rockfish Recruitment Survey	Estimated Spawning Biomass (metric tons)	Commercial Landings (metric tons)
	2017 (metric tons)	2018 (metric tons)	2019 (metric tons)[2]	2016-2019 (total no.)[3]		
Chinook salmon	0.017	Not reported	Not reported	91	N/A	421[4]
Pacific hake	0.043	0.07	2	104,591	1.4 million[5]	253,100[6]
Pacific sardine	0.081	0.112	0.183	862	19,500[7]	414[8]

[1]Sub-sample weight.
[2]Data set not complete; does not include rockfish surveys; additional data requested.
[3]Data provided by SWFSC Nov. 22, 2019. Note that the vast majority of these are pelagic young-of-the-year, in the 20 to 40 mm standard length size range.
[4]2018 landings from Review of 2018 Ocean Salmon Fisheries (PFMC 2019).
[5]2018 estimate (Edwards et al. 2018, cited in 2018 Pacific Coast Groundfish SAFE report, Nov. 2018)

[6]2016 landings in the Pacific region. Fisheries Economics of the United States 2016. NOAA Technical memorandum NMFS-F/SPO-187a.
[7]Projected January 2020 spawning stock biomass (Hill et al. 2019).
[8]2016 landings in California. Fisheries Economics of the United States 2016. NOAA Technical memorandum NMFS-F/SPO-187a. The fishery is closed but PFMC allowed up to 8,000 metric tons to be harvested in 2016.

Table 46. Total biomass of important forage fish removed during CPS surveys 2007-2019 (SPEA).

	Average per Year 2007-2011 (mt)[1]	2016 (mt)[2]	2017 (mt)[2]	2018 (mt)[2]	2019 (mt)[2,3]
Potential Prey Biomass Removed	11.7[4]	11.3	7.4	5.1	2.4

[1]Data from Table 4.2-5 2015 PEA. Does not include Pacific herring and market squid.
[2]Includes Pacific sardine, northern anchovy, chub and jack mackerels, market squid, Pacific herring and Pacific hake only.
[3]Data set not complete; does not include rockfish surveys; additional data requested.

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 2.12.5.3 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 28,276 mt (Kuriyama et al. 2020). The recent estimates of sardine biomass represents low total biomass estimate historically, where the mt biomass of sardines used to be typically estimated in the millions of mt. 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 past SWFSC research surveys in the past years was 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 10,700 mt per year (2013-2017 landings data; PFMC 2019). For jack mackerel, average combined SWFSC research catch in the past (0.39 mt) compares to an overfishing level of 126,000 mt and recent commercial harvests of about 1060 mt (2013-2017 landings data; PFMC 2019). 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.

Although Table 46 suggests that the trend in biomass removals from SWFSC research (CPS trawl survyes) has been declining, we recognize that the new purse survey may add an additional 5-10 mt of (sampled) catch mostly of CPS species such as sardine, anchovies, and other species, if the maximum levels of sampling proposed are realized. This is still in range of previous biomass removals from historical CPS surveys that have been analyzed in previous biological opinions and other environmental compliance documents.

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 2.12.

2.5.1.5 Effect of Issuing the MMPA LOA

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 1.3.3. 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 2.6 or 2.12 in this opinion.

2.5.2. Risk

As described in the analysis of effects in section 2.5.1, 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.

2.5.2.1 Sea Turtles

In section 2.6.1, we determined that up to one sea turtle may be captured or entangled in survey trawls in the CCE during any year. We expect that one sea turtle to be released alive (and handled well as required to maximize survival). Similarly, we determined that up to one 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 2.2.1. For loggerhead sea turtles, any individual that may be captured or entangled in the CCE is expected to be from the North Pacific DPS originating from Japan, based on tracking information discussed in section 2.2.1. For olive ridley sea turtles, any individual that may be captured or entangled in SWFSC research gear in the CCE will be from the eastern Pacific population, and may well be from the endangered Mexico nesting beach origin. For green sea turtles, any individual that may be captured or entangled in SWFSC research gear is expected be from the East Pacific DPS.

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 two 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 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.

2.5.2.2 Marine Fish

2.5.2.2.1 Eulachon, Southern DPS

The analysis of the proposed action has determined that we expect that up to ~ 2 kg, or 91 individuals, may be captured in SWFSC survey trawls and purse seines 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 research 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.

Although there is no comprehensive estimate of abundance for this species, the available information from Section 2.2.2 suggest that spawning abundance in two major systems (Fraser River and Columbia River) in recent years has been around 37 million individuals. Most of what has been inferred about the eulachon population trends 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 ~2 kg that may be removed by SWFSC research trawls. 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 up to 91 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.

2.5.2.2 Salmonids

In the "Status of the Species" section above, we presented recent estimated average 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 47 displays the estimated annual abundance of hatchery-propagated and naturally produced ESA-listed salmonids.

Table 47. Summary of estimated annual abundance of ESA-listed salmonid ESU/DPS.

Species	Life Stage	Natural	Listed Hatchery Intact Adipose	Listed Hatchery Adipose Clip	Total
Sacramento River winter-run Chinook	Adult	2,232	-	210	2,442
	Smolt	195,354	-	200,000	395,354

	Adult	3,727	-	2,273	6,000
Central Valley spring-run Chinook	Smolt	775,474	-	2,169,329	2,944,803
	Adult	7,034	-	-	7,034
California Coastal Chinook	Smolt	1,278,078	-	-	1,278,078
	Adult	10,337	12,508	13,551	36,396
Snake River fall Chinook	Smolt	692,819	2,862,418	2,483,713	6,038,950
	Adult	12,798	421	2,387	15,606
Snake River spring/summer Chinook	Smolt	1,296,641	868,679	4,760,250	6,925,570
	Adult	29,469	38,594	-	68,063
Lower Columbia River Chinook	Smolt	11,745,027	962,458	31,353,395	44,060,880
	Adult	10,203	31,476	-	41,679
Upper Willamette River Chinook	Smolt	1,211,863	157	4,709,045	5,921,065
	Adult	2,872	3,364	6,226	12,462
Upper Columbia River spring Chinook	Smolt	468,820	368,642	621,759	1,459,221
	Adult	22,398	15,543	-	37,941
Puget Sound Chinook	Smolt	3,035,288	7,271,130	36,297,500	46,603,918
	Adult	38,697	1,829	-	40,526
Hood Canal summer run chum	Smolt	5,926,865	275,000	-	6,201,865
	Adult	10,644	426	-	11,070
Columbia River chum	Smolt	6,626,218	101,503	-	6,727,721
	Adult	1,932	-	327	2,259
Central California Coast coho	Smolt	158,130	-	165,880	324,010
Southern Oregon/Northern California	Adult	9,065	10,934	-	19,999
Coast coho	Parr	2,013,593	575,000	200,000	2,788,593
	Adult	94,320	559	-	94,879
Oregon Coast coho	Parr	6,641,564	60,000	-	6,701,564
	Adult	29,866	8,791	-	38,657
Lower Columbia River coho	Smolt	661,468	249,784	7,287,647	8,198,899
	Adult	546	-	4,004	4,550
Snake River sockeye	Smolt	19,181	-	242,610	261,791
	Adult	5,036		-	5,036
Ozette Lake Sockeye	Smolt	1,037,787	45,750	259,250	1,342,787
	Adult	11	-	-	11
Southern California steelhead	Smolt	1,262	-	-	1,262
	Adult	695	-	-	695
South-Central California steelhead	Smolt	79,057	-	-	79,057
	Adult	2,187	-	3,866	6,053
Central California Coast steelhead	Smolt	248,771	-	648,891	897,662
	Adult	1,686	-	3,856	5,542
California Central Valley steelhead	Smolt	630,403	-	1,600,653	2,231,056
	Adult	7,221	-	-	7,221
Northern California steelhead	Smolt	821,389	-	-	821,389
Upper Columbia River steelhead	Adult	1,931	1,163	5,309	8,403

	Smolt	199,380	138,601	687,567	1,025,548
	Adult	10,547	16,137	79,510	106,194
Snake River Basin steelhead	Smolt	798,341	705,490	3,300,152	4,803,983
	Adult	12,920	22,297	-	35,217
Lower Columbia River steelhead	Smolt	352,146	9,138	1,197,156	1,558,440
	Adult	2,912	-	-	2,912
Upper Willamette River steelhead	Smolt	140,396	-	-	140,396
	Adult	5,052	112	448	5,612
Middle Columbia River steelhead	Smolt	407,697	110,469	444,973	963,139
	Adult	19,313		-	19,313
Puget Sound steelhead	Smolt	2,196,901	112,500	110,000	2,419,401

Table 48 compares the total expected bycatch of salmon in SWFSC research to the species' estimated abundance. The total take represents the maximum estimate of the total take that could result from the proposed activities. As described above, we conservatively assume that salmon that may be incidentally captured could potentially result in mortality. 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.

Table 48. Summary of total proposed/expected take relative to abundance by ESA-listed ESU/DPS.

Species		Total	SWFSC Bycatch	% ESU/DPS killed
Sacramento River winter-run Chinook	sub-adult	2,442	1	0.04%
	juvenile	39,5354	3	0.00%
Central Valley spring-run Chinook	sub-adult	6,000	6	0.10%
	juvenile	2,944,803	26	0.00%
California Coastal Chinook	sub-adult	7,034	8	0.11%
	juvenile	1,278,078	34	0.00%
Snake River fall Chinook	sub-adult	36,396	13	0.04%
	juvenile	6,038,950	62	0.00%
Snake River spring/summer Chinook	sub-adult	15,606	1	0.01%
	juvenile	6,925,570	1	0.00%
Lower Columbia River Chinook	sub-adult	68,063	70	0.10%
	juvenile	44,060,880	348	0.00%
Upper Willamette River Chinook	sub-adult	41,679	2	0.00%
	juvenile	5,921,065	6	0.00%
Upper Columbia River spring Chinook	sub-adult	12,462	1	0.01%
	juvenile	1,459,221	1	0.00%
Puget Sound Chinook	sub-adult	37,941	8	0.02%
	juvenile	46,603,918	37	0.00%
Hood Canal summer run chum	sub-adult	40,526	104	0.26%
	juvenile	6,201,865	520	0.01%
Columbia River chum	sub-adult	11,070	29	0.26%

Species		Total	SWFSC Bycatch	% ESU/DPS killed
	juvenile	6,727,721	142	0.00%
Central California Coast coho	sub-adult	2,259	4	0.18%
	juvenile	324,010	17	0.01%
Southern OR/Northern CA Coast coho	sub-adult	19,999	17	0.09%
	juvenile	2,788,593	75	0.00%
Oregon Coast coho	sub-adult	94,879	11	0.01%
	juvenile	6,701,564	68	0.00%
Lower Columbia River coho	sub-adult	38,657	19	0.05%
	juvenile	8,198,899	124	0.00%
Snake River sockeye	sub-adult	4,550	1	0.02%
	juvenile	261,791	2	0.00%
Ozette Lake Sockeye	sub-adult	5,036	1	0.02%
	juvenile	1,342,787	2	0.00%
Southern California steelhead	sub-adult	11	1	9.09%
	juvenile	1,262	2	0.16%
South-Central California steelhead	sub-adult	695	1	0.14%
	juvenile	79,057	2	0.00%
Central California Coast steelhead	sub-adult	6,053	1	0.02%
	juvenile	897,662	2	0.00%
California Central Valley steelhead	sub-adult	5,542	1	0.02%
	juvenile	2,231,056	2	0.00%
Northern California steelhead	sub-adult	7,221	1	0.01%
	juvenile	821,389	2	0.00%
Upper Columbia River steelhead	sub-adult	8,403	1	0.01%
	juvenile	1,025,548	2	0.00%
Snake River Basin steelhead	sub-adult	106,194	2	0.00%
	juvenile	4,803,983	9	0.00%
Lower Columbia River steelhead	sub-adult	35,217	1	0.00%
	juvenile	1,558,440	3	0.00%
Upper Willamette River steelhead	sub-adult	2,912	1	0.03%
	juvenile	140,396	2	0.00%
Middle Columbia River steelhead	sub-adult	5,612	1	0.02%
	juvenile	963,139	2	0.00%
Puget Sound steelhead	sub-adult	19,313	1	0.01%
	juvenile	2,419,401	3	0.00%

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. As discussed

previously, 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 likely not affect structure or diversity at all. Because the research effects would affect hatchery fish along with natural production, any effects to the structure and diversity of hatchery fish would be of lesser concern.

The only DPSs/life stage that may be incidentally captured and killed at a percentage of abundance greater than 1% according to this analysis are SC steelhead adults at 9% (although sub-adult is the actual life stage at risk of bycatch). This population of steelhead is the smallest population on the U.S. West Coast by a substantial margin (Table 47), and the likelihood that any steelhead from this DPS would be incidentally captured anywhere in the CCE would be very small. Based on historical data on SWFSC activities, the limited extent of steelhead bycatch (and all salmonids in general) that has occurred primarily has been in the northern part of the SWFSC research area far away from the freshwater systems that SC steelhead originate from and return to, which further decreases the chances of SC steelhead to some degree. While we acknowledge that the prospect of incidentally capturing one SC steelhead sub-adult during any year cannot be eliminated, we conclude that it is very unlikely that SC steelhead (both sub-adults and juveniles) would be repeatedly captured year after year, even in low numbers, given the small number of them that are anticipated to be present in the marine environment anywhere in the CCE.

Despite the low probability of occurrence, if there is a mortality of a SC steelhead sub-adult during SWFSC research, this would have a small effect on the species' abundance and potentially on productivity (assuming this individual would have survived to have reproduced). In the marine environment, steelhead sub-adults are subject to numerous threats of mortality from natural and man-made causes that vary in extent on a seasonal and/or annual basis. Occasional mortality of SC steelhead sub-adults in the marine environment is inevitable given those threats. Given this, we conclude that we would not be able to detect any impact on the population from the possible loss of one sub-adult that could be infrequently incidentally captured and killed in SWFSC research.

As described in the sections on species status, the status of ESA-listed salmonids, and SC steelhead in particular, is such that there must be a substantial improvement in the environmental conditions of their habitat and other factors affecting their survival if they are to begin to approach recovery. While the proposed research activities would in fact have some negative effect on each of the species' abundance, this effect would be small relative to their current total abundance numbers. In addition, in no case would the proposed actions exacerbate any of the other factors that are affecting their structure and diversity, including habitat features such as increasing stream temperatures or continuing land development. Therefore, we expect the detrimental effects on ESA-listed salmonids species, including SC steelhead, are expected to be minimal and those impacts would only be seen in terms of slight reductions in abundance and productivity. Because these reductions are so slight, we conclude they would have no appreciable effect on the species' diversity or distribution.

2.6. Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02 and 402.17(a)). 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.

Some continuing non-Federal activities are reasonably certain to contribute to the overall environmental health and habitat quality within the action area. In section 2.4 *Environmental Baseline*, we described the current and ongoing impacts associated with other activities that affect ESA-listed species along the U.S. West Coast. We are reasonably certain that these activities and impacts will continue to occur while this proposed action occurs.

Some continuing non-Federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult if not impossible to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline *vs.* cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the environmental baseline (Section 2.4).

This consultation incorporates a large project action area encompassing domestic and international ocean waters in different parts of the Western Hemisphere. During this consultation, we were not provided with and did not identify any specific additional state, private, or foreign government activities that are reasonably certain to occur within the action area, which do not involve Federal activities, and could result in cumulative effects to ESA-listed species and designated critical habitat within the action area. Activities that may occur in these areas will likely consist of state, federal, or foreign government actions related to ocean use policy and management of public resources, such as fishing or energy development projects. Changes in ocean use policies as a result of non-federal government action 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 fisheries which may alter fishing patterns or influence the bycatch of ESA-listed marine mammals and sea turtles; installation of hydrokinetic projects near areas where marine mammals and sea turtles are known to migrate through or congregate; designation or modification of marine protected areas that include habitat or resources that are known to affect marine mammals and sea turtles; and coastal development which may alter patterns of shipping or boating 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, and most of those described as examples would likely involve federal involvement of some type given the federal government's role in regulating activity in the ocean across numerous agencies and activities.

2.7. Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section,

we add the effects of the action (Section 2.5) to the environmental baseline (Section 2.4) and the cumulative effects (Section 2.6), taking into account the status of the species and critical habitat (Section 2.2), to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) Reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminish the value of designated or proposed critical habitat as a whole for the conservation of the species.

2.7.1. 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 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 DPS of loggerhead sea turtle; olive ridley sea turtle; and East Pacific DPS green sea turtle.

2.7.2. Marine Fish

2.7.2.1 Southern DPS of Eulachon

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 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. As stated in section 2.5.1.1.2, 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 91 (~2 kg) of these individuals to removal in SWFSC research trawls or purse seine sets 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 91 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 91 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 or purse seine sets or 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.

2.7.2.2 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 capture in research trawl and purse seine surveys 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.

For almost all of the 28 salmonid ESU/DPSs potentially affected by this research, the potentially lethal effects that may occur as a result of the proposed research activities included in this opinion represents less than 1% of the estimated abundance for a given life stage. While the extent of effects for almost all of 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 potentially lethal effects are conservative to assume worst case scenarios where all salmon bycatch in SWFSC research could be lethal, even though it may be likely that many individuals will survive incidental capture and sampling upon release. Still, if even the worst case scenarios were to occur 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). 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.

Southern California steelhead – As described before in Section 2.2.3, we do not have good (i.e., incomplete) abundance data for SC steelhead, so the estimated impact of the proposed action in terms of relative effect on the total population that may be affected for either the juvenile or adult life stage is based on an underestimate of the total abundance and productivity of this population. As described in Section 2.5.2.3, in the marine environment, steelhead sub-adults are subject to numerous threats and occasional mortality of SC steelhead sub-adults in the marine environment is inevitable. In Section 2.5.2.3 we also described that any incidental capture of an SC steelhead individual is likely to be extremely rare, and is not expected to occur repeatedly every year during SWFSC research activities. As described in Section 2.5.2.3 we conclude that we would not be able to detect any impact on the population from the possible loss of one sub-adult that could be infrequently incidentally captured and killed in SWFSC research.

As described in Section 2.4.3, salmon in the CCE are subject to impacts from numerous sources of man-made and natural factors that include targeted fisheries, bycatch in other fisheries, scientific research, predation for numerous marine species, and varying environmental conditions. Generally speaking, SWFSC research activities affects up to ~2000 (mostly juvenile) salmonids per year, compared to the hundreds of millions of ESA-listed juvenile and adult salmon that may be present in the CCE ecosystem each year. While the numerous sources of impacts on salmonids may affect and potentially remove the majority of these ESA-listed salmonids each year, the potential additional removal of ~2000 (mostly juvenile) salmonids has virtually an undetectable impact on the abundance, distribution, or diversity of ESA-listed salmonid populations. Where we have conservatively assumed that impacts could occur for relatively small and more vulnerable ESA-listed salmon populations such as SC steelhead, the reality is that the potential impacts to such small populations are more likely to be proportionally scaled to their relative abundance, and consequently likely to be far less than what was conservatively estimated for all ESA-listed salmonids. 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 occur in the CCE.

2.8. Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, the effects of other activities caused by the proposed action, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of the following ESA-listed species: leatherback sea turtle; North Pacific DPS of loggerhead sea turtle; olive ridley sea turtle; East Pacific DPS of green sea turtle; Southern DPS of Pacific eulachon; Chinook (Sacramento River winter 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 (Hood Canal summer run ESU; and Columbia River ESU); coho (Central California coastal ESU; S. Oregon/N. California coastal ESU; Oregon Coast ESU; and Lower Columbia River ESU); sockeye (Snake River ESU; and Ozette Lake ESU); and steelhead (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.

Critical habitat has been designated 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 and Southern Pacific DPS of eulachon; therefore, no further analyses were conducted for those designated critical habitats that lie exclusively within freshwater, estuarine, or marine environments completely outside the proposed action area (including Southern Resident killer whales).

Potential effects on blue whales, fin whales, Mexico DPS and Central America DPS humpback whales, sei whales, sperm whales, Southern Resident killer whales, Western North Pacific DPS gray whales, North Pacific right whales, Guadalupe fur seals, southern right whales, hawksbill sea turtles, Southern DPS green sturgeon, Gulf grouper, giant manta rays, East Pacific DPS scalloped hammerhead sharks, oceanic whitetip sharks, white abalone, and black abalone are analyzed in section 2.12. Potential effects on these species, and on designated critical habitats in marine areas for Stellar sea lions, Southern DPS green sturgeon, and leatherback sea turtles that overlap with the proposed action area are analyzed in section 2.12. After reviewing the proposed project and potential effects, we conclude that these species and designated critical habitats for any ESA-listed species are not likely to be adversely affected by the proposed action.

Critical habitat proposed for ESA-listed species that overlap with the proposed action were also considered in this biological opinion. Potential effects of proposed critical habitats for Southern Resident killer whales, and the Mexico DPS and Central America DPS humpback whales, are analyzed in section 2.12. After reviewing the proposed project and potential effects, we conclude that no proposed critical habitats for any ESA-listed species are likely to be adversely affected by the proposed action.

2.9. Incidental Take Statement

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

2.9.1. Amount or Extent of Take

In the biological opinion, NMFS determined that incidental take is reasonably certain to occur as follows:

Table 49. Description of incidental take of ESA-listed sea turtles and eulachon 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 DPS loggerhead				
olive ridley				
East Pacific DPS green				
Sea turtles	1	juvenile/adult	Captured/entangled in CCE longline surveys	released alive
leatherback				
North Pacific loggerhead				
olive ridley				
East Pacific DPS green				
Southern DPS Pacific eulachon	2 kg or 91 individuals	juvenile/adult	Captured in CCE trawl or purse seine surveys	100% 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 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 91 individuals, or 2 kg, of eulachon may be incidentally captured and killed in any year in SWFSC survey trawls or purse seine sets in the CCE.

Table 50. Description of incidental take of salmon expected each year through capture in SWFSC research surveys. For each salmon species, the take each year could come from any of the ESA-listed ESUs/DPSs, as described in section 2.5.1.1.3.

Species	Expected Take	Life Stage	Manner of Take	Final Disposition
Chinook	838	juvenile	Captured in CCE trawl surveys	100% mortality
Chinook	184	sub-adult	Captured in CCE trawl surveys	100% mortality
Chinook	79	juvenile	Captured in CCE purse seine surveys	100% mortality
chum	605	juvenile	Captured in CCE trawl surveys	100% mortality
chum	133	sub-adult	Captured in CCE trawl surveys	100% mortality
chum	57	juvenile	Captured in CCE purse seine surveys	100% mortality
coho	134	juvenile	Captured in CCE trawl surveys	100% mortality
coho	29	sub-adult	Captured in CCE trawl surveys	100% mortality
coho	13	juvenile	Captured in CCE purse seine surveys	100% mortality
sockeye	1	juvenile	Captured in CCE trawl surveys	100% mortality
sockeye	1	sub-adult	Captured in CCE trawl surveys	100% mortality
sockeye	1	juvenile	Captured in CCE purse seine surveys	100% mortality
steelhead	15	juvenile	Captured in CCE trawl surveys	100% mortality
steelhead	3	sub-adult	Captured in CCE trawl surveys	100% mortality
steelhead	1	juvenile	Captured in CCE purse seine surveys	100% mortality

Although the SWFSC will conduct analysis to identify the specific populations that incidentally captured salmonids may be associated with, we expect that this information may not be immediately available for all incidental salmonid bycatch throughout the 5-year period of this proposed action. As a result, we will rely upon information provided by SWFSC on the numbers of each salmonid species incidentally captured to serve as a surrogate for the incidental take of each ESA-listed salmonid population as needed during this 5-year period in the absence of complete knowledge of the origin of all salmonid bycatch (Table 50).

For salmonids, we expect that a total of up to 838 Chinook, 605 chum, 134 coho, 1 sockeye, and 15 steelhead juveniles, and up to 184 Chinook, 133 chum, 29 coho, 1 sockeye, and 3 steelhead sub-adults, will be incidentally captured and killed in SWFSC survey trawls in the CCE each year. We also expect that up to 79 Chinook, 57 chum, 13 coho, 1 sockeye, and 1 steelhead juvenile will be incidentally captured and killed during sampling in SWFSC purse seine surveys in the CCE each year. If these totals are exceeded, then take will have occurred in excess of what has been considered in this opinion. SWFSC purse seine research may additionally take salmonids during surveys as fish are held in the purse seine during sampling before release of the purse seine, with no significant injury or mortality of salmonids taken in this manner expected. Given that the extent of take in this manner cannot be enumerated at this time with the available information, we use the extent of total catch and the number of salmonids that are sampled from purse seine surveys as a surrogate to monitor the extent of non-lethal salmon take in purse seine surveys.

The exact proportions of these totals that will be composed of individual ESUs or DPSs, both ESA-listed and non-listed populations, are uncertain and will not be known unless or 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 salmon species in Table 50. Where possible, genetic analyses will be used to determine if any of the ESA-listed ESUs or DPSs are being taken in excess of what has been considered in this opinion.

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 (85 FR 53606). 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 take as defined under the ESA of ESA-listed marine mammals as a result of exposure to active acoustic sources used during SWFSC research activity is anticipated.

2.9.2. Effect of the Take

In the biological opinion, NMFS 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 the species or destruction or adverse modification of critical habitat.

2.9.3. 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.

2.9.4. Terms and Conditions

The terms and conditions described below are non-discretionary, and the SWFSC must comply with them in order to implement the RPMs (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 ITS (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

Or via email at Chris.Yates@noaa.gov

   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.

2d. The SWFSC shall collect estimates of the total amount of catch in purse seine surveys conducted each year, and provide this information to WCR PRD as part of the annual reporting process that should also include information on the number/size of salmonids that are collected from sampling of SWFSC purse seine surveys.

2.10. 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 there are increasing conservation and management needs for information about the factors that influence the presence, abundance, and 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 how these species interact with the marine ecosystem. This effort could be used to complement other SWFSC and NOAA initiatives aimed at developing approaches to use this type of ecosystem knowledge to inform management of ESA-listed species and other protected resources.

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. Specific examples include research into efficacy and modification of

exclusion devices in survey trawl nets, along with investigation of other operational strategies to minimize incidental bycatch risks.

2.11. Reinitiation of Consultation

This concludes formal consultation for Continued Prosecution of Fisheries Research Conducted and Funded by the Southwest Fisheries Science Center, Including Issuance of a Letter of Authorization under the Marine Mammal Protect Act for the Incidental Take of Marine Mammals Pursuant to those Research Activities.

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

As described earlier, we have concluded that the effects of acoustic devices 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 adverse under the standards of the ESA, 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.

2.12. "Not Likely to Adversely Affect" Determinations

Under the ESA, "effects of the action" are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (50 CFR 402.02). In our analysis, which describes the effects of the proposed action, we considered 50 CFR 402.17(a) and (b). When evaluating whether the proposed action is not likely to adversely affect listed species or critical habitat, NMFS considers whether the effects are expected to be completely beneficial, insignificant, or discountable. Completely 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. Effects are considered discountable if they are extremely unlikely to occur.

We do not anticipate the proposed action will adversely affect blue whales, fin whales, Mexico DPS and Central America DPS humpback whales, sei whales, sperm whales, Southern Resident killer whales, Western North Pacific DPS gray whales, North Pacific right whales, Guadalupe fur seals, southern right whales, hawksbill sea turtles, Southern DPS green sturgeon, Gulf grouper,

giant manta rays, East Pacific DPS scalloped hammerhead sharks, oceanic whitetip sharks, white abalone, and black abalone.

A conclusion that a proposed action "Is not likely to adversely affect critical habitat" is appropriate when the effects of an action on critical habitat physical or biological features (PBFs) are expected to be discountable, insignificant, or wholly beneficial. Wholly beneficial effects are positive only: an action cannot be deemed wholly beneficial if it has any adverse effect on critical habitat. Insignificant effects relate to the magnitude and duration of the impact and should never reach the scale where any critical habitat physical or biological feature is altered to the point that its ability to support listed species' conservation needs is reduced. Therefore, effects would be insignificant when a person would not be able to meaningfully measure, detect, or evaluate changes in the value of one or more PBFs. Effects are considered discountable if they are extremely unlikely to occur.

NMFS does not anticipate that the proposed action proposed action will adversely affect the designated critical habitats of Steller sea lions, Southern DPS green sturgeon, or leatherback sea turtles, or the proposed critical habitats for Southern Residents, and Mexico DPS and Central America DPS humpback whales.

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 and proposed 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 proposed action, we detail some of the relevant details of the effects analysis in this section for reference as necessary within section 2.5.

2.12.1. Marine Mammals

One important limitation of the analysis of potential impacts to ESA-listed marine mammals conducted by the SWFSC in the PEA, 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 PEA and Appendix A of the MMPA LOA application) 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.

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

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 2.12.5).

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. Information from tagging, photo-identification and genetic studies show that some whales identified in the WNP off Russia have been observed in the ENP, including coastal waters of Canada, the U.S. and Mexico (Lang et al. 2011; Weller et al. 2012; Urbán et al.

2013, Mate et al. 2015). In combination, these studies have recorded about 30 gray whales observed in both the WNP and ENP. 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 25,849 (Carretta et al. 2019a). The most recent minimum estimate of WNP gray whale abundance is 271 individuals (Carretta et al. 2019a). At any given time during the migration, WNP gray whales could be part of the approximately 25,000 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, and much of it occurs outside of the primary annual gray whale migration period (Appendix B in PEA). 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 PEA and MMPA LOA application. 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 (Southern Residents) 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 73 whales as of December 2019[16]. In November 2006, NMFS designated critical habitat for Southern Residents, based primarily on their known distribution during summer and fall. Critical habitat for Southern Residents 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.

In September, 2019, NMFS proposed revision to the designated critical habitat including roughly 15,627 square miles of marine waters along the U.S. West Coast include between the 6.1-meter depth contour and the 200-meter depth contour from the U.S. international border with Canada south to Point Sur, California. Historically there has been little information available about their range and distribution during the winter and early spring, although new information is coming to

[16] Annual census: https://www.whaleresearch.com/orca-population

light. Southern Residents 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. Land- and vessel-based opportunistic and survey-based visual sightings, satellite tracking, and passive acoustic research conducted have provided an updated estimate of the whales' coastal range that extends from the Monterey Bay area in California, north to Chatham Strait in southeast Alaska. Since 1975, confirmed and unconfirmed opportunistic Southern Resident sightings from the general public or researchers have been collected off British Columbia, Washington, Oregon, and California have confirmed their presence as far north as Chatham Strait, southeast Alaska and as far south as Monterey Bay, California (NMFS 2019d).

The results of satellite tagging with deployment durations from late December to mid-May indicated their range in recent years has extended across the entire Salish Sea, from the northern end of the Strait of Georgia and Puget Sound, and coastal waters from the central West Coast of Vancouver Island, British Columbia to northern California (Hanson et al. 2017). Satellite tagging indicated approximately 95 percent of the Southern Resident locations were within 34 km of the shore and 50 percent of these were within 10 km of the coast (Hanson et al. 2017). Only 5 percent of locations were greater than 34 km away from the coast, but no locations exceeded 75 km. Most locations were in waters less than 100m in depth. Passive acoustic recorders deployed off the coasts of California, Oregon and Washington in most years since 2006 to assess their seasonal uses of these areas via the recording of stereotypic calls of Southern Residents also reveal similar patterns of seasonal use as tagging and opportunistic sightings (Hanson et al. 2013; Emmons et al. 2019).

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 CCA does not occur during the winter and spring when Southern Residents 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 Southern Residents 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 Southern Residents during research activities, such as Chinook salmon. Since we cannot discount potential interaction between SWFSC research and Southern Residents, we will consider them further in this analysis.

2.12.1.1 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* PEA for the SWFSC marine mammal bycatch history). They also capture/entangled 5 California sea lions during HMS and Thresher Shark pelagic longline surveys. Since 2013 (through 2019), an additional 27 marine mammals (mostly Pacific white-sided dolphins and California sea lions) have been incidentally captured or entangled in trawl survey, and 2 (California sea lions). 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. 2020), 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, especially within the CCE where densities of many of the ESA-listed marine mammal species that may be affected by SWFSC research are relatively high, at least seasonally. 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 introduction of purse seine gear to SWFSC research surveys does present a risk for marine mammal interactions with surveys that has not existed previously. Historically, commercial purse seine gear fishing for Coastal Pelagic Species on the U.S. West Coast has been associated with marine mammal bycatch, including California sea lions and several species of small cetaceans that are not ESA-listed (Carretta et al. 2019a). As a result, authorizations for small numbers of takes for Dall's porpoise, Pacific white-sided dolphin, Risso's dolphin, northern right whale dolphin, Steller sea lion, and harbor porpoise have been included in the MMPA LOA application by the SWFSC. However, purse seine gear is generally not known to be a source of interactions with larger marine mammals such as whales along the U.S. West Coast, although these interactions are not unheard of in other areas, including salmon purse seine fishing in Alaska.[17] Use of dedicated marine mammal observers prior to and during purse sein 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.

Based on the proposed gear and methods to be utilized, the SWFSC does not generally anticipate deep-set buoy surveys to result in any marine mammal takes. The gear is specifically designed to minimize the risk of protected species interactions. The MMPA LOA applications indicates that no historical takes using deep-set buoy gear have occurred during SWFSC research during their previous 54 sets (approximately 2,200 hook hours). Information from NMFS WCR Observer program indicates that at least 2 elephant seals have been documented as bycatch in the course of research and experimental fishing with buoy gear on the West Coast in recent years (NMFS WCR SFD unpublished data), but that effort has been conducted by numerous individuals under a wide array of circumstances that may not reflect the scale of SWFSC research. In the Atlantic, no protected species interactions have been recorded in the Swordfish Buoy Fishery that uses similar gear configuration and has higher effort levels than surveys conducted in the Pacific (MMPA LOA application), although observer coverage in the fishery has been limited. The SWFSC does not anticipate that rod and reel surveys will result in any marine mammal takes. Although takes from deployment of deep-set buoy gear and longline gear in SWFSC research surveys are not expected, SWFSC has requested a small number of M/SI takes for several non-ESA-listed cetacean species (2) and pinniped species (5) that may occur near these research activities (MMPA LOA application). Use of dedicated marine mammal observers prior to and during research 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.

In Antarctica, SWFSC does not propose to deploy any gear that poses a risk of incidental capture or entanglement, which eliminates this risk for ESA-listed species in Antarctica.

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

[17] https://www.fisheries.noaa.gov/national/marine-mammal-protection/list-fisheries-summary-tables

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 and what is known about the risks of interactions with gear that is proposed for use, we conclude that the likelihood of incidental capture or entanglement of ESA-listed marine mammals is discountable

2.12.1.2 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 1.3.3). 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.

2.12.1.3 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.

In 2019, Southall et al. (2019) published an update to the 2007 Marine Mammal Noise Exposure Criteria, which confirms the weighting functions and thresholds used by NMFS and cited in the 2018 revised NMFS Technical Guidance (NMFS 2018a). The NMFS Technical Guidance continues to be used for defining regulatory thresholds for calculating incidental takes of marine mammals under the MMPA were used by SWFSC in development of their MMPA LOA application. Table 51 presents the functional hearing groups and representative species or taxonomic groups for each.

Table 51. Summary of the five functional hearing groups of marine mammals.

Hearing Group	Hearing Range
Low-frequency cetaceans (e.g. baleen whales)	**7 Hz to 35kHz**
Mid-frequency cetaceans (e.g. killer whales)	**150 Hz to 160 kHz**
High-frequency cetaceans (e.g. Pacific white-sided dolphins)	**275 Hz to 160 kHz**
Phocids (e.g. harbor seals)	**50 Hz to 86 kHz**
Otariids and other non-phocid marine carnivores (e.g. California sea lions)	**60 Hz to 39 kHz**

As shown in Table 51, marine mammals found in the SWFSC research areas fall into the following categories: baleen whales are low-frequency cetaceans; killer whales and Pacific white-sided dolphins are mid frequency cetaceans; harbor porpoise are high frequency cetaceans; harbor seals are in the phocid category; and California sea lions are classified as otariids. NMFS (2018a) considered acoustic thresholds by hearing group to acknowledge that not all marine mammals have identical hearing ability or identical susceptibility to noise or noise-induced permanent threshold shifts (PTS). NMFS (2018a) also used the hearing groups to establish marine mammal auditory weighting functions for use in determining potential acoustic impacts.

Active Acoustics Footprint and the MMPA LOA Application

The PEA and SPEA 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 the different geographical areas where it operates these devices (CCE and Antarctica) that is essentially identical to the approach used in the 2015 biological opinion on SWFSC research activities. 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 PEA and in the MMPA LOA application) 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 2 in section 1.3 characterizes the general source parameters for the primary SWFSC vessels operating active acoustic sources (Appendix A of the PEA; MMPA LOA application; 85 FR 53606). This enables a full assessment of all sound sources, including those that are entirely outside the range of marine mammal hearing (> 160 kHz; Table 51 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[18] (> 160 dB re 1 μPa RMS (root mean square) for impulsive sound sources[19]) would occur.

Although the 2018 guidance identifies dual criteria to assess auditory injury (Level A harassment) to five different marine mammal groups (based on hearing sensitivity) as a result of exposure to noise from two different types of sources (impulsive or non-impulsive), given the highly directional, e.g., narrow beam widths of acoustic equipment, NMFS does not anticipate animals would be exposed to noise levels resulting in injury (Level A harassment). This is the same conclusion reached during the previous MMPA LOA application and permit issuance in 2015. Although more recent literature provides documentation of marine mammal responses to the use of these and similar acoustic systems (*e.g.*, Cholewiak et al. 2017; Quick et al. 2017; Varghese et al. 2020), the described responses do not generally comport with the degree of severity that should be associated with Level B harassment, as defined by the MMPA (85 FR 53606). As a result, the SWFSC applied only for incidental Level B harassment take

[18] 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.

[19] 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.

authorization under the MMPA resulting from active acoustic sources, and no incidental Level A injury take authorizations.

In the MMPA LOA application, 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* PEA Appendix C; MMPA LOA application; 85 FR 53606). Table 52 describes the estimated levels of Level B harassment under the MMPA for marine mammals also protected under the ESA.

Table 52. Estimates of annual Level B acoustic harassment under the MMPA for ESA-listed marine mammals by survey region.

ESA-listed Species	Incidents of MMPA Level B Acoustic Harassment
CCE	
Humpback whale (Mexico DPS	21
Humpback whale (Central America DPS)	2
Sei whale	10
Fin whale	124
Blue whale	18
Sperm whale	96
Killer whale (Southern Resident DPS)[20]	13
Guadalupe fur seal	313
Antarctica[21]	
Fin whale	57
Sperm whale	5

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

[20] The annual MMPA take number is for killer whales generically and is more likely to affect the non-ESA-listed Eastern North Pacific Offshore and West Coast Transient stocks, but MMPA takes could occur for the ESA-listed Southern Resident stock during times when whales may be foraging on the coasts of California, Oregon, or Washington (OPR consultation request).

[21] There are acoustic harassment takes of humpback whales by SWFSC research activities anticipated in Antarctica, but these whales are expected to belong to unlisted DPSs of humpback whales that commonly occur in this area, and thus are not considered in this opinion.

events is considered beneficial, as long as no other contemporaneous adverse effects are occurring as a result. At this point, we assume pingers may be beneficial in helping to reduce the chances of bycatch for at least some 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 a result, we do not expect these pingers to produce any injurious effects to any ESA-listed species.

ESA Exposure to Active Acoustics

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 PEA, MMPA LOA application, and 85 FR 53606. 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 PEA 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 52 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 Residents); 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, Mexico DPS and Central America 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 of Mexico DPS and Central America DPS 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 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* PEA 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 45 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 biological 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 (which is not proposed). 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 45 minutes that SWFSC vessels may be engaged in sampling at fairly slow speeds, vessels are expected to cover 2.7 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 *Active Acoustics Response and Risk*). 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.

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). 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, NMFS 2018a). 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; NMFS 2018a)

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, we ultimately

conclude the risks of adverse effects to ESA-listed marine mammals are discountable, as described in detail below. While our analytical approach and conclusions about the potential effects of acoustic sources on ESA-listed marine mammals are identical to what was described in the 2015 biological opinion on SWFSC research activities, NMFS has since formalized guidance on the interpretation of the term "harass" under the ESA (NMFS 2016d) which we rely upon to guide our analysis and conclusions in this biological opinion, as well as the updated Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (NMFS 2018a) used for determining thresholds for onset of PTS and TTS in marine mammal hearing.

Temporary or Permanent Hearing Loss, Physical Injury, and Masking

As discussed in more detail (see PEA section 4.2.4; MMPA LOA application; 85 FR 53606), current scientific information supports the conclusion that direct physiological harm is quite unlikely. NMFS 2018a provides a framework to assess the potential for permanent hearing damage (PTS) for different hearing groups from discrete sound exposures that generally indicate very high levels sound levels received over time would be required to result in PTS from exposure for most marine mammal species. Southall et al. 2007 concluded that typically quite large TTS is required (shift of ~40 dB) to result in PTS. 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 2018a provides acoustic thresholds for MMPA Level A injury (*i.e.*, PTS) shown in Table 53. Although the 2018 guidance identifies dual criteria to assess auditory injury (Level A harassment) to five different marine mammal groups (based on hearing sensitivity) as a result of exposure to noise from two different types of sources (impulsive or non-impulsive), given the highly directional, e.g., narrow beam widths of acoustic equipment, we do not anticipate animals would be exposed to noise levels resulting in injury.

Table 53. Acoustic threshold for MMPA Level A injury (NMFS 2018a).

	Permanent Threshold Shift (PTS) Onset Acoustic Thresholds (Received Level)		
Hearing Group	**Impulsive Sources**		**Non-impulsive Sources**
	Peak, L_{pk}, flat *(dB re 1 µPa)*	**Cumulative weighted SEL_{24h}** *(dB re 1 µPa²·s)*	**Cumulative weighted SEL_{24h}** *(dB re 1 µPa²·s)*
Low-frequency cetaceans	219	183	199
Mid-frequency cetaceans	230	185	198

Hearing Group	Permanent Threshold Shift (PTS) Onset Acoustic Thresholds (Received Level)		
	Impulsive Sources		Non-impulsive Sources
	Peak, L_{pk}, flat *(dB re 1 µPa)*	Cumulative weighted SEL_{24h} *(dB re 1 µPa²·s)*	Cumulative weighted SEL_{24h} *(dB re 1 µPa²·s)*
High-frequency cetaceans	202	155	173
Phocid pinnipeds in water	218	185	201
Otariid pinnipeds in water	232	203	219

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, 2019), 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. 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 described by NMFS 2018a are based on available data calculated using the approach developed by Finneran (2016). Based on the recent NMFS guidance, there is a potential for TTS from some of the Category 2 active sources, particularly for high-frequency cetaceans (see Table 6 in NMFS 2018a). Thus, there is a potential for TTS from some active sources, particularly for high-frequency cetaceans. However, given the most recent data and guidance, animals would have to be very close (few hundreds of meters) and remain near sources for many repeated pings to receive overall exposures sufficient to cause TTS onset (NMFS 2018a; Lucke et al. 2009; Finneran and Schlundt 2010; PEA). 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.[22] 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 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 and Harassment

The proposed action includes MMPA authorization for a number of temporary behavioral disturbances that may occur as a result of exposure to the acoustics associated with SWFSC research activities. 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 health or 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 PEA. 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-

[22] 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.

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, Southern Residents, Mexico DPS and Central America DPS humpback whales, and Guadalupe fur seals, are most likely to occur in the CCE and Antarctica. 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 where SWFSC research occurs. Southern Resident breeding typically occurs during spring and summer when these individuals are expected to be within inland waters of the Salish Sea. Humpback whales are known to breed in waters along Mexico and Central America, which does not overlap with the proposed research activities. Guadalupe fur seals breed on Guadalupe Island, which is located in Mexican waters, which also does not overlap with proposed research activities.

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 2.5 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 overall patterns and amounts of 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 biological opinion issued by NMFS regarding the impacts of Navy training activity in the Pacific Northwest, including areas in the CCE (NMFS 2020c), NMFS concluded that the brief amount of time ESA-listed marine mammals are expected to experience acoustic impacts was unlikely to significantly impair their ability to communicate, forage, or breed, and was not expected to have long-term fitness consequences for the individuals affected. In that biological opinion, NMFS did not anticipate these species would experience long duration or repeat exposures within a short period of time due to the species' wide ranging life history coupled with Navy activities occurring over large geographic areas (i.e., both the animal and the activity are moving within the action area, most likely not in the same direction). NMFS concluded this decreases the likelihood that animals and Navy activities would co-occur for extended periods of time or repetitively over the duration of any activity.

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., 96 sperm whale exposures in the CCE; Table 52) 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.

Based on a similar analysis conducted as part of the 2015 biological opinion on SWFSC research activities, we concluded at that time that exposure of ESA-listed marine mammals and other species to active acoustics from SWFSC research activities was not likely to adversely affect any ESA-listed species. Since that time, NMFS has issued policy guidance to further clarify the distinction between the term "harass" as used in ESA context, in contrast to how it is used for regulatory purposes under the MMPA (NMFS 2016d). Specifically, the "Interim Guidance on the Endangered Species Act Term 'Harass'" describes how NMFS will interpret harass in a manner similar to the USFWS regulatory definition for non-captive wildlife:

Consistent with the "Interim Guidance on the Endangered Species Act Term 'Harass'" (NMFS 2016d), we interpret harass in a manner similar to the U.S. Fish and Wildlife Service regulatory definition for non-captive wildlife to mean:

"To create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering."

Under this "Interim Guidance" we interpret the phrase "significantly disrupt normal behavioral patterns" to mean a change in the animal's behavior (breeding, feeding, sheltering, resting, migrating, etc.) that could reasonably be expected, alone or in concert with other factors, to create or increase the risk of injury to an ESA-listed animal when added to the condition of the exposed animal before the disruption occurred. An injury in the context of analyzing behavioral responses could be a physical injury or a physiological or other impact that would reasonably be expected to negatively affect the animal's growth, health, reproductive success, and/or ability to survive (i.e., an effect that results from a more than inconsequential behavioral response). Harassment does not require that an injury actually result or is proven; only that the behavioral response creates or increases the likelihood of injury.

Through our analysis in this biological opinion, we have established that we do not expect a fitness level effect for any ESA-listed marine mammals as a result of temporary disturbance. We conclude this finding is synonymous with an analysis of harassment using the standard provided for guidance under the ESA, which equates to a conclusion that no injuries as a result of temporary disruption of normal behavioral patterns as a result of exposure to SWFSC research activities are expected. 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, or lead to any injury related to these functions. We expect the effects of disturbance and avoidance from this proposed action to be temporary and insignificant. In other words, we don't expect any harassment to occur under the ESA, per the interim guidance from NMFS. 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.

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) 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 Residents), and to a lesser degree Mexico DPS and Central America DPS 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" by means of harassment 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.

2.12.1.4 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).

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 vessel noise from this action on ESA-listed marine mammals are insignificant.

2.12.1.5 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 46 in section 2.5.1.4 describes some historical information on 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.

In the SPEA, SWFSC provided some specific updates on the removals of some prey species for marine mammals and other species where data was readily available from recent surveys. Table 45 in section 2.5.1.4 illustrates CPS and Rockfish Recruitment and Ecosystem Assessment Survey removals of the three target species brought forward for analysis compared to spawning biomass (where available) and commercial and recreational landings. Table 46 shows that biomass of prey species removed during surveys varies but has decreased from 2016 likely due to reduced level of survey efforts. Note the biomass numbers in Table 46 do not include jellyfish, salps, dogfish, sharks, rays or other organisms taken in CPS surveys that are not considered potential prey species for marine mammals.

The 2015 PEA analyzed the potential impacts of prey removals on marine mammal species and determined that the total amount of these species taken in research surveys is very small relative

to their overall biomass in the area. In addition to the small amount of biomass removed, the size classes of fish targeted in research surveys are juvenile individuals, some of which are only centimeters long, that are not expected to be prey of many ESA-listed species in the CCE. As described further in the analysis in section 2.5, 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. 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, and for humpback whales and CCE forage fish).

Southern Residents and Salmon

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 Southern Resident population dynamics. The Panel found good evidence that Chinook salmon are a very important part of the Southern Resident diet and good evidence that some Southern Residents 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 Southern Resident survival and reproductions. They identified "reasonably strong" evidence that vital rates of Southern Residents 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 Southern Residents, and the likelihood of any adverse effect to the fitness of any individuals as a result of this activity.

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 2020b; NMFS and WDFW 2018). Direct observations of predation events have occurred when Southern Residents were in coastal waters, and prey has identified to species and stock using genetic analysis of prey remains (NMFS 2019d; NMFS and WDFW 2018). 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 remains strong when Chinook salmon are available; however, Southern Residents 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 and winter (NMFS 2020b).

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 and purse seine surveys, we anticipate the following total of juvenile and sub-adult salmon that may be captured, and killed (mortality):

Table 54. Maximum number of salmon expected to be captured, and killed or released alive during all SWFSC trawl and purse surveys per year.

	Total	Sub-adult	Juvenile
Chinook	1101	184	917
chum	795	133	662
coho	176	29	147
sockeye	2[1]	1	2
steelhead	19	3	16

[1] Total reflects the possibility that takes could include a sub-adult or be all juveniles.

For Chinook, we expect a total of up to 917 juveniles and 184 sub-adults to be killed per year during SWFSC research trawl surveys (Table 54). Based on the information available, it is unlikely that small juvenile salmon are the primary source of prey for Southern Residents, given relative small size of juvenile Chinook and the apparent preference of Southern Residents for larger fish (Ford and Ellis 2006; NMFS 2020b). As a result, removal of juvenile Chinook by SWFSC research activity is not expected to result in significant direct competition with Southern Resident foraging. In addition, much of SWFSC trawl research occurs in the CCE during the spring, summer, and fall, while Southern Residents 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 Southern Residents. 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 (917 x 0.5 =

459 sub-adults), and that the total impact of SWFSC research on reductions of Chinook for Southern Residents is equal to the sum 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 (184 + 459 = 643 sub-adults).

Noren (2011) estimated the energetic needs and subsequent prey requirements of Southern Residents 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 Southern Resident 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 U.S. EEZ portion of the range of Southern Residents has average 3.6 million over the last decade (between 2 and 6 million each year; NMFS 2020b). Using the maximum estimate of 643 current or future sub-adult Chinook killed during SWFSC research each year, the resulting loss of potential Chinook prey for Southern Residents equates to 0.02% the total number of adult Chinook salmon present in the marine coastal range of Southern Residents each year, on average. This represents a very small fraction of what would otherwise be available to Southern Residents in marine coastal waters. Even if we assumed all lost sub-adult Chinook resulting from the proposed action would have consumed by Southern Residents, 643 Chinook would not support the entire Southern Resident population 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 Southern Residents. 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 Southern Residents, 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 Southern Residents given their wide-ranging distribution in coastal waters. In addition, over time, 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 Southern Residents, 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 54 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 Southern Residents, the totals (~2000, mostly juveniles) represent insignificant totals compared to the amount of salmon that are in expected to be available to Southern Residents 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 Southern Residents are not present in the CCE.

As a result of this analysis, we conclude that the risks of adverse effects to Southern Residents via the reduction of prey caused by incidental salmon capture are insignificant based on the undetectable reduction of no more than a few hundred juvenile and sub-adult salmon from the total number of salmon in the range of Southern Residents that may have been available prey for them at some point immediately or in the future.

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. As described above, critical habitat has been proposed for coastal areas that do overlap with SWFSC research activities in the CCE. As a result, potential effects to this proposed critical habitat are considered in this biological opinion in section 2.12.6.

Mexico DPS and Central America DPS humpback whales and CCE forage fish

Humpback whales have a diverse diet that slightly varies across feeding aggregation areas. The species is known to feed on both small schooling fish and on euphausiids (krill). Known prey organisms include species representing Clupea (herring), Scomber (mackerel), Ammodytes (sand lance), Sardinops (sardine), Engraulis (anchovy), Mallotus (capelin), and krills such as Euphausia, Thysanoessa, and Meganyctiphanes (Baker 1985; Geraci et al. 1989; Clapham et al. 1997). Humpback whales also exhibit flexible feeding strategies, sometimes foraging alone and sometimes cooperatively (Clapham 1993). Unlike most baleen whales, which forage primarily on euphausiids (krill), humpbacks will shift trophic levels, depending on the oceanographic conditions and these shifts are between krill and small schooling fish (primarily anchovies and sardines). Scientists estimate that large baleen whales consume around 3-4 percent of their body weight per day. Since a large humpback whale may weigh ~40 tons, during a normal day in the summer feeding season, one whale may consume between 1-1.5 tons of food per day (Clapham and Baxter 2013). Given that humpback whales generally feed off the U.S. West Coast from April through November (~8 months), one humpback whale can eat up to 240 tons of food (including euphausiids and small schooling fish) during the foraging season.

Along the U.S. West Coast, Calambokidis et al. (2015) identified seven Biologically Important Areas (BIAs) for feeding humpback whales, among other marine mammal species. While the BIAs represent only 3 percent of waters within the U.S. EEZ, they encompass nearly 90 percent of the sightings from small boat surveys, ship surveys, and opportunistic sources. Six of the BIAs are located off Oregon and Washington, including: (1) Stonewall and Heceta Bank (May-November); (2) Point St. George (July-November); (3) Fort Bragg to Point Arena (July-November); (4) Gulf of the Farallones-Monterey Bay (July-November); (5) Morro Bay to Point Sal (April-November); and (6) Santa Barbara Channel-San Miguel Island (March-September). The majority of the humpback whale BIAs are located in waters shallower than 400 meters, while SWFSC research occurs throughout the EEZ including waters much deeper than 400 meters.

Fleming et al. (2016) collected skin samples during 1993-2012 from humpback whales throughout the California Current (between 34°N and 42°N), and used stable isotope analysis to evaluate the relative contribution of euphausiids versus fish to the diet. In this study, shifts in stable isotope signatures over the 20-year time shifts corresponded to shifts in relative prey abundance (krill versus anchovy and sardine) and changing oceanographic conditions within the California Current. Fleming et al. (2016) demonstrated that krill dominated humpback whale diet during positive phases of the North Pacific Gyre Oscillation (NPGO), with cool sea surface temperature, strong upwelling, and high krill biomass. Conversely, schooling fish dominated humpback whale diet during years characterized by negative NPGO shifts, delayed seasonal upwelling, and warmer temperatures. These results suggest that the dominant prey in humpback whale diet switched from krill to fish, and back to krill during the 20-year period, depending on the relative abundance of each prey.

As described above in section 2.5.1.4, SWFSC is expected to remove ~10 mt or less of fish/prey biomass from the CCE during trawl surveys each year, including important prey for humpback whales such as sardines, anchovies, and krill, based on recent historical efforts. SWFSC may also remove another 5-10 mt of potential humpback whale forage (mostly CPS such as sardine and anchovy), at most, as a result of purse seine surveys each year. Assuming each whale is consuming between 1 and 1.5 tons of fish per day, a typical whale would need at least 210 tons of food during the season and assuming it is feeding daily during the 7 months off the coast of Washington (May-November). Given that there may be ~5000 humpback whales off the U.S. West Coast (Calambokidis and Barlow 2020), that may equate to a foraging need of ~1 million mt for a given feeding season. Ultimately, the potential removal of prey by SWFSC may represent far less than 0.002% of the minimum prey needs of the humpback whale population, and less than 10% of any individual humpback whales needs, for the entire season. As described earlier, prey removals for humpback whales are not concentrated in one particular area at one time, but are more generally spread out across the CCE in small increments throughout the course of a year or feeding season in the CCE for humpback whales. We know that humpback whales are plastic feeders, capable of switching prey among schooling fish or euphausiids, as available. In addition, the CA/OR/WA stock of humpback whales are increasing at a rate of ~6-7 percent per year, indicating that they are not currently compromised by a lack of prey availability, despite previous removals of prey by SWFSC research activities at similar or even higher levels previously than what we will expect. As a result, we conclude SWFSC prey removals will have insignificant effects on both the Central America and Mexico humpback whale DPSs.

2.12.1.6 Conclusion for Marine Mammals

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

2.12.2. 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. Simiarly, in 2019 another dead hawksbill stranding was also reported in the San Diego area (NMFS stranding data). Hawksbills are more commonly found in nearshore waters the ETP, but not in the offshore areas of the CCE where SWFSC surveys that use fish sampling gears such as trawls and longlines in the CCE are expected to occur.

Considering the relatively low population numbers that exist and that lack of any research effort in nearshore waters of the ETP, 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 2.5.1 are discountable for hawksbill sea turtles as well.

2.12.3. Marine Fish

For reasons discussed in section 2.5.1, 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 (Southern DPS of green sturgeon, Gulf grouper, giant manta ray, East Pacific DPS of scalloped hammerhead shark, and oceanic whitetip shark) here in this section.

2.12.3.1 Southern DPS of 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, hook and line, and buoy gear surveys also largely target fish in the water column, mostly are conducted in waters south of central California, and likely do not overlap at all with green sturgeon in coastal waters. Consequently, it is unlikely that green sturgeon would encounter or be captured or entangled in SWFSC survey gear. As a result, we conclude that the risk of adverse effects to Southern DPS green sturgeon via any of the potential stresses considered in section 2.5.1 and including incidental capture or entanglement, are discountable.

2.12.3.2 Gulf Grouper

Gulf grouper live in shallow, coastal areas during their first 2 years of life, before moving on to rocky reefs and kelp beds in the Gulf of California and the eastern Pacific Ocean (Aburto-Oropeza et al. 2008; Dennis 2015). Gulf grouper used to be very common in the eastern Pacific Ocean, however their abundance has severely declined since the mid-20th century, primarily due to direct harvest by commercial and artisanal (i.e., small-scale, traditional) fisheries, and are now considered rare in U.S. waters (Aburto-Oropeza et al. 2008; Dennis 2015). The biggest threat to the species is direct harvest, particularly at spawning aggregation sites in the Gulf of California (Dennis 2015). On July 15, 2013, NMFS received a petition to list 81 marine species or populations under the ESA, including gulf grouper. A final rule updating the gulf grouper status to endangered, was published on October 20, 2016 (81 FR 72545).

Outside of a known population in Bahia Magdalena, Mexico, there is no published evidence of gulf grouper along the Pacific coast of the Baja California peninsula, and current gulf grouper distribution appears to be much more limited than their historical range (Dennis 2015). To date, no Gulf grouper have been incidentally captured or entangled during SWFSC research surveys, and no proposed research activities are slated to occur in the ETP, including specifically within the Gulf of California. Consequently, it is unlikely that Gulf grouper would encounter or be captured or entangled in SWFSC survey gear. As a result, we conclude that the risk of adverse effects to Gulf grouper via any of the potential stresses considered in section 2.5.1 and including incidental capture or entanglement, are discountable.

2.12.3.3 Giant Manta Ray

The giant manta ray, is found worldwide in tropical, subtropical, and temperate waters, commonly found offshore and near productive coastlines (NMFS 2017d). The giant manta ray is considered to be a migratory species; yet, despite their large range, the species is infrequently encountered with the exception of a few areas noted for manta ray aggregations (NMFS 2017d). In the Eastern Pacific ocean, giant manta rays are generally found in higher abundance throughout the ETP, with limited presence in CCE waters (NMFS 2017d). Historically, giant manta rays were occasionally observed as bycatch in the California drift gillnet fishery targeting swordfish and threshers, but in low numbers and only during El Niño events (Larese and Coan 2008). Since 2010, no bycatch of giant manta rays in this fishery has been reported (NMFS 2017d). The main threat to the giant manta ray is commercial fishing as the species is both targeted and caught as bycatch in a number of global fisheries throughout its range (NMFS 2017d). Manta rays are particularly valued for their gill rakers and increasing demand for manta ray products is accompanied by observed declines of up to 95% in sightings and landings of the species (NMFS 2017d). NMFS announced a final rule to list the giant manta ray as threatened on January 22, 2018 (83 FR 2916).

Given the type of research activities and gear types that have been proposed for use by the SWFSC, the limited occurrence of giant manta rays in the CCE, and the lack of any historical interactions between SWFSC research and giant manta rays, we conclude it is unlikely that giant manta rays would encounter or be captured or entangled in SWFSC survey gear. As a result, we conclude that the risk of adverse effects to giant manta ray via any of the potential stresses considered in section 2.5.1 and including incidental capture or entanglement, are discountable.

2.12.3.4 Eastern Pacific DPS Scalloped Hammerhead Shark

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). 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). 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 (Miller et al. 2014). The 2014 Status Review Report (Miller et al. 2014) identified 6 DPSs of scalloped hammerhead populations, and ultimately four were listed under the ESA in 2014, 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 (79 FR 38213). In 2020, NMFS affirmed there would be no change in the endangered listing of the Eastern Pacific DPS of scalloped hammerhead sharks (NMFS 2020).

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. In the last biological opinion on SWFSC research activities (NMFS 2015a), we determined that the incidental capture or entanglement of Eastern Pacific DPS scalloped hammerhead sharks during longline research survey efforts in the CCE was not likely to occur, but that the risks of encounters and subsequent hooking or entanglement was expected to be higher in the ETP. In order to be conservative and for the sake of rounding small numbers, in 2015 we expected that up to one scalloped hammerhead may be incidentally captured or entangled during any year when HMS longline surveys occur in the ETP.

SWFSC has not proposed to conduct any research activities in the ETP as part of this proposed action. Given that no scalloped hammerhead sharks have been incidentally captured or entangled during SWFSC research surveys in the CCE, and no proposed research activities are slated to occur in the ETP, we again determine it is unlikely that Eastern Pacific DPS scalloped hammerhead sharks would encounter or be captured or entangled in SWFSC survey gear in the CCE. As a result, we conclude that the risk of adverse effects to Eastern Pacific DPS scalloped hammerhead sharks via any of the potential stresses considered in section 2.5.1 and including incidental capture or entanglement, are discountable.

2.12.3.5 Oceanic Whitetip Shark

The oceanic whitetip shark is a circumglobal species of shark, found in tropical and subtropical seas worldwide. While the range of the oceanic whitetip in the Eastern Pacific is noted as extending as far north as southern California waters, based on the available data, the distribution of the species appears to be concentrated in areas farther south, and in more tropical waters (Young et al. 2018). There are limited data on global population size of the oceanic whitetip shark; however, available data suggests that the species has experienced a potentially significant decline due to fishing pressure. Bycatch in commercial fisheries, combined with the rise in demand for shark fins, is threatening oceanic whitetip sharks (Young et al. 2018). In 2018, NMFS announced a final rule to list the global population of oceanic whitetip sharks as threatened under the ESA (83 FR 4153).

To date, SWFSC has not recorded or reported any catch of oceanic whitetip sharks in research surveys conducted in the CCE. Similar to scalloped hammerhead sharks, research activities that may have previously occurred in the ETP would seem to be more at risk for interactions with oceanic whitetip sharks than research in the CCE based on what is known about the likely distribution and occurrence of this species in more tropical waters. Given the type of research activities and gear types that have been proposed for use by the SWFSC, the limited occurrence of oceanic whitetip sharks in the CCE, and the lack of any historical interactions between SWFSC research and oceanic whitetip sharks, we conclude it is unlikely that oceanic whitetip sharks would encounter or be captured or entangled in SWFSC survey gear. As a result, we conclude that the risk of adverse effects to oceanic whitetip sharks via any of the potential stresses considered in section 2.5.1 and including incidental capture or entanglement, are discountable.

2.12.4. Invertebrates (white abalone and black abalone).

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 2.5.1 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.

2.12.5. 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.

2.12.5.1 Steller Sea Lion Critical Habitat

On November 4, 2013, NMFS 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.

2.12.5.2 Southern DPS Green Sturgeon Critical Habitat

Critical habitat has been designated for the Southern DPS of green sturgeon (74 FR 52300). 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 (SPEA; Appendix B *in* PEA). 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).

Tables 44-46 describes available information on recent and historical catches of 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.

2.12.5.3 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. 2007) 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 (SPEA; Appendix B *in* DEA).

Table 44 describes the historical 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 SPEA does provide any upated assessment of recent catches of jellyfish during the last 5 year of research, and although total biomass of catches that may represent removals of potential prey for ESA-listed species appear to be decreasing in recent years, we assume that recent jellyfish catches could still be similar to what was documented previously. Historically, the average annual catch of *Chrysaora* in the course of all SWFSC research surveys was about 18,473 kg, and the estimated total average annual catch of *Aurelia* was 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 PEA).

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 potential 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 tows 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.

2.12.6. Effects to Proposed Critical Habitat

Currently, there are two proposed designations for critical habitat under public review and consideration for finalization by NMFS that include marine waters of the CCE that may be affected by SWFSC research activities. Although consultation on proposed critical habitats may not be required under the ESA for proposed actions that are not expected to adversely affect any critical habitats as proposed, WCR and SWFSC agreed to proceed with a conference consultation on these two proposed critical habitats as a conservative measure to ensure a thorough consideration of the potential impacts of SWFSC research activities over the next 5 years should critical habitat ultimately be designated for these species in marine waters where SWFSC research occurs.

2.12.6.1 Southern Resident Killer Whale

On September 19, 2019, NMFS proposed to revise the critical habitat designation for Southern Residents to include six new areas in marine waters along the U.S. West Coast (84 FR 49214). Specific new areas proposed along the U.S. West Coast include 15,627 mi^2 of marine waters between the 6.1-meter (m) depth contour and the 200-m depth contour from the U.S. international border with Canada south to Point Sur, California (Figure 18). In the proposed rule (84 FR 49214), NMFS states that the "proposed areas are occupied and contain physical or biological features that are essential to the conservation of the species and that may require special management considerations or protection." The three physical or biological features essential to conservation in the 2006 designated critical habitat were also identified for the six new areas along the U.S. West Coast, including "prey species of sufficient quantity, quality and availability to support individual growth, reproduction and development, as well as overall population growth."

The proposed action has the potential to affect passage conditions and the quantity and availability of prey in the proposed critical habitat, as a result of the incidental bycatch of salmon during SWFSC research activities. Although the proposed critical habitat remains at risk from serious spills because of the heavy volume of shipping traffic and proximity to petroleum refining centers, we do not expect SWFSC to impact water quality because research vessels do not carry large amounts of oil, making the risk from spills minor. Therefore, we do not anticipate adverse effects to water quality. For reasons described above, if there are interactions between SWFSC research activities and Southern Residents in proposed critical habitat, any disturbance is expected to be temporary at most. Therefore, it is unlikely that any small transitory disturbance that might occur would have more than a very minor effect on passage in the proposed critical habitat.

Effects of the proposed fishing reduce prey quantity and availability in proposed critical habitat resulting from the harvest of adult salmon. As described previously, studies have correlated Chinook salmon abundance indices (i.e. quantity) with Southern Resident killer whale population growth rates, but that relationship has weakened with the inclusion of more recent years of Southern Resident and Chinook abundance data (NMFS 2020b). As described in

section 2.12.1.5, we concluded that the risks of adverse effects to Southern Residents via the reduction of prey caused by the incidental salmon capture are insignificant. Similarly, without any additional potential effects to proposed critical habitat from SWFSC identified in this analysis, we conclude that the quantity and availability of prey in the proposed critical habitat for Southern Residents will not be adversely affected

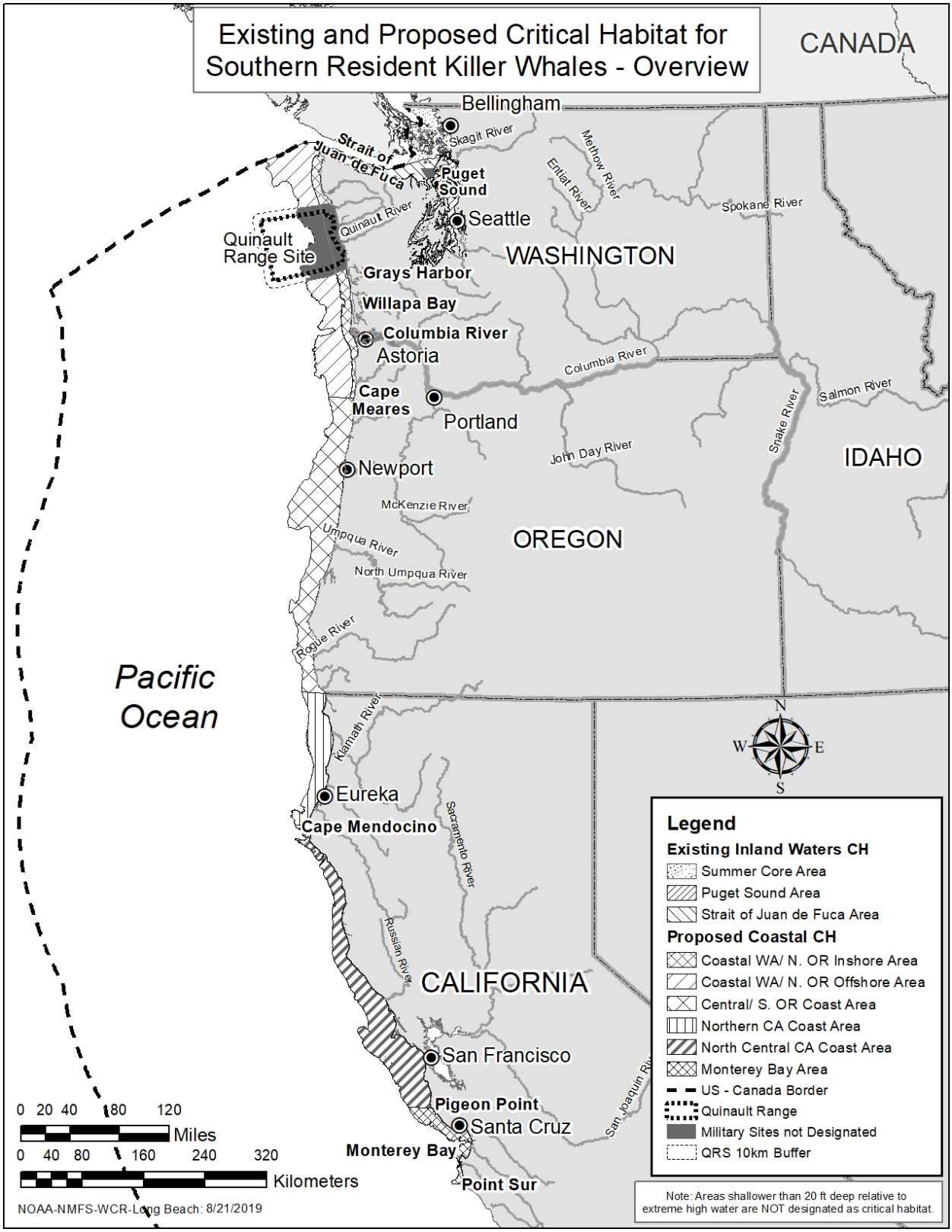

Figure 8. Map of proposed revision to designated critical habitat for Southern Residents (84 FR 49214).

2.12.6.2 Mexico DPS and Central America DPS Humpback Whales

In addition, on October 9, 2019, NMFS published a proposed rule to designate humpback whale critical habitat for the Mexico DPS and Central America DPSs (84 FR 54354). For both the Mexico DPS and Central America DPS humpback whales off the U.S. West Coast, NMFS proposed to designate 48,459 mi^2 of marine habitat off the coasts of Washington, Oregon, and California that extends from northern Washington/entrance to the Strait of Juan de Fuca south to/and including the Channel Islands Area. Specifically, this includes

(1) Washington. The nearshore boundary is defined by the 50-m isobath, and the offshore boundary is defined by the 1,200-m isobath relative to MLLW. Critical habitat also includes waters within the U.S. portion of the Strait of Juan de Fuca to an eastern boundary line at Angeles Point at 123°33′ W.

(2) Oregon. The nearshore boundary is defined by the 50-m isobath. The offshore boundary is defined by the 1,200-m isobath relative to MLLW; except, in areas off Oregon south of 42°10′, the offshore boundary is defined by the 2,000-m isobath.

(3) California. The nearshore boundary is defined by the 50-m isobath relative to MLLW except, from 38°40′ N to 36°00′ N, the nearshore boundary is defined by the 15-m isobath relative to MLLW; and from 36°00′ N to 34°30′ N, the nearshore boundary is defined by the 30-m isobath relative to MLLW. North of 40°20′ N, the offshore boundary of the critical habitat is defined by a line corresponding to the 2,000-m isobath, and from 40°20′ N to 38°40′ N, the offshore boundary is defined by the 3,000-m isobath. From 38°40′ N southward, the remaining areas have an offshore boundary defined by a line corresponding to the 3,700-m isobath.

Through the proposed critical habitat designation, NMFS has identified that "prey species, primarily euphausiids and small pelagic schooling fishes of sufficient quality, abundance, and accessibility within humpback whale feeding areas to support feeding and population growth" is an essential biological feature of the proposed critical habitat designation. As described in section 2.12.1.5 earlier, prey removals for humpback whales by SWFSC in the CCE are not concentrated in one particular area at one time, and are not limited or concentrated in areas within the confines of the proposed critical habitat designation. They are more generally spread out across the CCE in small increments throughout the course of a year or feeding season in the CCE for humpback whales. We know that humpback whales are plastic feeders, capable of switching prey among schooling fish or euphausiids, as available. Given that the CA/OR/WA stock of humpback whales are increasing at a rate of ~6-7 percent per year in these areas, and that Mexico and Central America DPSs constitute a large percentage of the whales on the U.S. West Coast (Wade 2017), we conclude that previous removals of prey by SWFSC research activities at similar or even higher levels previously than what we will expect have not diminished the quality of Mexico and Central America DPS humpback whale foraging habitat along the U.S. West Coast in the past. As a result, we conclude future SWFSC prey removals will have insignificant effects both the Central America and Mexico humpback whale DPSs.

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 and Antarctic, and the large pool of stakeholders and the general public that may have specific interests in conservation of any of the 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. The document will be available within two weeks at the NOAA Library Institutional Repository [https://repository.library.noaa.gov/welcome]. 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., and the MSA implementing regulations regarding EFH, 50 CFR 600.

Best Available Information: This consultation and supporting documents use the best available information, as referenced in the References section. The analyses in this 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

Abatzoglou, J.T., D.E. Rupp, and P.W. Mote. 2014. Seasonal climate variability and change in the Pacific Northwest of the United States. Journal of Climate. 27(5):2125-2142.

Adams, P. B., C. B. Grimes, S. T. Lindley, and M. L. Moser. 2002. Status review for North American green sturgeon, Acipenser medirostris. NOAA, National Marine Fisheries Service, Southwest Fisheries Science Center, Santa Cruz, CA. 50 p.

Aburto-Oropeza, O., B. Erisman, V. Valdez-Ornelas, and G. Danemann. 2008. Commercially important Serranid fishes from the Gulf of California: Ecology, Fisheries and Conservation. Ciencia y Conservacion. 2008(1):1-23.

AMIP (Adaptive Management and Implementation Plan). 2020. The FCRPS Adaptive Management and Implementation Plan (AMIP) ESU-Level Abundance and Trend Tracking Spreadsheet—updated January, 2020. J. Thompson pers comm. Feb. 6, 2020.

Arendt, M.D., J.A. Schwenter, B.E. Witherington, A.B. Meylan, and V.S. Saba. 2013. Historical versus contemporary climate forcing on the annual variability of loggerhead sea turtles in the Northwest Atlantic Ocean. 2013. PLOS ONE. DOI:10.1371/journal.pone.0081097.

Baker, C.S. 1985. The population structure and social organization of humpback whales (Megaptera novaeangliae) in the Central and Eastern North Pacific. University of Hawaii.

Barlow, J., and G.A. Cameron. 2003. Field experiments show that acoustic pingers reduce marine mammal bycatch in the California drift gill net fishery. Marine Mammal Science 19(2):265-283.

Barnhart, R.A. 1986. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Southwest), steelhead. United States Fish and Wildlife Service Biological Report 82 (11.60).

Bartol, S.M. and D. Ketten. 2003. Auditory brainstem responses of multiple species of sea turtles. In: Gisner, R., ed. Environmental consequences of underwater sound (ECOUS) abstracts, May 12-16, 2003. Office of Naval Research: Arlington, VA.

Beacham, T.D., D.E. Hay, and K.D. Le. 2005. Population structure and stock identification of eulachon (Thaleichthys pacificus), an anadromous smelt, in the Pacific Northwest. Marine Biotechnology. Volume 7, pages 363 to 372.

Beamer, E.M., R.E. McClure, and B.A. Hayman. 2000. Fiscal Year 1999 Skagit River Chinook Restoration Research. Skagit System Cooperative.

Behrenfeld, M.J., R.T. O'Malley, D.A. Siegel, C.R. McClain, J.L. Sarmiento, G.C. Feldman, A.J. Milligan, P.G. Falkowski, R.M. Letelier, and E.S. Boss. 2006. Climate-driven trends in contemporary ocean productivity. Nature 444: 752–755.

Bell, E., and W.G. Duffy. 2007. Previously undocumented two-year freshwater residency of juvenile coho salmon in Prairie Creek, California. Transactions of the American Fisheries Society 136: 966-970.

Bell, E., R. Dagit, and F. Ligon. 2011. Colonization and persistence of a Southern California steelhead (Oncorhynchus mykiss) population. Bull. Southern California Acad. Sci. 110: 1–16.

Benson, S.R., K.A. Forney, J.T. Harvey, J.V. Carretta, and P.H. Dutton. 2007. Abundance, distribution, and habitat of leatherback turtles (Dermochelys coriacea) off California, 1990-2003. Fishery Bulletin 105(3):337-347.

Benson, S.R., T. Eguchi, D.G. Foley, K.A. Forney, H. Bailey, C. Hitipeuw, B.P. Samber, R.F. Tapilatu, V. Rei, P. Ramohia, J. Pita, and P.H. Dutton. 2011. Large-scale movements and high use areas of western Pacific leatherback turtles, Dermochelys coriacea. Ecosphere 27. Article 84.

Benson, S.R. K.A. Forney, E. LaCasella, J.T. Harvey, and J.V. Carretta. 2018. A long-term decline in the abundance of leatherback turtles, Dermochelys coriacea, at a foraging ground off California, USA. Presentation at the 38th Annual Symposium on Sea Turtle Biology & Conservation. 18-23 February 2018 in Kobe, Hyogo, Japan.

Beverly, S. and L. Chapman. 2007. Interactions between sea turtles and pelagic longline fisheries. Western and Central Pacific Fisheries Commission, Scientific Committee Third Regular Session, August 13-24 2007, WCPFC-SC3-EB SWG/IP-01. 76.

Bickham, J.W, J.C. Patton, and T.R. Loughlin. 1996. High variability for control-region sequences in a marine mammal: Implications for conservation and biogeography of Steller Sea Lions (Eumetopias jubatus). J. Mammalogy 77:95-108.

Bigg, M.A., P.F. Olesiuk, G.M. Ellis, J.K.B. Ford, and K.C. Balcomb III. 1990. Social organization and genealogy of resident killer whales (Orcinus orca) in the coastal waters of British Columbia and Washington State. Report of the International Whaling Commission, Special Issue 12:383-405.

Bjorndal, K.A., K.J.Riech, and A.B. Bolten. 2010. Effect of repeated tissue sampling on growth rates of juvenile loggerhead turtles Caretta caretta. Diseases of Aquatic Organisms 88: 271-273.

Boughton, D.A., H. Fish, K. Pipal, J. Goin, F. Watson, J. Hager, J. Casagrande, and M. Stoecker. 2005. Contraction of the southern range limit for anadromous Oncorhynchus mykiss. NOAA Fisheries Technical Memorandum SWFSC 380.

Boughton, D.A., P.B. Adams, E. Anderson, C. Fusaro, E. Keller, E. Kelley, L. Lentsch, J. Nielsen, K. Perry, H. Regan, J. Smith, C. Swift, L. Thompson, and F. Watson. 2006. Steelhead of

the South-Central/Southern California Coast: Population Characterization for Recovery Planning. NOAA Fisheries Technical Memorandum NOAA-TM-NMFS-SWFSC-394.

Bowen, B.W., F.A. Abreu-Grobois, G.H. Balazs, N. Kamezaki, C.J. Limpus, and R.J. Ferl. 1995. Trans-Pacific migrations of the loggerhead turtles (Caretta caretta) demonstrated with mitochondrial DNA markers. Proceedings of the National Academy of Sciences of the United States of America 92:3731-3734.

Bowlby, C.E. 1994. Observations of leatherback turtles offshore of Washington and Oregon. Northwestern Naturalist 75:33–35.

Broadhurst, M.K, P. Suuronen, and A. Hulme. 2006. Estimating collateral mortality from towed fishing gear. Fish and Fisheries 7: 180–218.

Burdin, A.M., D. Weller, O. Sychenko, and A.L. Bradford. 2012. "Western Gray Whales off Sakhalin Island, Russia: A Catalog of Photo-Identified Individuals". 205 individuals. Period 1994-2011.

Busby, P.J., T.C. Wainwright, G.J. Bryant, L. Lierheimer, R.S. Waples, F.W. Waknitz and I.V. Lagomarsino. 1996. Status review of west coast steelhead from Washington, Idaho, Oregon, and California. United States Department of Commerce, National Oceanic and Atmospheric Administration Technical Memorandum NMFS-NWFSC-27. 261 pages.

California Climate Change Center. 2006. Our changing climate: Assessing the risks to California. Sacramento, California.

Calambokidis, J., and J. Barlow. Update on blue and humpback whale abundances off the U.S. West Coast using data through 2018. Draft Administrative Report, Southwest Fisheries Science Center. July, 2020.

Calambokidis, J, G.H. Steiger, C. Curtice, J. Harrison, M.C. Ferguson, E. Becker, M. DeAngelis, and S.M. Van Parijs. 2015. Biologically Important Areas for selected cetaceans within U.S. waters – West Coast region. Aquatic Mammals 41:39-53.

Carretta, J.V. and J. Barlow. 2011. Long-term effectiveness, failure rates, and "dinner bell" properties of acoustic pingers in a gillnet fishery. Marine Technology Society Journal 45(5):7-19.

Carretta, J.V., K.A. Forney, E.M. Oleson, D.W. Weller, A.R. Lang, J. Baker, M.M. Muto, B. Hanson, A.J. Orr, H. Huber, M.S. Lowry, J. Barlow, J.E. Moore, D. Lynch, L. Carswell, and R.L. Brownell Jr. 2019a. U.S. Pacific Marine Mammal Stock Assessments: 2018. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-617.

Carretta, J.V., K.A. Forney, E.M. Oleson, D.W. Weller, A.R. Lang, J. Baker, M.M. Muto, B. Hanson, A.J. Orr, H. Huber, M.S. Lowry, J. Barlow, J.E. Moore, D. Lynch, L. Carswell, and R.L. Brownell Jr. 2019b. Draft Pacific Marine Mammal Stock Assessments: 2019. U.S.

Department of Commerce, NOAA Technical Memorandum published for public review in November, 2019.

Carretta, J.V., J.E. Moore, and K.A. Forney. 2019c. Regression tree and ratio estimates of marine mammal, sea turtle, and seabird bycatch in the California drift gillnet fishery: 1990-2017. NOAA Technical Memorandum, NOAA-TM-NMFS-SWFSC-619.

Casale, P. and Y. Matsuzawa. 2015. Caretta caretta (North Pacific subpopulation). The IUCN Red List of Threatened Species 2015: e.T83652278A83652322.

Casalea, P., D. Freggib, V. Paduanoa, and M. Oliverioa. 2016. Biases and best approaches for assessing debris ingestion in sea turtles, with a case study in the Mediterranean. Marine Pollution Bulletin 110:238-249.

California Department of Fish and Game. 1965. California Fish and Wildlife Plan.

CASWRB. 2010. Policy on the Use of Coastal and Estuarine Waters for Power Plant Cooling. California State Water Resources Control Board. Effective on October 1, 2010.

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

CDFW. 2018. California Central Valley Chinook Population Database Report - GrandTab 2018.04.09. Available at: GrandTab 2018.04.09

Chan, E.H. and H.C. Liew. 1995. Incubation temperatures and sex ratios in the Malaysian leatherback turtle Dermochelys coriacea. Biological Conservation 74:169-174.

Chan, H.L. and M. Pan. 2012. Spillover effects of environmental regulation for sea turtle protection: the case of the Hawaii shallow-set longline fishery. U.S. Dep. Of Comm., NOAA Tech. Memo. NMFS PIFSC-30. 38 p. + Appendices.

Chan, S.K., J. Cheng, T. Zhou, H.J. Wang, H.X. Gu, and X.J. Song. 2007. A comprehensive overview of the population and conservation status of sea turtles in China. Chelonian Conservation and Biology 6(2):185-198.

Chasco, B.E., I.C. Kaplan, A.C. Thomas. 2017. Competing tradeoffs between increasing marine mammal predation and fisheries harvest of Chinook salmon. Sci Rep 7:15439.

Chittenden, C.M, R.J. Beamish, and R.S. McKinley. 2009. A critical review of Pacific salmon marine research relating to climate. ICES Journal of Marine Science 66:2195-2204.

Cholewiak, D., A.I. DeAngelis, D. Palka, P.J. Corkeron, and S.M. Van Parijs. 2017. Beaked whales demonstrate a marked acoustic response to the use of shipboard echosounders. R. Soc. open sci.4170940 http://doi.org/10.1098/rsos.170940.

CHSRG (California Hatchery Scientific Review Group). 2012. California Hatchery Review Report – Appendix VIII: Coleman National Fish Hatchery Steelhead Program Report. Prepared for the US Fish and Wildlife Service and Pacific States Marine Fisheries Commission. June 2012. Available at: California Hatchery Review Project Appendix VIII - Coleman NFH steelhead program report

Clapham, P.J. 1993. Social and reproductive biology of North Atlantic humpback whales (Megaptera novaeangliae). University of Aberdeen, Scotland.

Clapham, P.J., S. Leatherwood, I. Szczepaniak, and R.L. Brownell Jr. 1997. Catches of humpback and other whales from shore stations at Moss Landing and Trinidad, California, 1919-1926. Marine Mammal Science 13:368-394.

Clapham, P.J., C. Good, S.E. Quinn, R.R. Reeves, J.E. Scarff, and R.L. Brownell. 2004. Distribution of North Pacific right whales (Eubalaena japonica) as shown by 19th and 20th century whaling catch and sighting records. Journal of Cetacean Research and Management. 6(1):1-6.

Clapham, P.J., K.E. W. Shelden, and P.R. Wade. 2006. Review of Information Relating to Possible Critical Habitat for Eastern North Pacific Whales. Alaska Fisheries Science Center, National Marine Fisheries Service, Seattle, WA.

Clapham, P. and C. Baxter. 2013. Winged Leviathan. The Story of the Humpback Whale. Published by Colin Baxter Photography Ltd., Grantown-on-Spey, Moray, Scotland.

Clark, C.W., W.T. Ellison, B.L. Southall, L. Hatch, S.M. Van Parijs, A. Frankel, and D. Ponirakis. 2009. Acoustic masking in marine ecosystems: intuitions, analysis, and implication. Marine Ecology Progress Series 395:201–222.

Clifton, K., D. Cornejo, and R. Felger. 1982. Sea turtles of the Pacific coast of Mexico. Pp: 199-209 In: K. Bjorndal (Ed.), Biology and Conservation of sea turtles. Smithsonian Inst. Press: Washington, D.C.

Compagno, L.J.V. 1984. Sharks of the World. An annotated and illustrated catalogue of shark species known to date. Vol. 4, Part 2 (Carcharhiniformes). FAO Fisheries Synopsis No. 125, Vol. 4, Part 2: 251-655.

Conant, T.A., P.H. Dutton, T. Eguchi, S.P. Epperly, C.C. Fahy, M.H. Godfrey, S.L. MacPherson, E.E. Possardt, B.A. Schroeder, J.A. Seminoff, M.L. Snover, C.M. Upite, and B.E. Witherington. 2009. Loggerhead sea turtle (Caretta caretta) 2009 status review under the U.S. Endangered Species Act. Report of the Loggerhead Biological Review Team to the National Marine Fisheries Service, August 2009. 222 pages.

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2011a. COSEWIC assessment and status report on the Eulachon, Cass/Skeena Rivers population, Central Pacific Coast population and the Fraser River population Thaleichthys pacificus in Canada. Committee

on the Status of Endangered Wildlife in Canada. Ottawa. xv + 88 pp. Available at: http://www.registrelep-sararegistry.gc.ca/default.asp?lang=En&n=C2D0CBF6-1

Cox, P., and D. Stephenson. 2007. A Changing Climate for Prediction. Science 317(5835):207-8.

Cox, T.M., T.J. Ragen, A.J. Read, E. Vos, R.W. Baird, K. Balcomb, J. Barlow, J. Caldwell, T. Cranford, L. Crum, A. D'Amico, G. D'Spain, A. Fernández, J. Finneran, R. Gentry, W. Gerth, F. Gulland, J. Hildebrand, D. Houser, T. Hullar, P.D. Jepson, D. Ketten, C.D. MacLeod, P. Miller, S. Moore, D. Mountain, D. Palka, P. Ponganis, S. Rommel, T. Rowles, B. Taylor, P. Tyack, D. Wartzok, R. Gisiner, J. Mead, L. Benner. 2006. Understanding the impacts of anthropogenic sound on beaked whales. Journal of Cetacean Research Management 7(3):177-187.

Crozier, L.G., A.P. Hendry, P.W. Lawson, T.. Quinn, N.J. Mantua, J. Battin, R.G. Shaw, and R.B. Huey. 2008. Potential responses to climate change in organisms with complex life histories: evolution and plasticity in Pacific salmon. Evolutionary Applications. 1(2):252-270.

Crozier, L.G., M.D. Scheuerell, and E.W. Zabel. 2011. Using Time Series Analysis to Characterize Evolutionary and Plastic Responses to Environmental Change: A Case Study of a Shift Toward Earlier Migration Date in Sockeye Salmon. The American Naturalist. 178(6):755-773.

Cózar, A., F. Echevarría, J.I. González-Gordillo, X. Irigoien, B. Úbeda, S. Hernández-León, Á.T. Palma, S. Navarro, J. García-de-Lomas, A. Ruiz, M.L. Fernández-de-Puelles, and C.M. Duarte. 2014. Plastic debris in the open ocean. PNAS 111:10239-10244.

Curtis, K.A., J.E. Moore, S.R. Benson. 2015. Estimating limit reference points for western Pacific leatherback turtles (Dermochelys coriacea) in the U.S. west coast EEZ. PLoS ONE 10(9):e0136452. Doi:10.1371/jornal.pone.0136452.

Davis, M.W. 2002. Key principles for understanding fish bycatch discard mortality. Can. J. Fish. Aquatic Sci. 59:1834-1843.

Delgado S.G., and W.J. Nichols. 2005. Saving sea turtles from the ground up: awakening sea turtle conservation in northwestern Mexico. Maritime Studies 4:89-104.

Deng Z.D., B.L Southall, T.J. Carlson, J. Xu, and J.J. Martinez. 2014. 200 kHz Commercial Sonar Systems Generate Lower Frequency Side Lobes Audible to Some Marine Mammals. PLoS ONE 9(4): e95315. doi:10.1371/journal.pone.0095315

Dennis, M. 2015. Status Review of the Gulf Grouper (Mycteroperca jordani). NOAA Fisheries, West Coast Region. May, 2015. 73 p.

Denton, K. 2018. Estimating the 2017 Sockeye Salmon Escapement into Lake Ozette Using an ARIS multi-beam SONAR. K. Denton and Associates, LLC. Sequim, WA. 28 pp.

Department of Commerce. 2016. Addendum to the Bienniel Report to Congress Pursuant to Section 403(a) of the Magnuson-Stevens Fishery Conservation and Management Reauthorization Act of 2006.

Diffenbaugh, N.S., D.L. Swain, and D. Touma. 2015. Anthropogenic warming has increased drought risk in California, Proc. Natl. Acad. Sci. U.S.A., 112, 3931– 3936, doi:10.1073/pnas.1422385112.

Dodd, C.K., Jr. 1988. Synopsis of the biological data on the loggerhead sea turtle Caretta caretta (Linnaeus 1758). U.S. Fish and Wildlife Service, Biological Report 88(14). 110 pages.

Dominguez, F., E. Rivera, D.P. Lettenmaier, and C.L. Castro. 2012. Changes in Winter Precipitation Extremes for the Western United States under a Warmer Climate as Simulated by Regional Climate Models. Geophysical Research Letters. 39(5). DOI:10.1029/2011GL050762.

Dommasnes, A., and I. Røttingen. 1985. Acoustic stock measurements of the Barents Sea capelin 1972.1984. A review. In The Proceedings of the Soviet.Norwegian Symposium on the Barents Sea Capelin. Edited by H. Gjøsæter. Institute of Marine Research, Bergen, Norway. page 45.108.

Doney, S.C., M. Ruckelshaus, J.E. Duffy, J.P. Barry, F. Chan, C.A. English, H.M. Galindo, J.M. Grebmeier, A.B. Hollowed, N. Knowlton, J. Polovina, N.N. Rabalais, W.J. Sydeman, and L.D. Talley. 2012. Climate Change Impacts on Marine Ecosystems. Annual Review of Marine Science. 4:11-37.

Dow Piniak, W.E., S.A. Eckert, C.A. Harms, and E.M. Stringer. 2012. Underwater hearing sensitivity of the leatherback sea turtle (Dermochelys coriacea): Assessing the potential effect of anthropogenic noise. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Headquarters, Herndon, VA. OCS Study BOEM 2012-01156. 35pp.

Duarte, C.M. 2002. The future of seagrass meadows. Environmental Conservation 29(2):192-206.

Dumbauld, B.R., D.L. Holden, and O.P. Langness. 2008. Do sturgeon limit burrowing shrimp populations in Pacific Northwest estuaries? Environmental Biology of Fishes 83:283-296.

Dutton, P. 2003. Molecular ecology of Chelonia mydas in the eastern Pacific Ocean. In: Proceedings of the 22nd Annual Symposium on Sea Turtle Biology and Conservation, April 4-7, 2002, Miami, Florida.

Dutton, P.H., C. Hitpuew, M. Zein, S.R. Benson, G. Petro, J. Pita, V. Rei, L. Ambio, and J. Bakarbessy. 2007. Status and Genetic Structure of Nesting Populations of Leatherback Turtles (Dermochelys coriacea) in the Western Pacific. Chelonian Conservation and Biology 6:47-53.

Eckert, S.A. 1999. Habitats and migratory pathways of the Pacific leatherback sea turtle. Hubbs Sea World Research Institute Technical Report 99-290.

Eckert, S.A. and L.M. Sarti. 1997. Distant fisheries implicated in the loss of the world's largest leatherback nesting population. Marine Turtle Newsletter 78:2-7.

Eckert, K.L., B.P. Wallace, J.G. Frazier, S.A. Eckert, and P.C.H. Pritchard. 2012. Synopsis of the biological data on the leatherback sea turtle (Dermochelys coriacea). Biological Technical Publication BTP-R40 J 5-2012.

Eguchi, T., T. Gerrodette, R.L. Pitman, J.A. Seminoff, and P.H. Dutton. 2007. At-sea density and abundance estimates of the olive ridley turtle Lepidochelys olivacea in the eastern tropical Pacific. Endangered Species Research 3:191-203.

Eguchi, T., J.A. Seminoff, R.A. LeRoux, P.H. Dutton, D.L. Dutton. 2010. Abundance and survival rates of green turtles in an urban environment: coexistence of humans and an endangered species. Marine Biology 157:1869-1877.

Eguchi, T., S. McClatchie, C. Wilson, S.R. Benson, R.A. LeRoux, and J.A. Seminoff. 2018. Loggerhead turtles (Caretta caretta) in the California Current: abundance, distribution, and anomalous warming of the North Pacific. Front. Mar. Sci. 5:452.

Emmons, C.K., M.B. Hanson, and M.O. Lammers. 2019. Monitoring the occurrence of Southern resident killer whales, other marine mammals, and anthropogenic sound in the Pacific Northwest. Prepared for: U.S. Navy, U.S. Pacific Fleet, Pearl Harbor, HI. Prepared by: National Oceanic and Atmospheric Administration, Northwest Fisheries Science Center under MIPR N00070-17-MP-4C419. 25 February 2019. 23p.

Feely, R.A., C.L. Sabine, K. Lee, W. Berelson, J. Kleypas, V.J. Fabry, F.J. Millero. 2004. Impact of Anthropogenic CO2 on the CaCO3 System in the Oceans. Science 305:362–366.

Feely, R.A., T. Klinger, J.A. Newton, and M. Chadsey (editors). 2012. Scientific summary of ocean acidification in Washington state marine waters. NOAA Office of Oceanic and Atmospheric Research Special Report.

Finneran, J.J. 2016. Auditory Weighting Functions and TTS/PTS Exposure Functions for Marine Mammals Exposed to Underwater Noise, Technical Report 3026, December 2016. San Diego: Systems Center Pacific.

Finneran, J.J., C.E. Schlundt, R. Dear, D.A. Carder, & S.H. Ridgway. 2002. Temporary Shift in Masked Hearing Thresholds in Odontocetes After Exposure to Single Underwater Impulses from a Seismic Watergun. Journal of the Acoustical Society of America 111:2929-2940.

Finneran, J.J., D.A. Carder, C.E. Schlundt, S.H. & Ridgway. 2005. Temporary threshold shift in bottlenose dolphins (Tursiops truncatus) exposed to mid-frequency tones. The Journal of the Acoustical Society of America 118(4):696-2705.

Finneran, J.J., and C.E. Schlundt. 2010. Frequency-dependent and longitudinal changes in noise-induced hearing loss in a bottlenose dolphin (Tursiops truncatus). Journal of the Acoustical Society of America 127:3267-3272.

Fleming, A.H., C.T. Clark, J. Calambokidis, and J. Barlow. 2016. Humpback whale diets respond to variance in ocean climate and ecosystem conditions in the California Current. Global Change Biology 22:1214-1224.

Ford, J.K.B., and G.M. Ellis. 2006. Selective foraging by fish--eating killer whales Orcinus orca in British Columbia. Mar. Ecol. Prog. Ser. 316:185–199.

Ford, J.K.B., G.M. Ellis, and K.C. Balcomb. 2000. Killer whales: the natural history and genealogy of Orcinus orca in British Columbia and Washington State. 2nd ed. UBC Press, Vancouver, British Columbia.

Fry, Jr., D.H. 1979. Anadromous fishes of California, California Department of Fish and Game, Sacramento. Online at http://cdm15024.contentdm.oclc.org/cdm4/item_viewer.php? CISOROOT=/ p178601ccp2&CISOPTR=103.

Gaos, A.R., F.A. Abreu-Grobois, J. Alfaro-Shigueto, D. Amorocho, R. Arauz, A. Baquero, R. Briseno, D. Chacon, C. Duenas, C. Hasbun, M. Liles, G. Mariona, C. Muccio, J.P. Munoz, W.J. Nichols, M. Pena, J.A. Seminoff, M. Vasquez, J. Urteaga, B. Wallace, I.L. Yanez, and P. Zarate. 2010. Signs of hope in the eastern Pacific: international collaboration reveals encouraging status for the severely depleted population of hawksbill turtles Eretmochelys imbricata. Oryx 44:595-601.

Geraci, J.R., D.M. Anderson, R.J. Timperi, D.J. St Aubin, G.A. Early, J.H. Prescott, and C.A. Mayo. 1989. Humpback whales (Megaptera novaeangliae) fatally poisoned by dinoflagellate toxin. Canadian Journal of Fisheries and Aquatic Sciences 46:1895-1898.

Glick, P., J. Clough, and B. Nunley. 2007. Sea-Level Rise and Coastal Habitats in the Pacific Northwest: An analysis for Puget Sound, southwestern Washington, and northwestern Oregon. National Wildlife Federation, Seattle, WA.

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

Goode, J.R., J.M. Buffington, D. Tonina D.J. Isaak, R.F. Thurow, S. Wenger, D. Nagel, C. Luce, D. Tetzlaff, and C. Soulsby. 2013. Potential effects of climate change on streambed scour and risks to salmonid survival in snow-dominated mountain basins. Hydrological Processes 27(5):750-765.

Gordon, J., Gillespie, D., Potter, J., Frantzis, A., Simmonds, M. P., Swift, R., & Thompson, D. 2004. Our view of the effects of seismic surveys on marine mammals. Marine Technology Society Journal, 37(4),16-34.

Graham, T.R. 2009. Scyphozoan jellies as prey for leatherback sea turtles off central California. Master's Theses. Paper 3692. Available at: http://scholarworks.sjsu.edu/etd_theses/3692

Green, G.A., J.J. Brueggerman, R.A. Grotefendt, C.E. Bowlby, M L. Bonnell, and K.C. Balcomb III. 1992. Cetacean distribution and abundance off Oregon and Washington, 1989-1990. Oregon and Washington Marine Mammal and Seabird Surveys. Minerals Management Service Contract Report 14-12-0001-30426.

Griffith, J., M. Alexandersdottir, R. Rogers, J. Drotts, and P. Stevenson. 2004. 2003 annual Stillaguamish smolt report. Stillaguamish Tribe of Indians.

Gustafson, R.G., M.J. Ford, D. Teel, and J.S. Drake. 2010. Status review of eulachon (Thaleichthys pacificus) in Washington, Oregon, and California. U.S. Dept. Commerce., NOAA Tech. Memo. NMFS-NWFSC-105, 360 pages.

Gustafson, R., Y.-W. Lee, E. Ward, K. Somers, V. Tuttle, and J. Jannot. 2016. Status review update of eulachon (Thaleichthys pacificus) listed under the Endangered Species Act: southern distinct population segment. 25 March 2016 Report to National Marine Fisheries Service – West Coast Region from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA 98112.

Haggerty, M.J., A.C. Ritchie, J.G. Shellberg, M.J. Crewson, and J. Jalonen. 2009. Lake Ozette Sockeye Limiting Factors Analysis. Prepared for the Makah Indian Tribe and NOAA Fisheries in Cooperation with the Lake Ozette Sockeye Steering Committee, Port Angeles, WA.

Hallock, R.J., W.F Van Woert, L. Shapovalov. 1961. An evaluation of stocking hatchery-reared steelhead rainbow trout (Salmo gairdnerii gairdnerii) in the Sacramento River system. California Department of Fish and Game. Fish Bulletin 114. 74 p.

Hamilton, J.B., G.L. Curtis, S.M. Snedaker, and D.K. White. 2005. Distribution of anadromous fishes in the upper Klamath River watershed prior to hydropower dams—A synthesis of the historical evidence. Fisheries. Volume 30(4), pages 10 to 20.

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

Hanson, M.B., C.K. Emmons, E.J. Ward, J.A. Nystuen, and M.O. Lammers. 2013. Assessing the coastal occurrence of endangered killer whales using autonomous passive acoustic recorders. The Journal of the Acoustical Society of America. 134(5): 3486–3495.

Hanson, M.B., E.J. Ward, C.K. Emmons, M.M. Holt, and D.M. Holzer. 2017. Assessing the movements and occurrence of Southern Resident Killer Whales relative to the U.S. Navy's Northwest Training Range Complex in the Pacific Northwest. Prepared for: U.S. Navy, U.S.

Pacific Fleet, Pearl Harbor, HI. Prepared by: National Oceanic and Atmospheric Administration, Northwest Fisheries Science Center under MIPR N00070-15-MP-4C363. 30 June 2017. 23p

Harris, H.S., S.R. Benson, K.V. Gilardi, R.H. Poppenga, T.M. Work, P.H. Dutton, and J.A.K. Mazet. 2011. Comparative health assessment of Wester Pacific leatherback turtles (Dermochelys coriacea) foraging off the coast of California, 2005-2007. Journal of Wildlife Diseases 47(2):321–337.

Hastie, G.D., C. Donovan, T. Gotz, and V.M. Janik. 2014. Behavioral responses by grey seals (Halichoerus grypus) to high frequency sonar. Marine Pollution Bulletin 79:205-210.

Hatase, H., M. Kinoshita, T. Bando, N. Kamezaki, K. Sato, Y. Matsuzawa, K. Goto, K. Omita, Y. Nakashima, H. Takeshita, and W. Sakamoto. 2002. Population structure of loggerhead turtles, Caretta caretta, nesting in Japan: bottlenecks on the Pacific population. Marine Biology 141:299-305.

Hawkes, L.A., A.C. Brodeaick, M.H. Godfrey, and B.J. Godley. 2009. Climate change and marine turtles. Endangered Species Research 7:137-154.

Hawkins, A.D., A.E. Pembroke, and A.N. Popper. 2014. Information gaps in understanding the effects of noise on fishes and invertebrates. Rev Fish Biol Fisheries DOI 10.1007/s11160-014-9369-3.

Hawkins, A.D., and A.D.F. Johnstone. 1978. "The hearing of the Atlantic salmon, Salmo solar." Journal of Fish Biology 13:655-673.

Hay, D.E., and McCarter, P.B. 2000. Status of the eulachon Thaleichthys pacificus in Canada. Department of Fisheries and Oceans Canada, Canadian Stock Assessment Secretariat, Research Document 2000-145. Ottawa, Ontario.

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

Hazel, J., Lawler, I.R. and M. Hamann. 2009. Diving at the shallow end: green turtle behavior in near-shore foraging habitat. J.Expt. Mar.Biol.Ecol. 371: 84-92.

Healey, M.C. 1991. Life history of Chinook salmon (Oncorhynchus tshawytscha). Pages 396-445 In: C. Groot and L. Margolis, editors. Pacific Salmon Life Histories. University of British Columbia Press, Vancouver, B.C.

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

Hedgecock, D. 1994. Does variance in reproductive success limit effective population sizes of marine organisms? In A.R. Beaumont (ed.), Genetics and Evolution of Aquatic Organisms, p. 122–134. Chapman & Hall, London.

Hilborn, R., S.P. Cox, F.M.D. Gulland, D.G. Hankin, N.T. Hobbs, D.E. Schindler, and A.W. Trites. 2012. The Effects of Salmon Fisheries on Southern Resident Killer Whales: Final Report of the Independent Science Panel. Prepared with the assistance of D.R. Marmorek and A.W. Hall, ESSA Technologies Ltd., Vancouver, B.C. for National Marine Fisheries Service (Seattle. WA) and Fisheries and Oceans Canada (Vancouver. BC). xv + 61 pp. + Appendices.

Hill K.T., P.R. Crone, and J.P. Zwolinski. 2019. Assessment of the Pacific Sardine Resource in 2019 for U.S. Management in 2019-2020. NOAA Technical Memorandum NOAA-TM-SWFSC-615. Fisheries Resource Division, SWFSC, La Jolla CA, and Institute of Marine Sciences U.C. Santa Cruz. 119 pp. + appendices.

Hitipuew, C., P.H. Dutton, S. Benson, J. Thebu, and J. Barkarbessy. 2007. Population Status and Internesting Movement of Leatherback Turtles, Dermochelys coriacea, Nesting on the Northwest Coast of Papua, Indonesia. Chelonian Conservation and Biology 6:28-36.

Holt, M.M., D.P. Noren, V. Veirs, C.K. Emmons, and S. Veirs. (2009). Killer whales (Orcinus orca) increase their call amplitude in response to vessel noise. J Acoust Soc Am 125:EL27–EL32.

Hourston, A.S., and C.W. Haegele. 1980. Herring on Canada's Pacific Coast. Canadian Special Publication of Fisheries and Aquatic Sciences. 48 pages.

Howell, E.A., D.R. Kobayashi, D.M. Parker, G.H. Balazs, and J.J. Polovina. 2008. TurtleWatch: A tool to aid in the bycatch reduction of loggerhead turtles Caretta caretta in the Hawaii-based pelagic longline fishery. Endangered Species Research. Published online July 1, 2008 (open access).

Huff, D.D., S.T. Lindley, P.S. Rankin, and E.A. Mora. 2011. Green sturgeon physical habitat use in the coastal Pacific Ocean. PLoS One 6(9):e25156. DOI: 10.1371/journal.pone.0025156.

Intaratep, N., W. Alexander, W. Devenport, S. Grace, and A. Dropkin. 2016. Experimental study of quadcopter acoustics and performance at static thrust conditions. https://doi.org/10.2514/6.2016-2873.

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

ISAB (Independent Scientific Advisory Board). 2007. Climate change impacts on Columbia River Basin fish and wildlife. ISAB Climate Change Report, ISAB 2007-2, Northwest Power and Conservation Council, Portland, Oregon.

Isaak, D. J., S. Wollrab, D. Horan, and G. Chandler. 2012. Climate change effects on stream and river temperatures across the northwest US from 1980–2009 and implications for salmonid fishes. Climatic Change. 113(2):499-524.

Ishihara, T. 2009. Status of Japanese Coastal Sea Turtle Bycatch. In: E. Gilman (Ed.), Proceedings of the Technical Workshop on Mitigating Sea Turtle Bycatch in Coastal Net Fisheries. 20-22 January 2009, Honolulu, HI. Western Pacific Regional Fishery Management Council, IUCN, Southeast Asian Fisheries Development Center, Indian Ocean – South-East Asian Marine Turtle MoU, U.S. National Marine Fisheries Service, Southeast Fisheries Science Center: Honolulu; Gland, Switzerland; Bangkok; and Pascagoula, USA. 76 p.

Israel, J.A., J.F. Cordes, M.A. Blumberg, and B. May. 2004. Geographic patterns of genetic differentiation among collections of green sturgeon. North American Journal of Fisheries Management 24:922-931.

Iwamoto, T., M. Ishii, Y. Nakashima, H. Takeshita, and A. Itoh. 1985. Nesting cycles and migrations of the loggerhead sea turtle in Miyazaki, Japan. Japanese Journal of Ecology 35:505-511.

Jacobs, S.R., Terhune, J.M., 2002. The effectiveness of acoustic harassment devices in the Bay of Fundy, Canada: seal reactions and noise exposure model. Aquatic Mammals 28, 147–158.

Jones, T.T., S. Martin, T. Eguchi, B. Langseth, J. Baker, and A. Yau. 2018. Review of draft response to PRD's request for information to support ESA section 7 consultation on the effects of Hawaii-based longline fisheries on ESA listed species. NMFS Pacific Islands Fisheries Science Center, Honolulu, HI. 35 p.

Jorgensen, S.J., A.P. Klimley, and A.F. Muhlia-Melo. 2009. Scalloped hammerhead shark Sphyrna lewini, utilizes deep-water, hypoxic zone in the Gulf of California. Journal of Fish Biology 74: 1682–1687.

Kamezaki, N., I. Miyakawa, H. Suganuma, K. Omuta, Y. Nakajima, K. Goto, K. Sato, Y. Matsuzawa, M. Samejima, M. Ishii, and T. Iwamoto. 1997. Post-nesting migration of Japanese loggerhead turtle, Caretta caretta. Wildlife Conservation Japan 3:29-39.

Kamezaki, N., Y. Matsuzawa, O. Abe, H. Asakawa, T. Fujii, K. Goto, S. Hagino, M. Hayami, M. Ishii, T. Iwamoto, T. Kamata, H. Kato, J. Kodama, Y. Kondo, I. Miyawaki, K. Mizobuchi, Y. Nakamura, Y. Nakashima, H. Naruse, K. Omuta, M. Samejima, H. Suganuma, H. Takeshita, T. Tanaka, T. Toji, M. Uematsu, A. Yamamoto, T. Yamato, and I. Wakabayashi. 2003. Loggerhead Turtles Nesting in Japan. Pages 210-217 ill: A. B. Bolten and B. E. Witherington (eds.), Loggerhead Sea Turtles. Smithsonian Institution, Washington. 319 pages.

Kaska, Y., C. Ilgaz, A. Ozdemir, E. Baskale, O. Ttirkozan, I. Baran, and M. Stachowitsch. 2006. Sex ratio estimations of loggerhead sea turtle hatchlings by histological examination and nest temperatures at Fethiye beach, Turkey. Naturwissenschaften 93:338-343.

Kastak, D., R.J. Schusterman, B.L. Southall, and C.J. Reichmuth. 1999. Underwater temporary threshold shift induced by octave-band noise in three species of pinniped. Journal of the Acoustical Society of America 106:1142-1148.

Kastelein, R.A., van der Heul, S., Verboom, W.C., Triesscheijn, R.J.V., Jennings, N.V., 2006. The influence of underwater data transmission sounds on the displacement of harbour seals (Phoca vitulina) in a pool. Marine Environmental Research 61, 19–39.

Kelly, J.T., A.P. Klimley, and C.E. Crocker. 2007. Movements of green sturgeon, Acipenser medirostris, in the San Francisco Bay Estuary, California. Environmental Biology of Fishes 79:281-295.

Kier, M.C., J. Hileman, and S. Cannata. 2015. Annual Report Trinity River Basin Salmon and Steelhead Monitoring Project.

Klimley, A.P. 1993. Highly directional swimming by scalloped hammerhead sharks, Sphyrna lewini, and subsurface irradiance, temperature, bathymetry, and geomagnetic field. Marine Biology 117: 1–22.

Knowlton, A.R. and S.D. Kraus. 2001. Mortality and serious injury of northern right whales (Eubalaena glacialis) in the western North Atlantic Ocean. J. Cetacean Res. Manage. (Special Issue) 2:193-208.

Kobayashi, D.R., J.J. Polovina, D.M. Parker, N. Kamezaki, I.J. Cheng, I. Uchida, P.H. Dutton and G.H. Balazs. 2008. Pelagic habitat utilization of loggerhead sea turtles, Caretta caretta, in the North Pacific Ocean (1997-2006): Insights from satellite tag tracking and remotely sensed data. Journal of Experimental Marine Biology and Ecology 356:96-114.

Krahn, M.M., M.J. Ford, W.F. Perrin, P.R. Wade, R.P. Angliss, M.B. Hanson, B.L. Taylor, G.M. Ylitalo, M.E. Dahlheim, J.E. Stein, and R.S. Waples. 2004. 2004 status review of southern resident killer whales (Orcinus orca) under the Endangered Species Act. NOAA Technical Memorandum NMFS-NWFSC-62, U.S. Department of Commerce, Seattle, Washington.

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

Krahn, M.M., M.B. Hanson, G.S. Schorr, C.K. Emmons, D.G. Burrows, J.L. Bolton, R.W. Baird, and Gina Ylitalo. 2009. Effects of age, sex and reproductive status on persistent organic pollutant concentrations in “Southern Resident” killer whales. Marine Pollution Bulletin 58:1522-1529.

Kunkel, K.E., L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, K.T. Redmond, and J.G. Dobson. 2013. Regional Climate Trends and Scenarios for the U.S. National Climate Assessment: Part 6. Climate of the Northwest U.S. NOAA Technical Report NESDIS 142-6.

Kuriyama, P.T., J.P. Zwolinski, K.T. Hill, and P.R. Crone. 2020. Assessment of the Pacific sardine resource in 2020 for U.S. management in 2020-2021, U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-628.

Laist, D.W., A. R. Knowlton, J.G. Mead, A.S. Collet, and M. Podesta. 2001. Collisions between ships and whales. Marine Mammal Science 17:35-75.

Lang, A.R., D.W.Weller, R. LeDuc, A.M. Burdin, V.L. Pease , D. Litovka ,V. Burkanov, R.L. Brownell, Jr.. 2011. Genetic analysis of stock structure and movements of gray whales in the eastern and western North Pacific. International Whaling Commission.

Larson, Z.S., and M.R. Belchik. 1998. A preliminary status review of eulachon and Pacific lamprey in the Klamath River Basin. Yurok Tribal Fisheries Program, Klamath, California.

Lawson, P.W., E.A. Logerwell, N.J. Mantua, R.C. Francis, and V.N. Agostini. 2004. Environmental factors influencing freshwater survival and smolt production in Pacific Northwest coho salmon (Oncorhynchus kisutch). Canadian Journal of Fisheries and Aquatic Sciences. 61(3):360-373

Lawson, D., C. Fahy, J. Seminoff, T. Eguchi, R LeRoux, P. Ryono, L. Adams, and M. Henderson. 2011. A report on recent green sea turtle presence and activity in the San Gabriel River and vicinity of Long Beach, California. Poster presentation at the 31st Annual Symposium on Sea Turtle Biology and Conservation in San Diego, California.

Lenhardt, M.L. 1994. Auditory behavior of loggerhead sea turtle (Caretta caretta). In: K.A. Bjorndal, A.B. Bolten, D.A. Johnson, and P.J. Eliazar (compilers). Proceedings of the 14th Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-351.

LeRoux, R.A., C. Fahy, J. Cordaro, B. Norberg, E.L. LaCasella, S. Wilkin, P. Dutton, and J. Seminoff. 2011. Marine turtle strandings on the U.S. west coast. Poster presented at 31st Annual International Sea Turtle Symposium. La Jolla, CA.

Lewis, M., E. Brown, B. Sounhein, M. Weeber, E. Suring, and H. Truemper. 2009. Status of Oregon stocks of coho salmon, 2004 through 2008. Monitoring Program Report Number OPSW-ODFW-2009-3, Oregon Department of Fish and Wildlife, Salem, Oregon.

Lewis, M., B. Sounhein, M. Weeber, and E. Brown. 2010. Status of Oregon stocks of coho salmon, 2009. Monitoring Program Report Number OPSW-ODFW-2010-3, Oregon Department of Fish and Wildlife, Salem, Oregon.

Lewis, M., M. Weeber, E. Brown, and B. Sounhein. 2011. Status of Oregon stocks of coho salmon, 2010. Monitoring Program Report Number OPSW-ODFW-2011-3, Oregon Department of Fish and Wildlife, Salem, Oregon.

Lewis, M., E. Brown, B. Sounhein, and M. Weeber. 2012. Status of Oregon stocks of coho salmon, 2011. Monitoring Program Report Number OPSW-ODFW-2012-3, Oregon Department of Fish and Wildlife, Salem, Oregon.

Lewis, M., B. Sounhein, M. Weeber and E. Brown. 2014. Status of Oregon stocks of coho salmon, 2012. Monitoring Program Report Number OPSW-ODFW-2013-3, Oregon Department of Fish and Wildlife, Salem, Oregon.

Lewison, R.L., S.A. Freeman, and L.B. Crowder. 2004. Quantifying the effects of fisheries on threatened species: the impact of pelagic longlines on loggerhead and leatherback sea turtles. Ecology Letters 7:221-231.

Limpus, C.J. and J.D. Miller. 2008. Australian Hawksbill Turtle Population Dynamics Project. Queensland. Environmental Protection Agency. 130 pages.

Lindley, S.T., R. Schick, E. Mora, P.B. Adams, J.J. Anderson, S. Greene, C. Hanson, B. P. May, D.R. McEwan, R.B. MacFarlane, C. Swanson, and J.G. Williams. 2007. Framework for assessing viability of threatened and endangered Chinook salmon and steelhead in the Sacramento-San Joaquin Basin. San Francisco Estuary and Watershed Science 5(1), Article 4: 26 pages. Available at: http://repositories.cdlib.org/jmie/sfews/vol5/iss1/art4.

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

Lindley, S.T., C.B. Grimes, M.S. Mohr, W. Peterson, J. Stein, J.T. Anderson, L.W. Botsford, D. L. Bottom, C.A. Busack, T.K. Collier, J. Ferguson, J.C. Garza, A.M. Grover, D.G. Hankin, R.G. Kope, P.W. Lawson, A. Low, R.B. MacFarlane, K. Moore, M. Palmer-Zwahlen, F.B. Schwing, J. Smith, C. Tracy, R. Webb, B.K. Wells, and T.H. Williams. 2009. What caused the Sacramento River fall Chinook stock collapse? Pre-publication report to the Pacific Fishery Management Council. March 18, 2009, 57 p.

Lindley, S.T., D.L. Erickson, M.L. Moser, G. Williams, O.P. Langness, B.W. McCovey, M. Belchik, D. Vogel, W. Pinnix, J.T. Kelly, J.C. Heublein, and A.P. Klimley. 2011. Electronic tagging of green sturgeon reveals population structure and movement among estuaries. Transactions of the American Fisheries Society 140:108-122.

Lopez, K., and A. Barragan y L Sarti (Comps.). 2012. Proyecto Laud: Conservacion de la Tortuga Laud Dermochelys coriacea en el Pacífico mexicano. Temporada de Anidación 2011-2012. Dirección de Especies Prioritarias para la Conservacion. Conanp-Semarnat. Kutzari, Asociacion para el Estudio y Conservacion de las Tortugas Marinas. 16 p.

Lurton, X., and S. DeRuiter. 2011. Sound radiation of seafloor-mapping echosounders in the water column, in relation to the risks posed to marine mammals. International Hydrographic Review (November):7-17.

Macaulay, G.J., B. Scoulding, E. Ona, and S.M. Fässler. 2018. Comparisons of echo-integration performance from two multiplexed echosounders, ICES Journal of Marine Science, Volume 75, Issue 6, November-December 2018, Pages 2276–2285, https://doi.org/10.1093/icesjms/fsy111.

Mackas, D.L., Goldblatt, and A.G. Lewis. 1989. Importance of walleye Pollack in the diets of marine mammals in the Gulf of Alaska and Bering Sea and implications for fishery management, Pages 701–726 in Proceedings of the international symposium on the biology and management of walleye Pollack, November 14-16,1988, Anchorage, AK.Univ. AK Sea Grant Rep. AK-SG-89-01.

Mattole Salmon Group. 2011. Spawning Ground Surveys, 2010-2011 Season Mattole River Watershed – Final Report. Petrolia, CA. 41 pp.

McMahon, T.E. and G.F. Hartman. 1989. Influence of cover complexity and current velocity on winter habitat use by juvenile coho salmon (Oncorhynchus kisutch). Canadian Journal of Fisheries and Aquatic Sciences. 46:1551-1557.

Mantua, N., I. Tohver, and A. Hamlet. 2009. Impacts of Climate Change on Key Aspects of Freshwater Salmon Habitat in Washington State. in The Washington Climate Change Impacts Assessment: Evaluating Washington's Future in a Changing Climate, M. M. Elsner, J. Littell, and L. Whitely Binder, Eds. The Climate Impacts Group, University of Washington, Seattle, Washington, pp. 217-253.

Mantua, N., I. Tohver, and A. Hamlet. 2010. Climate change impacts on streamflow extremes and summertime stream temperature and their possible consequences for freshwater salmon habitat in Washington State. Climatic Change. 102(1):187-223.

Martin, K.J., S.C. Alessi, J.C. Gaspard, A.D. Tucker, G.B. Bauer, and D.A. Mann. 2012. Underwater hearing in the loggerhead turtle (Caretta caretta): a comparison of behavioral and auditory evoked potential audiograms. Journal of Experimental Biology 215:3001-3009.

Martin S.L., Z. Siders, T. Eguchi, B. Langseth, A. Yau, J. Baker, R. Ahrens, and T.T. Jones. 2020. Assessing the population-level impacts of North Pacific loggerhead and western Pacific leatherback turtle interactions in the Hawaii-based shallow-set longline fishery. U.S. Dept. of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-95, 183 p. doi:10.25923/ydp1-f891

Mate, B., A.L. Bradford, G. Tsidulko, V. Vertyankin, and V. Ilyashenko. 2011. Late-feeding season movements of a western North Pacific gray whale off Sakhalin Island, Russia and subsequent migration into the Eastern North Pacific. Paper SC/63/BRG23 presented to the International Whaling Commission Scientific Committee.

Matsuzawa, Y., K. Sato, W. Sakamoto, and K.A. Bjorndal. 2002. Seasonal fluctuations in sand temperature: effects of the incubation period and mortality of loggerhead sea turtle (Caretta caratta) pre-emergent hatchlings in Minabe, Japan. Marine Biology 140:629-646.

McElhany, P., M.H. Rucklelshaus, M.J. Ford, T.C. Wainwright, and E.P. Bjorkstedt. 2000. Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units. United States Department of Commerce, National Oceanic and Atmospheric Administration Technical Memorandum NMFS-NWFSC-42. 156 pages.

McEwan, D.R. 2001. Central Valley steelhead. California Department of Fish and Game, Fish Bulletin 179(1):1-44.

McKenna, M.F., D. Ross, S.M. Wiggins, and J.A. Hildebrand. 2012. Underwater radiated noise from modern commercial ships. J. Acoust. Soc. Am. 131(1):92-103.

McPherson, S. and J. C. Woodey. 2009. Cedar River and Lake Washington Sockeye Salmon Biological Reference Point Estimates. Prepared for Washington Department of Fisheries and Wildlife. Olympia, WA. 62pp.

Meehan, W.R., and T.C. Bjornn. 1991. Salmonid distribution and life histories. Pages 47-82 in Influences of Forest and Rangeland Management on Salmonid Fishes and their Habitats. W.R. Meehan, editor. American Fisheries Society Special Publication 19. American Fisheries Society. Bethesda, Maryland. 751 pages.

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

Meyer, J.L., M.J. Sale, P.J. Mulholland, and N.L. Poff. 1999. Impacts of climate change on aquatic ecosystem functioning and health. JAWRA Journal of the American Water Resources Association. 35(6):1373-1386.

Miller, M.H., J. Carlson, P. Cooper, D. Kobayashi, M. Nammack, and J. Wilson. 2014. Status Review Report: Scalloped Hammerhead Shark (Sphyrna lewini). Final Report to National Marine Fisheries Service, Office of Protected Resources. March 2014. 133 p.

Moody, M.F. 2008. Eulachon past and present. Master's thesis. Univ. British Columbia, Vancouver. Online at the following website address: https://circle.ubc.ca/bitstream/2429/676/1/ubc_2008_spring_moody_megan.pdf.

Morreale, S., E. Standora, F. Paladino, and J. Spotila. 1994. Leatherback migrations along deepwater bathymetric contours. In: Proc. 13th Annual Symposium Sea Turtle Biology and Conservation. NOAA Tech. Memo NMFS-SEFSC-341. p: 109.

Mote, P.W., J. Abatzoglou, and K. Kunkel. 2013. Climate Change in the Northwest: Implications for Our Landscapes, Waters, and Communities. Island Press, 224 pp.

Mote, P.W, A.K. Snover, S. Capalbo, S.D. Eigenbrode, P. Glick, J. Littell, R.R. Raymondi, and W.S. Reeder. 2014. Ch. 21: Northwest. in Climate Change Impacts in the United States: The

Third National Climate Assessment, J.M. Melillo, T.C. Richmond, and G.W. Yohe, Eds., U.S. Global Change Research Program, pp. 487-513.

Mote, P.W., D.E. Rupp, S. Li, D.J. Sharp, F. Otto, P.F. Uhe, M. Xiao, D.P. Lettenmaier, H. Cullen, and M.R. Allen. 2016. Perspectives on the cause of exceptionally low 2015 snowpack in the western United States. Geophysical Research Letters. 43:10980-10988. doi:10.1002/2016GLO69665

Moyle, P.B., R.M. Yoshiyama, J.E. Williams, and E.D. Wikramanayake. 1995. Eulachon In Fish species of special concern in California, Second Edition, p. 123-127. California Department of Fish & Game, Inland Fisheries Division, Rancho Cordova, CA.

Moyle, P.B. 2002. Inland Fisheries of California. Second Edition. University of California Press. Berkeley, CA.

Musick, J.A. and C.J. Limpus. 1997. Habitat utilization and migration in juvenile sea turtles. Pages 137-163 in Lutz, P. L. and J. A. Musick (editors). The Biology of Sea Turtles. CRC Press. Boca Raton, Florida.

Myers, J.M., R.G. Kope, G.J. Bryant, D. Teel, L.J. Lierheimer, T.C. Wainwright, W.S. Grant, F.W. Waknitz, K. Neely, S.T. Lindley, and R.S. Waples. 1998. Status Review of Chinook Salmon from Washington, Idaho, Oregon, and California. U.S. Department of Commerce, National Oceanic and Atmospheric Administration Technical Memorandum NMFS-NWFSC-35, Seattle, Washington.

Myrick, C. A., and J. J. Cech. 2005. Effects of temperature on the growth, food consumption, and thermal tolerance of age-0 Nimbus-strain steelhead. North American Journal of Aquaculture 67:324–330.

Nel, R. 2012. Assessment of the conservation status of the leatherback turtle in the Indian Ocean and Southeast Asia IOSEA MOU.

NMFS. 1997. Impact of California sea lions and Pacific harbor seals on salmonids and on the coastal ecosystems of Washington, Oregon, and California. NOAA Technical Memorandum NMFS-NWFSC-28. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, WA.

NMFS. 1999. Endangered Species Act – Reinitiated Section 7 Consultation Biological Opinion, Fishing Conducted under the Pacific Coast Groundfish Management Plan for the California, Oregon, and Washington Groundfish Fishery.

NMFS 2006a. Formal Consultation on the Continued Operation of the Diablo Canyon Nuclear Power Plant and the San Onofre Nuclear Generating Station. September 18, 2006.

NMFS. 2006b. Biological and Conference Opinion on the Adoption of Amendment 11 to the Coastal Pelagic Species Fishery Management Plan. National Marine Fisheries Service, Southwest Region. March 10, 2006.

NMFS. 2006c. Sea Turtle Research Permit Application, File No. 1551.

NMFS. 2006d. Final supplement to the Puget Sound Salmon Recovery Plan. Available at: Final supplement to PS Salmon Recovery Plan weblink

NMFS. 2008a. Reducing the Impact on At-risk Salmon and Steelhead by California Sea Lions in the Area Downstream of Bonneville Dam on the Columbia River, Oregon and Washington. Final Environmental Assessment. National Marine Fisheries Service, Northwest Region. March 12, 2008.

NMFS. 2008b. Biological Opinion on the Issuance of two Scientific Research Permits for the Southwest Fisheries Science Center's Annual Sardine Research Surveys along the coasts of California, Oregon, and Washington during the month of April from 2008 through 2010. National Marine Fisheries Service, Southwest Region. May 8, 2008.

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

NMFS. 2009. Middle Columbia Steelhead ESA Recovery Plan. National Marine Fisheries Service, West Coast Region, Portland, OR. 260 pp.

NMFS. 2010. Biological Opinion on the Continued Prosecution of the U.S. West Coast Pacific Sardine Fishery under the Coastal Pelagic Species Fishery Management Plan. National Marine Fisheries Service, Southwest Regional Office, Long Beach, CA.

NMFS. 2010b. Endangered Species Act Section 7(a)(2) Consultation for the Proposed Award of a Saltonstall-Kennedy Grant to Capture and Tag Swordfish (Xiphias g/adius) off the Coast of Southern California Using Experimental Buoy Gear. National Marine Fisheries Service. West Coast Region. Memo from Yates to Helvey. March 30, 2010.

NMFS. 2012a. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion Continued Operation of the Hawaii-based Shallow-set Longline Swordfish Fishery Under Amendment 18 to the Fishery Management Plan for Pelagic Fisheries of the Western Pacific Region. National Marine Fisheries Service, Pacific Islands Regional Office. Honolulu, HI. January 30, 2012.

NMFS. 2012b. Southern California Steelhead Recovery Plan. Southwest Region, Protected Resources Division. Long Beach, California.

NMFS 2012c. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Section 7(a)(2) "Not Likely to Adversely Affect" Determination for the Continuing Operation of the Pacific Coast Groundfish Fishery. National Marine Fisheries Service, Northwest Regional Office. Seattle, WA. December 7, 2012.

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

NMFS. 2013a. South-Central California Coast Steelhead Recovery Plan. West Coast Region, California Coastal Area Office, Long Beach, California.

NMFS. 2013b. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion on Continued Management of the Drift Gillnet Fishery under the Fishery Management Plan for U.S. West Coast Fisheries for Highly Migratory Species. National Marine Fisheries Service, Southwest Regional Office. May 2, 2013.

NMFS. 2013c. Federal Recovery Outline, Eulachon Southern DPS. National Marine Fisheries Service, Northwest Region. June 21, 2013. 24 p.

NMFS. 2013d. ESA Recovery Plan for Lower Columbia River Coho Salmon, Lower Columbia River Chinook Salmon, Columbia River Chum Salmon, and Lower Columbia River Steelhead. National Marine Fisheries Service, West Coast Region, Portland, OR. 503 pp.

NMFS. 2014a. Biological Opinion on the Continued Operation of the Hawaii-based Deep-set Pelagic Longline Fishery. National Marine Fisheries Service, Pacific Islands Regional Office. Honolulu, HI. September 19, 2014.

NMFS. 2014b. Final Recovery Plan for the Southern Oregon/Northern California Coast Evolutionarily Significant Unit of Coho Salmon (Oncorhynchus kisutch). National Marine Fisheries Service. Arcata, CA. 406 pp.

NMFS. 2014c. Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon and the Distinct Population Segment of California Central Valley Steelhead. California Central Valley Area Office. July 2014.

NMFS. 2015a. 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. NMFS, West Coast Region, 7600 Sand Point Way NE, Seattle, Washington 98115. Signed August 31, 2015. 279 pp.

NMFS 2015b. Reinitiated Biological Opinion on U.S. Navy Hawaii-Southern California Training and Testing. National Marine Fisheries Service, Office of Protected Resources. Silver Spring, MD. April 2, 2015.

NMFS. 2015c. Southern Distinct Population Segment of the North American Green Sturgeon (Acipenser medirostris) – 5-Year Review: Summary and Evaluation. National Marine Fisheries Service. Long Beach, CA. 42 pp.

NMFS. 2016a. 2016 5-Year Review: Summary & Evaluation of Ozette Lake Sockeye. NMFS, West Coast Region. Portland, OR. 47 pp.

NMFS. 2016b. Coastal Multispecies Recovery Plan. National Marine Fisheries Service, West Coast Region, Santa Rosa, California.

NMFS 2016c. Endangered Species Act Section 7(a)(2) Biological Opinion and Letter of Concurrence for the Fisheries Research Conducted and Funded by the Northwest Fisheries Science Center; Issuance of a Letter of Authorization under the Marine Mammal Protection 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 Marine Fishes. November 10, 2016.

NMFS. 2016d. Interim Guidance on the Endangered Species Act Term "Harass". National Marine Fisheries Service Procedural Instruction 02-110-19. December 21, 2016. http://www.nmfs.noaa.gov/og/gds/index.html

NMFS. 2016e. Final ESA Recovery Plan for Oregon Coast Coho Salmon (Oncorhynchus kisutch). National Marine Fisheries Service, West Coast Region, Portland, OR. 230 pp.

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

NMFS. 2017a. Biological and Conference Opinion on the Proposed Implementation of a Program for the Issuance of Permits for Research and Enhancement Activities on Threatened and Endangered Sea Turtles Pursuant to Section l0(a) of the Endangered Species Act. National Marine Fisheries Service, Office of Protected Resources Division. December 21, 2017.

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

NMFS. 2017c. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion Reinitiation of Section 7 Consultation Regarding the Pacific Fisheries Management Council's Groundfish Fishery Management Plan. National Marine Fisheries Service, West Coast Region. December 11, 2017.

NMFS. 2017d. Giant Manta Ray Endangered Species Act Status Review Report. NOAA Fisheries. Silver Spring, MD. September, 2017. 128 p.

NMFS. 2018a. 2018 Revisions to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0): Underwater Thresholds for Onset of Permanent and Temporary Threshold Shifts. U.S. Dept. of Commer., NOAA. NOAA Technical Memorandum NMFS-OPR-59, 167 p.

NMFS. 2018b. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion on the Continuing Operation of the Pacific Coast Groundfish Fishery. National Marine Fisheries Service, West Coast Regional Office. October 12, 2018.

NMFS. 2018c. Endangered Species Act Section 7(a)(2) Consultation for the Proposed Issuance of Deep-Set Buoy Gear Exempted Fishing Permits for Highly Migratory Species. National Marine Fisheries Service, West Coast Regional Office. March 15, 2018.

NMFS. 2018d. Endangered Species Act Section 7(a)(2) Consultation for the Proposed Issuance of Deep-Set Linked Buoy Gear Exempted Fishing Permits for Highly Migratory Species. National Marine Fisheries Service, West Coast Regional Office. May 9, 2018.

NMFS. 2018e. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion on Consideration of an Exempted Fishing Permit to Fish with Longline Gear in the West Coast Exclusive Economic Zone. National Marine Fisheries Service, West Coast Regional Office. July 11, 2018.

NMFS. 2018f. Proposed Recovery Plan for the Puget Sound Steelhead Distinct Population Segment (Oncorhynchus mykiss). National Marine Fisheries Service. Seattle, WA. 291 pp.

NMFS. 2018g. Recovery Plan for the Southern Distinct Population Segment of North American Green Sturgeon (Acipenser medirostris). National Marine Fisheries Service, Sacramento, CA. 95 pp

NMFS. 2019a. Endangered Species Action Section 7(a)(2) Consultation on the Continued Operation of the Hawaii Pelagic Shallow-set Longline Fishery. National Marine Fisheries Service, Pacific Island Regional Office. June 26, 2019.

NMFS. 2019b. Memo from Golden, D., Pacific Islands Regional Office, to the record re: Observed captures and estimated mortality of sea turtles in the American Samoa longline fishery, 2006 - 2018. 8 p.

NMFS. 2019c. Endangered Species Act Section 7(a)(2) Consultation for the Proposed Issuance of a Deep-Set Shortline Exempted Fishing Permit for Highly Migratory Species. National Marine Fisheries Service, West Coast Regional Office. August 15, 2019.

NMFS. 2019d. Proposed Revision of the Critical Habitat Designation for Southern Resident Killer Whales Draft Biological Report. September 2019. Pp 122 available online at: https://archive.fisheries.noaa.gov/wcr/publications/protected_species/marine_mammals/killer_whales/CriticalHabitat/0648-bh95_biological_report_september_2019_508.pdf

NMFS. 2020. Scalloped Hammerhead Shark (Sphyrna lewini) 5-Year Review: Summary and Evaluation. NOAA Fisheries Office of Protected Resources, Silver Spring, MD. May, 2020. 45 p.

NMFS. 2020b. Endangered Species Act Section 7(a)(2) Consultation on Implementation of the Pacific Fishery Management Council Salmon Fishery Management Plan in 2020 for Southern Resident Killer Whales and their Current and Proposed Critical Habitat. National Marine Fisheries Service, West Coast Regional Office. April 29, 2020.

NMFS. 2020c. Endangered Species Act Section 7(a)(2) Biological and Conference Opinion on (1) U.S. Navy Northwest Training and Testing Activities (NWTT); and (2) the National Marine Fisheries Service's promulgation of regulations and issuance of a letter of authorization pursuant to the Marine Mammal Protection Act for the U.S. Navy to "take" marine mammals incidental to NWTT activities from November 2020 through November 2027. National Marine Fisheries Service, Office of Protected Resources. October 19, 2020.

NMFS and USFWS. 1998a. Recovery Plan for U.S. Pacific Populations of the Leatherback Turtle (Dermochelys coriacea). National Marine Fisheries Service, Silver Spring, MD.

NMFS and USFWS. 1998b. Recovery Plan for U.S. Pacific Populations of the Loggerhead Turtle (Caretta caretta). National Marine Fisheries Service, Silver Spring, MD.

NMFS and USFWS. 1998c. Recovery Plan for U.S. Pacific Populations of the Olive Ridley Turtle (Lepidochelys olivacea). National Marine Fisheries Service, Silver Spring, MD.

NMFS and USFWS. 1998d. Recovery Plan for U.S. Pacific Populations of the East Pacific Green Turtle (Chelonia mydas). National Marine Fisheries Service, Silver Spring, MD.

NMFS and USFWS. 2007a. Leatherback Sea Turtle (Dermochelys coriacea). 5-Year Review: Summary and Evaluation. 67 p.

NMFS and USFWS. 2007b. Loggerhead Sea Turtle (Caretta caretta). 5-Year Review: Summary and Evaluation. 81 p.

NMFS and USFWS. 2007c. Olive Ridley Sea Turtle (Lepidochelys olivacea). 5-Year Review: Summary and Evaluation. 67 p.

NMFS and USFWS. 2007d. Green Sea Turtle (Chelonia mydas). 5-Year Review: Summary and Evaluation. 105 p.

NMFS and USFWS. 2013a. Leatherback Sea Turtle (Dermochelvs coriacea). 5-Year Review: Summary and Evaluation. 93 p.

NMFS and USFWS. 2013b. Hawksbill Sea Turtle (Eretmochelys imbricata). 5-Year Review: Summary and Evaluation. 89 p.

NMFS and USFWS. 2014. Olive Ridley Sea Turtle (Lepidochelys olivacea). 5-Year Review: Summary and Evaluation. 81 p.

NMFS and USFWS. 2020. Endangered Species Act status review of the leatherback turtle (Dermochelys coriacea). Report to the National Marine Fisheries Service Office of Protected Resources and U.S. Fish and Wildlife Service.

NOAA and WDFW. 2018. Southern Resident Killer Whale Priority Chinook Stocks Report. June 22, 2018. 8p.

Nelson, T.C., P. Doukakis, S.T. Lindley, A.D. Schreier, J.E. Hightower, L.R. Hildebrand, R.E. Whitlock, and M.A.H. Webb. 2010. Modern technologies for an ancient fish: tools to inform management of migratory sturgeon stocks. A report for the Pacific Ocean Shelf Tracking (POST) Project.

Nichols, W.J., A. Resendiz, J.A. Seminoff, and B. Resendiz. 2000. Transpacific migration of a loggerhead turtle monitored by satellite telemetry. Bulletin of Marine Science 67(3):937-947.

Nickelson, T.E. 1998. A Habit-Based Assessment of Coho Salmon Production Potential and Spawner Escapement Needs for Oregon Coastal Streams. INFORMATION REPORTS NUMBER 98-4. Oregon Department of Fish and Wildlife. April, 1998.

Noren, D.P., Estimated field metabolic rates and prey requirements of resident killer whales. 2011. Marine Mammal Science 27(1):60–77.

Nowacek, D.P., L.H. Thorne, D.W. Johnston, and P.L. Tyack. 2007. Responses of cetaceans to anthropogenic noise. Mammal Review 37:81-115.

NWFSC (Northwest Fisheries Science Center). 2015. Status review update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest. December 21, 2015. 357 pp.

ODFW. 2011. Upper Willamette River Conservation and Recovery Plan for Chinook Salmon and Steelhead. August, 2011.

ODFW and NMFS. 2011. Upper Willamette River Conservation and Recovery Plan for Chinook Salmon and Steelhead. 462 pp.

ODFW and WDFW. 2014. 2014 Joint Staff Report: Stock Status and Fisheries for Spring Chinook, Summer Chinook, Sockeye, Steelhead, and Other Species, and Miscellaneous Regulations. Joint Columbia River Management Staff, Oregon Department of Fish & Wildlife, and Washington Department of Fish & Wildlife. January 22, 2014.

ODFW and WDFW. 2015. 2015 Joint Staff Report: Stock Status and Fisheries for Spring Chinook, Summer Chinook, Sockeye, Steelhead, and Other Species, and Miscellaneous Regulations. Joint Columbia River Management Staff, Oregon Department of Fish & Wildlife, and Washington Department of Fish & Wildlife. January 21, 2015.

ODFW and WDFW. 2016. 2016 Joint Staff Report: Stock Status and Fisheries for Spring Chinook, Summer Chinook, Sockeye, Steelhead, and Other Species, and Miscellaneous

Regulations. Joint Columbia River Management Staff, Oregon Department of Fish & Wildlife, and Washington Department of Fish & Wildlife. January 20, 2016.

ODFW and WDFW. 2017. 2017 Joint Staff Report: Stock Status and Fisheries for Spring Chinook, Summer Chinook, Sockeye, Steelhead, and Other Species. Joint Columbia River Management Staff, Oregon Department of Fish & Wildlife, and Washington Department of Fish & Wildlife. November 9, 2017.

ODFW and WDFW. 2018. 2018 Joint Staff Report: Stock Status and Fisheries for Spring Chinook, Summer Chinook, Sockeye, Steelhead, and Other Species. Joint Columbia River Management Staff, Oregon Department of Fish & Wildlife, and Washington Department of Fish & Wildlife. February 20, 2018.

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

Osborne, R.W. 1999. A historical ecology of Salish Sea "resident" killer whales (Orcinus orca): with implications for management. Ph.D. thesis, University of Victoria, Victoria, British Columbia.

Page, L.M., and B.M. Burr. 1991. A Field Guide to the Freshwater Fishes of North America, North of Mexico. The Peterson Field Guide Series, Houghton Mifflin Company, Boston, Massachusetts. 432 pages.

Pauley, G.B., B.M. Bortz, and M.F. Shepard. 1986. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Northwest) -- steelhead trout. US Fish and Wildlife Service Biological Report 82(11.62). US Army Corps of Engineers, TR EL-82-4.

Pearson, W.H., J.R. Skalski, and C.I. Malme. 1992. Effects of sounds from a geophysical survey device on behavior of captive rockfish (Sebastes spp.). Canadian Journal of Fisheries and Aquatic Sciences 49:1343-1356.

Pease, D.E., S.A. Hayes, M.H. Bond, and C. Hanson. 2009. Over the falls? rapid evolution of ecotypic differentiation in steelhead/rainbow trout (Oncorhynchus mykiss). The Journal of Heredity 100(5):515-25.

Peatman, T., L. Bell, V. Allain, P. Caillot, S. Williams, I. Tuiloma, A. Panizza, L. Tremblay-Boyer, S. Fukofuka, and N. Smith. 2018. Summary of longline fishery bycatch at a regional scale, 2003-2017 Rev 2 (22 July 2018). Busan, Republic of Korea 8-16 August 2018. 61 p.

Peckham S.H., D. Maldonado-Diaz, A. Walli, G. Ruiz, and L.B. Crowder. 2007. Small-scale fisheries bycatch jeopardizes endangered Pacific loggerhead turtles. PLoS ONE 2(10):e1041.

Peterson, W.T., R.C. Hooff, C.A. Morgan, K.L. Hunter, E. Casillas, and J.W. Ferguson. 2006. Ocean Conditions and Salmon Survival in the Northern California Current. White Paper. 52 pages.

PFMC. 2013. Appendix B, Historical Record of Escapement to Inland Fisheries and Spawning Areas. Review of 2012 Ocean Salmon Fisheries (Document prepared for the Council and its advisory entities.) Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, OR 97220-1384.

PFMC. 2019. Status of the Pacific Coast Coastal Pelagic Species Fishery and Recommended Acceptable Biological Catches. Stock Assessment and Fishery Evaluation for 2018.

PFMC. 2019b. Proposal for an Exempted Fishery Permit provided to the PFMC by West Coast Pelagic Conservation Group Collaborative "Proof of Concept Project" for Nearshore Surveillance Acoustic Trawl Methodology Survey of North West Coastal Waters. October, 2019.

PFMC. 2020. Preseason Report I: Stock Abundance Analysis and Environmental Assessment Part 1 for 2020 Ocean Salmon Fishery Regulations. (Document prepared for the Council and its advisory entities.) Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, Oregon 97220-1384.

Pitman, R.L. 1990. Pelagic distribution and biology of sea turtles in the eastern tropical Pacific. Pages 143-148 in Richardson, T.H., J.I. Richardson, and M. Donnelly (compilers). Proceedings of the Tenth Annual Workshop on Sea Turtle Biology and Conservation, NOAA Technical Memorandum NMFS-SEFC-278.

Plotkin, P.T., R.A. Bales, and D.C. Owens. 1993. Migratory and reproductive behavior of Lepidochelys olivacea in the eastern Pacific Ocean. Schroeder, B.A. and B.E. Witherington (Compilers). Proc. of the Thirteenth Annual Symp. on Sea Turtle Biology and Conservation. NOAA, NMFS, Southeast Fish. Sci. Cent. NOAA Tech. Mem. NMFS-SEFSC-31.

Plotkin, P.T., R.A. Byles and D.W. Owens. 1994. Post-breeding movements of male olive ridley sea turtles Lepidochelys olivacea from a nearshore breeding area. Page 119, 14th Annual Symposium, Sea Turtle Biology and Conservation, Mar. 1-5, 1994, Hilton Head, South Carolina.

Polovina, J.J., E. Howell, D.M. Parker, G.H. Balazs. 2003. Dive-depth distribution of loggerhead (Caretta caretta) and olive ridley (Lepidochelys olivacea) sea turtles in the central North Pacific: Might deep longline sets catch fewer turtles? Fishery Bulletin 101:189-193.

Polovina, J.J., G.H. Balazs, E. A. Howell, D.M. Parker, M.P. Seki and P.H. Dutton. 2004. Forage and migration habitat of loggerhead (Caretta caretta) and olive ridley (Lepidochelys olivacea) sea turtles in the central North Pacitic. Fisheries Oceanography 13(1):36-51.

Polovina, J.J., I. Uchida, G.H. Balazs, E.A. Howell, D.M. Parker, and P.H. Dutton. 2006. The Kuroshio Extension Bifurcation Region: a pelagic hotspot for juvenile loggerhead sea turtles. Deep-sea Research II 53:326-339.

Popper, A.N. 2008. Effects of Mid- and High-Frequency Sonars on Fish. Environmental BioAcoustics, LLC. Contract N66604-07M-6056 Naval Undersea Warfare Center Division Newport, Rhode Island. February 2008. 52 p.

Popper, A.N., and M.C. Hastings. 2009. The effects on fish of human-generated (anthropogenic) sound. Integrative Zoology 4:43-52.

Popper, A.N., T.J Carlson, B.M. Casper, and M.B. Halvorsen. 2014. Does man-made sound harm fishes? The Journal of Ocean Technology 9(1):11-20.

Pritchard, P.C.H. 1982. Nesting of the leatherback turtle Dermochelys coriacea, in Pacific Mexico, with a new estimate of the world population status. Copeia 1982:741-747.

Quick, N., L. Scott-Hayward, D. Sadykova, D. Nowacek, and A. Read. 2017. Effects of a scientific echo sounder on the behavior of short finned pilot whales (Globicephala macrorhynchus). Can. J. Fish. Aquat. Sci. 74(5): 716–726. https://doi.org/10.1139/cjfas-2016-0293

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

Quinn, T.J., and H.J. Niebauer. 1995. Relation of eastern Bering Sea walleye pollock (Theragra chalcogramma) recruitment to environmental and oceanographic variables. In: Canadian Special Publication of Fisheries and Aquatic Sciences (Climate Change and Northern Fish Populations, Victoria, B.C., 19 October, 1992-24 October, 1992) (ed. R.J. Beamish) 121, National Research Council, Ottawa, 497-507.

Raymondi, R.R., J.E. Cuhaciyan, P. Glick, S.M. Capalbo, L.L. Houston, S.L. Shafer, and O. Grah. 2013. Water Resources: Implications of Changes in Temperature and Precipitation in Climate Change in the Northwest: Implications for Our Landscapes, Waters, and Communities, M. M. Dalton, P. W. Mote, and A. K. Snover, Eds., Island Press, Washington, DC, pp. 41-58.

Raum-Suryan, K.L, M.J. Rehberg, G.W. Pendleton, K.W. Pitcher, and T.S. Gelatt. 2004. Development of dispersal, movement patterns, and haul-out use by pup and juvenile Steller sea lions (Eumetopias jubatus) in Alaska. Mar Mammal Sci 20(4):823-850.

Reeder, W.S., P.R. Ruggiero, S.L. Shafer, A.K. Snover, L.L Houston, P. Glick, J.A. Newton, and S.M. Capalbo. 2013. Coasts: Complex Changes Affecting the Northwest's Diverse Shorelines. in Climate Change in the Northwest: Implications for Our Landscapes, Waters, and Communities, M.M. Dalton, P.W. Mote, and A.K. Snover, Eds. Island Press, Washington, DC, pp 41-58.

Resendiz, A., B. Resendiz, W.J. Nichols, J.A. Seminoff, and N. Kamezaki. 1998. First confirmed east-west transpacific movement of a loggerhead sea turtle, Caretta caretta, released in Baja California, Mexico. Pacific Science 52(2):151-153.

Richardson, W. J., C. R. J. Green, C. I. Malme, and D. H. Thomson. 1995. Marine Mammals and Noise. San Diego, CA, Academic Press.

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

Ridgeway, S.H., E.G. Wever, J.G. McCormick, J. Palin, and J.H. Anderson. 1969. Hearing in the giant sea turtle, Chelonia mydas. Proc. Nat. Acad. Sci (USA) 64:884-890.

Robinson, R.A., H. Crick, J.A. Learmonth, I. Maclean, C.D. Thomas, F. Bairlein, M.C. Forchhammer, C.M. Francis, J.A. Gill, B.J. Godley, J. Harwood, G.C Hays, B. Huntley, A.M. Hutson, G.J. Pierce, M.M. Rehfisch, D.W. Sims, M.B. Santos, T.H. Sparks, D.A. Stroud, and M.E. Visser. 2008. Traveling through a warming world: climate change and migratory species. Endangered Species Research: published online June 17, 2008.

Rowlett, R.A., G.A. Green, C.E. Bowlby, and M.A. Smultea. 1994. The first photographic documentation of a northern right whale off Washington State. (Eubalaena glacialis). Northwestern Naturalist. 75(3):102-104.

Ryder, C.E., T.A. Conant, and B.A. Schroeder. 2006. Report of the Workshop on Marine Turtle Longline Post-Interaction Mortality. U.S. Dept. of Commer., NOAA Tech. Memo. NMFSOPR-29. 40 p.

Ryer, C.H. 2004. Laboratory evidence for behavioral impairment of fish escaping trawls: a review. ICES Journal of Marine Science. 61:1157-1164.

Ryer, C.H., M.L. Ottmar, and E.A. Sturm. 2004. Behavioral impairment after escape from trawl codends may not be limited to fragile fish species. Fisheries Research. 66:261-269.

Saba, V.S., C.A. Stock, J.R. Spotila, F.V. Paladino and P. Santidrian Tomillo. 2012. Projected response of an endangered marine turtle population to climate change. Nature Climate Change Vol 2: 814-820.

Saez, L., D. Lawson, and M. DeAngelis. 2020. Large whale entanglements off the U.S. West Coast, from 1982-2017. NOAA Tech. Memo. NMFS-OPR-63, 48 p.

Sandercock, F.K. 1991. Life history of coho salmon. Pp. 397-445 in Groot and Margolis, “Pacific Salmon Life Histories”, 1991.

Santos, R.G., R. Andres, M. Boldrini, and A.S. Martins. 2015. Debris ingestion by juvenile marine turtles: An underestimated problem. Marine pollution bulletin. 93. 37-43.

Satterthwaite, W.H. M.S. Mohr, M.R. O’Farrell, E.C. Anderson, M.A. Banks, S.J. Bates, M.R. Bellinger, L.A. Borgerson, E.D. Crandall, J.C. Garza, B.J. Kormos, P.W. Lawson, and M.L. Palmer-Zwahlen. 2014. Use of Genetic Stock Identification Data for comparison of the ocean spatial distribution, size at age, and fishery exposure of an untagged stock and its indicator:

California Coastal versus Klamath River Chinook salmon. Transactions of the American Fisheries Society 143:117-133, DOI: 10.1080/00028487.2013.837096

Scarff, J.E. 1986. Historic and present distribution of the right whale (Eubalaena glacialis) in the eastern North Pacific south of 50°N and east of 180°W. Reports of the International Whaling Commission Special Issue. 10:43-63.

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

Schofield. G., C.M Bishop, G. MacLean, P. Brown, M. Baker, K.A. Katselidis, P. Dimopoulos, J.D Pantis, and G.C. Hays. 2007. Novel GPS tracking of sea turtles as a tool for conservation management. J.Expt. Mar.Biol.Ecol. 347:58-68.

Scott, W.B., and E.J. Crossman. 1973. Freshwater Fishes of Canada. Bulletin 184, Fisheries Research Board of Canada, Ottawa.

Scheuerell, M.D. and J.G. Williams. 2005. Forecasting climate-induced changes in the survival of Snake River spring/summer Chinook salmon (Oncorhynchus tshawytscha). Fisheries Oceanography 14:448-457.

Scholik, A.R. and H.Y. Yan. 2001. The effects of underwater noise on auditory sensitivity of fish. Proceedings of the Institute of Acoustics 23(4):27.

Scholik, A.R. and H.Y. Yan. 2002. The effects of noise on the auditory sensitivity of the bluegillsunfish,Lepomis macrochirus. Comparative Biochemistry and Physiology-Part A: Molecular & Integrative Physiology133(1):43-52.

Seiler, D., G. Volkhardt, P. Topping, and L. Kishimoto. 2002. 2000 Green River juvenile salmonid production evaluation. Washington Department of Fish and Wildlife.

Seiler, D., G. Volkhardt, P. Topping, L. Fleischer, T. Miller, S. Schonning, D. Rawding, M. Groesbeck, R. Woodard, and S. Hawkins. 2004. 2003 juvenile salmonid production evaluation report. Green River, Wenatchee River, and Cedar Creek. Washington Department of Fish and Wildlife.

Seiler, D., G. Volkhardt, and L. Fleischer. 2005. Evaluation of downstream migrant salmon production in 2004 from the Cedar River and Bear Creek. Washington Department of Fish and Wildlife.

Seminoff. J.A., W.J. Nichols, A. Resendiz, and L. Brooks. 2003. Occurrence of hawksbill turtles, Eretmochelys imbricata (Reptilia: Cheloniidae), near the Baja California Peninsula, Mexico. Pacific Science 57(1):9-16.

Seminoff , J.A., T. Eguchi, J. Carretta, C.D. Allen, D. Prosperi, R. Rangel, J.W. Gilpatrick Jr., K. Forney, S.H. Peckham. 2014. Loggerhead sea turtle abundance at a foraging hotspot in the

eastern Pacific Ocean: implications for at-sea conservation. Endangered Species Research 24:207-220.

Seminoff, J.A., S.R. Benson, K.E. Arthur, T. Eguchi, P.H. Dutton, R.F. Tapilatu, and B.N. Popp. 2012. Stable isotope tracking of endangered sea turtles: validation with satellite telemetry and δ15N analysis of amino acids. PLoS ONE 7(5):e37403 11 pages.

Seminoff, J.A., C.D. Allen, G.H. Balazs, P.H. Dutton, T. Eguchi, H.L. Haas, S.A. Hargrove,M.P. Jensen, D.L. Klemm, A.M. Lauritsen, S.L. MacPherson, P. Opay, E.E. Possardt, S.L. Pultz, E.E. Seney, K.S. Van Houtan, R.S. Waples. 2015. Status Review of the Green Turtle (Chelonia mydas) Under the U.S. Endangered Species Act. NOAA Technical Memorandum, NOAA-NMFS-SWFSC-539. 571pp.

Senko, J., A.J. Schneller, J. Solis, F. Ollervides, and W.J. Nichols. 2011. People helping turtles, turtles helping people: Understanding resident attitudes towards sea turtle conservation and opportunities for enhanced community participation in Bahia Magdalena, Mexico. Ocean and Coastal Management 54:148-157.

Shapavolov, L., and A.C. Taft. 1954. The life histories of the steelhead rainbow trout (Salmo gairdneri gairdneri) and silver salmon (Oncorhynchus kisutch) with special reference to Waddell Creek, California, and recommendations regarding their management. California Department of Fish and Game, Fish Bulletin 98:1-375.

Shelton, A., W. Satterthwaite, E. Ward, B. Feist and B. Burke. 2019. Using hierarchical models to estimate stock-specific and seasonal variation in ocean distribution, survivorship, and aggregate abundance of fall run Chinook salmon. Can. J. Fish. Aquatic. Sci. 76: 95-108, found at https://doi.org/10.1139/cjfas-2017-0204

Shenker, J.M. 1984. Scyphomedusae in surface waters near the Oregon coast, May-August, 1981. Estuarine Coastal Shelf Science. Volume 19, pages 619 to 632.

Shillinger, G.L., A.M. Swithenbank, H. Bailey, S.J. Bograd, M.R. Castelton, B.P. Wallace, J.R. Spotila, F.P. Paladino, R. Piedra, and B.A. Block. 2011. Vertical and horizontal habitat preferences of post-nesting leatherback turtles in the South Pacific Ocean. Marine Ecology Progress Series 422:275–289.

Shirvell, C.S. 1990. Role of instream rootwads as juvenile coho salmon (Oncorhynchus kisutch) and steelhead trout (O. mykiss) cover habitat under varying stream flows. Canadian Journal of Fisheries and Aquatic Sciences 47:852-860.

Short, F.T., and H.A. Neckles. 1999. The effects of climate change on seagrasses. Aquatic Botany 63:169-196.

Silva-Batiz, F.A., E. Godinez-Dominguez, J.A. Trejo-Robles. 1996. Status of the olive ridley nesting population in Playon de Mismaloya, Mexico: 13 years of data. Pg.302, 15th Annual

Symposium, Sea Turtle Biology and Conservation, Feb. 20-25, 1995, Hilton Head, South Carolina.

Skalski, J.R., W.H. Pearson, and C.I. Malme. 1992. Effects of sounds from a geophysical survey device on catch-per-unit-effort in a hook-and-line fishery for rockfish (Sebastes spp.). Canadian Journal of Fisheries and Aquatic Sciences 49:1357-1365.

Sounhein, B., E. Brown, M. Lewis and M. Weeber. 2014. Status of Oregon stocks of coho salmon, 2013. Monitoring Program Report Number OPSW-ODFW-2014-3, Oregon Department of Fish and Wildlife, Salem, Oregon.

Sounhein, B., E. Brown, M. Lewis and M. Weeber. 2015. Status of Oregon stocks of coho salmon, 2014. Monitoring Program Report Number OPSW-ODFW-2015-3, Oregon Department of Fish and Wildlife, Salem, Oregon.

Sounhein, B., E. Brown, M. Lewis and M. Weeber. 2016. Status of Oregon stocks of coho salmon, 2015. Monitoring Program Report Number OPSW-ODFW-2016-3, Oregon Department of Fish and Wildlife, Salem, Oregon.

Sounhein, B., E. Brown, M. Lewis and M. Weeber. 2017. Status of Oregon stocks of Coho Salmon, 2016. Monitoring Program Report Number OPSW-ODFW-2017-3, Oregon Department of Fish and Wildlife, Salem, Oregon.

Sounhein, B., E. Brown, M. Lewis and M. Weeber. 2018. Western Oregon adult Coho Salmon, 2017 spawning survey data report. Monitoring Program Report Number OPSW-ODFW-2018-3, Oregon Department of Fish and Wildlife, Salem, Oregon.

Southall, B.L., A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R. Greene Jr., D. Kastak, D.R. Ketten, J.H. Miller, P.E. Nachtigall, W.J. Richardson, J.A. Thomas, and P.L. Tyack. 2007. Marine mammal noise exposure criteria: initial scientific recommendations. Aquatic Mammals 33:411-521.

Southall, B.L., J.J. Finneran, C. Reichmuth, P.E. Nachtigall, D.R. Ketten, A.E. Bowles, W.T. Ellison, D.P. Nowacek and P.L. Tyack .2019. Marine Mammal Noise Exposure Criteria: Updated Scientific Recommendations for Residual Hearing Effects. Aquatic Mammals 45(2): 125-232.

Spotila, J.R., A.E. Dunham, A.J. Leslie, A.C. Steyermark, P.T. Plotkin and F.V. Paladino. 1996. Worldwide population decline of Dermochelys coriacea: Are leatherback turtles going extinct? Chelonian Conservation and Biology 2(2):209-222.

Spotila, J.R., R.D. Reina, A.C. Steyermark, P.T. Plotkin and F.V. Paladino. 2000. Pacific leatherback turtles face extinction. Nature 45:529-530.

SSDC (Shared Strategy Development Committee). 2007. Puget Sound Salmon Recovery Plan. Adopted by the National Marine Fisheries Service January 19, 2007. Available on-line at PS Salmon Recovery Plan weblink

Starbird, C.H., A. Baldridge, and J.T. Harvey. 1993. Seasonal occurrence of leatherback sea turtles (Dermochelys coriacea) in the Monterey Bay region, with notes on other sea turtles 1986-1991. California Fish and Game. Volume 79(2), pages 54 to 62.

STAJ (Sea Turtle Association of Japan). Matsuzawa, Y. 2009. Nesting beach management in Japan to conserve eggs and pre-emergent hatchlings of the north Pacific loggerhead sea turtle. Final Contract Report to the WPRFMC.

STAJ (Sea Turtle Association of Japan). Matsuzawa, Y. 2010. Nesting beach management in Japan to conserve eggs and pre-emergent hatchlings of the north Pacific loggerhead sea turtle. Final Contract Report to the WPRFMC.

STAJ (Sea Turtle Association of Japan). Matsuzawa, Y. 2012. Nesting beach management in Japan to conserve eggs and pre-emergent hatchlings of the north Pacific loggerhead sea turtle. Final Contract Report to the WPRFMC.

Suchman, C.L., and R.D. Brodeur. 2005. Abundance and distribution of large medusae in surface waters of the northern California Current: Deep Sea Research II. Volume 52, pages 51 to 72.

Sunda, W.G., and W.J. Cai. 2012. Eutrophication induced CO2-acidification of subsurface coastal waters: interactive effects of temperature, salinity, and atmospheric p CO2. Environmental Science & Technology. 46(19):10651-10659.

Suuronen, P., D. Erickson, and A/ Orrensalo. 1996. Mortality of herring escaping from pelagic trawl codends. Fisheries Research 25:305-321.

Swain, D.L., B. Langenbrunner, and J.D Neelin. 2018. Increasing precipitation volatility in twenty-first-century California. Nature Clim Change 8, 427–433 (2018). https://doi.org/10.1038/s41558-018-0140-y

SWFSC. 2019a. SWFSC Incidental Take of ESA Listed Salmonids From 2016-2018. Draft report of the SWFSC Salmon Working Group. NOAA Southwest Fisheries Science Center. May, 2019.

SWFSC. 2019b. Memorandum to the Record regarding the Exceedance of Authorized Take of Salmon. Memo from Kristen C. Koch, Director, SWFSC, to the record. May 30, 2019.

Tague, C.L., J.S. Choate, and G. Grant. 2013. Parameterizing sub-surface drainage with geology to improve modeling streamflow responses to climate in data limited environments. Hydrology and Earth System Sciences. 17(1): 341-354.

Tapilatu. R.F., P.H. Dutton, T. Wibbels, H.V. Fedinandus, W.G. lwanggin, and B.H. Nugroho. 2013. Long-term decline of the western Pacific leatherback, Dermochelys coriacea; a globally important sea turtle population. Ecosphere 4(2).

Tillmann, P., and D. Siemann. 2011. Climate Change Effects and Adaptation Approaches in Marine and Coastal Ecosystems of the North Pacific Landscape Conservation Cooperative Region. National Wildlife Federation.

Tomaszewicz, C.N. J.A. Seminoff, L. Avens, L.R. Goshe, S.H. Peckham, J.M. Rguez-Baron, K. Bickerman, C.M. Kurle. 2015. Age and residency duration of loggerhead turtles at a North Pacific bycatch hotspot using skeletochronology. Biological Conservation 186:134-142.

Tomillo, S.T., V.S. Saba, G.S. Blanco, C.A. Stock, F.V. Paladino, and J.R. Spotila. 2012. Climate Driven Egg and Hatchling Mortality Threatens Survival of Eastern. Pacific Leatherback Turtles. PLoS ONE 7(5): e37602.

Tschaplinski, P.J. 1988. The use of estuaries as rearing habitats by juvenile coho salmon. In Proceedings of a Workshop: Applying 15 years of Carnation Creek Results. Edited by T.W. Chamberlin. Carnation Creek Steering Committee, Nanaimo, B.C. pp.123-142.

UCSRB (Upper Columbia Salmon Recovery Board). 2007. Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan. 352 pp.

Urbán, J.R., D. Weller, O. Tyurneva, S. Swartz, A. Bradford, Y. Yakovlev, O. Sychenko, N.H. Rosales, S. Martínez A., A. Burdin, and A. Gómez-Gallardo. 2012. Photographic comparison of the western and Mexican gray whale catalogues: 2012. Laguna San Ignacio Ecosystem Science Program, June 2012.

Urbán, J.R., D. Weller, O. Tyurneva, S. Swartz, A. Bradford, Y. Yakovlev, O. Sychenko, N.H. Rosales, S. Martínez, A., Burdin, and A. Gómez-Gallardo. 2013. Report on the photographic comparison of the Sakhalin Island and Kamchatka Peninsula with the Mexican gray whale catalogues. Paper SC/65a/BRG04 presented to the International Whaling Commission Scientific Committee.

Van Houtan, K.S. 2011. Assessing the impact of fishery actions to marine turtle populations in the North Pacific using classical and climate-based models. National Marine Fisheries Service, Pacific Islands Fisheries Science Center, PIFSC Internal Report IR-11-024. 25 p.

Van Houtan, K.S. 2014. Addendum to an assessment of the impact of the Hawaii deep-set longline fishery to marine turtle populations in the North Pacific Ocean. National Marine Fisheries Service, Pacific Islands Fisheries Science Center, PIFSC Internal Report IR-14-021.

Van Houtan, K.S., and O.L. Bass. 2007. Stormy Oceans are associated with declines in sea turtle hatching. Current Biology Vol 17 No.15.

Van Houtan, K.S. and J.M Halley. 2011. Long-Term Climate Forcing in Loggerhead Sea Turtle Nesting. PLoS ONE 6(4): e19043. doi:I0.1371/journal.pone.0019043

Vanderlaan, A.S.M., and C.T. Taggart. 2007. Vessel collisions with whales: The probability of lethal injury based on vessel speed. Marine Mammal Science 23:144-156.

Varghese, K.H., J. Miksis-Olds, N. DiMarzio, K. Lowell, E. Linder, L. Mayer, and D. Moretti. 2020. The effect of two 12 kHz multibeam mapping surveys on the foraging behavior of Cuvier's beaked whales off of southern California. The Journal of the Acoustical Society of America 147: 3849. https://doi.org/10.1121/10.0001385

Volkhardt, G., P. Topping, L. Fleischer, T. Miller, S. Schonning, D. Rawding, M. Groesbeck. 2005. 2004 Juvenile salmonid production evaluation report. Green River, Wenatchee River, and Cedar Creek. Washington Department of Fish and Wildlife.

Wade, P.R. 2017. Estimates of abundance and migratory destination for North Pacific humpback whales in both summer feeding areas and winter mating and calving areas – revision of estimates in SC/66b/IA21. Paper SC/A17/NP11 presented to the IWC Workshop on the Comprehensive Assessment of North Pacific Humpback Whales, 18-21 April 2017, Seattle, USA. 9pp. Available at https://archive.iwc.int/.

Wainwright, T.C. and L.A. Weitkamp. 2013. Effects of Climate Change on Oregon Coast Coho Salmon: Habitat and Life-Cycle Interactions. Northwest Science. 87:219-242.

Waite, J.M., K. Wynne, and D.K. Mellinger. 2003. Documented sighting of a North Pacific right whale in the Gulf of Alaska and post-sighting acoustic monitoring. Northwestern Naturalist. 84(1):38-43.

Wallace B.P., A.D. DiMatteo, B.J. Hurley, E.M. Finkbeiner, and A.B. Bolten. 2010. Regional Management Units for Marine Turtles: A Novel Framework for Prioritizing Conservation and Research across Multiple Scales. PLoS ONE 5(12): e15465.doi:10.13711joumal.pone.0015465.

Ward, B.R., and P.A. Slaney. 1993. Egg-to-smolt survival and fry-to-smolt density dependence of Keogh River steelhead trout. Pages 209-217 in R.J. Gibson and R.E. Cutting [editors] Production of juvenile Atlantic salmon, Salmo salar, in natural waters. Canadian Special Publication Fisheries and Aquatic Sciences 118.

Ward, E.J., M.J. Ford, R.G. Kope, J.K.B. Ford, L.A. Velez-Espino, C.K. Parken, L.W. LaVoy, M.B. Hanson, and K.C. Balcomb. 2013. Estimating the impacts of Chinook salmon abundance and prey removal by ocean fishing on Southern Resident killer whale population dynamics. U.S. Dept. Commer., NOAA Tech. Memo. NMFS--NWFSC--123.

Watkins, W.A. and W.E. Schevill. 1975. Sperm whales (Physter catodon) react to pingers. Deep-Sea Research 22: 123-129.

Watkins, W.A., K.E. Moore, and P. Tyack. 1985. Sperm whale acoustic behaviors in the southeast Caribbean. Cetology 49:1-15.

WDFW. 2018. 2018 WDFW Future Brood Document Final. Available at https://wdfw.wa.gov/fishing/management/hatcheries/future-brood.

WDFW. 2020. 2020 WDFW Future Brood Document Final. Available at https://wdfw.wa.gov/fishing/management/hatcheries/future-brood.

WDFW/PNPTT (Washington Department of Fish and Wildlife and Point No Point Treaty Tribes). 2000. Summer chum salmon conservation initiative. Washington Department of Fish and Wildlife, Olympia.

Webster, P.J., G.J. Holland, J.A. Curry, and H.-R. Chang. 2005. Changes in tropical cyclone number, duration, and intensity in a warming environment. Science 309:1844-1846.

Weitkamp, L.A. 2010. Marine distributions of Chinook salmon from the west coast of North America determined by coded wire tag recoveries, Transactions of the American Fisheries Society 139:147-170.

Weitkamp, L. and K. Neely. 2002. Coho salmon (Oncorhynchus kistuch) ocean migration patterns: insight from marine coded-wire tag recoveries. Canadian Journal of Fisheries and Aquatic Sciences 59:1100-11115.

Welch, D.W., M.C. Melnychuk, J.C. Payne, E.L. Rechisky, A.D. Porter, G.D. Jackson, B.R. Ward, S.P. Vincent, C.C. Wood, and J. Semmens. 2011. In situ measurement of coastal ocean movements and survival of juvenile Pacific salmon. Proceedings of the National Academy of Sciences of the United States of America 108:8708-8713

Welch, H., E.L. Hazen, D.K. Brisco, S.J. Bograd, M.G. Jacox, T. Eguchi,, S.R. Benson, C.C. Fahy, T. Garfield, D. Robinson, J.A. Seminoff, and H. Bailey. 2019. Environmental indicators to reduce loggerhead turtle bycatch offshore of Southern California. Ecological Indicators 98:657–664.

Weller, D.W. A. Klimek, A.L. Bradford, J. Calambokidis, A.R. Lang, B. Gisborne, A.M. Burdin, W. Szaniszlo, J. Urbán, A. Gomez-Gallardo Unzueta, S. Swartz, and R.L. Brownell. 2012. Movements of gray whales between the western and eastern North Pacific. Endangered Species Research 18:193-199.

Wells, B.K., C.B. Grimes, J.C. Field and C.S. Reiss. 2006. Covariation between the average lengths of mature coho (Oncorhynchus kisutch) and Chinook salmon (O. tshawytscha) and the ocean environment. Fish. Oceanogr. 15:1, 67–79.

Westerling, A.L. 2018. Wildfire Simulations for California's Fourth Climate Change Assessment: Projecting Changes in Extreme Wildfire Events with a Warming Climate.

California's Fourth Climate Change Assessment, California Energy Commission. Publication Number: CCCA4-CEC-2018- 014.

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

Williams, T.H., B.C. Spence, D.A. Boughton, R.C. Johnson, L. Crozier, N. Mantua, M. O'Farrell, and S.T. Lindley. 2016. Viability assessment for Pacific salmon and steelhead listed under the Endangered Species Act: Southwest.2 February 2016 Report to National Marine Fisheries Service –West Coast Region from Southwest Fisheries Science Center, Fisheries Ecology Division 110 Shaffer Road, Santa Cruz, California 95060. 182 p.

Willson, M.F., R.H. Armstrong, M.C. Hermans, and K. Koski. 2006. Eulachon: a review of biology and an annotated bibliography. Alaska Fisheries Science Center Processed Report 2006-12. Auke Bay Laboratory, Alaska Fish. Sci. Cent., NOAA, NMFS, Juneau, Alaska.

Winder, M. and D.E. Schindler. 2004. Climate change uncouples trophic interactions in an aquatic ecosystem. Ecology. 85:2100–2106.

Wingfield, O.K., S.H. Peckham, D.G. Foley, D.M. Palacios, B.E. Lavaniegos, R. Durazo, W.J. Nichols, D.A. Croll, and S.J. Bograd. 2011. The making of a productivity hotspot in the coastal ocean. PLoS ONE 6(11):e27874.

Young, C.N., Carlson, J., Hutchinson, M., Hutt, C., Kobayashi, D., McCandless, C.T., Wraith, J. 2018. Status review report: oceanic whitetip shark (Carcharhinius longimanus). FinalReport totheNational Marine Fisheries Service, Office of Protected Resources. December 2017. 170pp.

Zabel, R.W., M.D. Scheuerell, M.M. McClure, and J.G. Williams. 2006. The interplay between climate variability and density dependence in the population viability of Chinook salmon. Conservation Biology. 20(1):190-200.

Zabel, R.W. 2014. Memorandum to Donna Weiting: Estimation of Percentages for Listed Pacific Salmon and Steelhead Smolts Arriving at Various Locations in the Columbia River Basin in 2014. Northwest Fisheries Science Center. November 4, 2014.

Zabel, R.W. 2015. Memorandum to Donna Weiting: Estimation of Percentages for Listed Pacific Salmon and Steelhead Smolts Arriving at Various Locations in the Columbia River Basin in 2015. Northwest Fisheries Science Center. October 5, 2015.

Zabel, R.W. 2017a. Memorandum for Christopher E. Yates: Update, Corrected Estimation of Percentages for Listed Pacific Salmon and Steelhead Smolts Arriving at Various Locations in the Columbia River Basin in 2016. Northwest Fisheries Science Center. January 25, 2017.

Zabel, R.W. 2017b. Memorandum for Chris Yates: Estimation of Percentages for Listed Pacific Salmon and Steelhead Smolts Arriving at Various Locations in the Columbia River Basin in 2017. Northwest Fisheries Science Center. November 3, 2017.

Zabel, R.W. 2018. Memorandum for Chris Yates: Estimation of Percentages for Listed Pacific Salmon and Steelhead Smolts Arriving at Various Locations in the Columbia River Basin in 2018. Northwest Fisheries Science Center. December 18, 2018.

Zabel, R.W. 2020. Memorandum for Chris Yates: Estimation of Percentages for Listed Pacific Salmon and Steelhead Smolts Arriving at Various Locations in the Columbia River Basin in 2019. Northwest Fisheries Science Center. February 13, 2020.

5. APPENDICES

Appendix 1. Listing classification and date, recovery plan reference, most recent status review, status summary, and limiting factors for each ESA-listed salmonid species considered in this opinion.

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
Puget Sound Chinook salmon	Threatened 06/28/2005 (70 FR 37160)	SSDC 2007 NMFS 2006d	NWFSC 2015	This ESU comprises 22 populations distributed over five geographic areas. Most populations within the ESU have declined in abundance over the past 7 to 10 years, with widespread negative trends in natural-origin spawner abundance, and hatchery-origin spawners present in high fractions in most populations outside of the Skagit watershed. Escapement levels for all populations remain well below the Technical Recovery Team (TRT) planning ranges for recovery, and most populations are consistently below the spawner-recruit levels identified by the TRT as consistent with recovery.	• Degraded f structure • Degraded of estuarin • Degraded river large • Excessive f spawning g • Degraded • Degraded • Impaired p • Severely al
Puget Sound steelhead	Threatened 05/11/2007 (72 FR 26722)	NMFS 2018f (draft)	NWFSC 2015	This DPS comprises 32 populations. The DPS is currently at very low viability, with most of the 32 populations and all three population groups at low viability. Information considered during the most recent status review indicates that the biological risks faced by the Puget Sound Steelhead DPS have not substantively changed since the listing in 2007, or since the 2011 status review. Furthermore, the Puget Sound Steelhead TRT recently concluded that the DPS was at very low viability, as were all three of its constituent MPGs, and many of its 32 populations. In the near term, the outlook for environmental conditions affecting Puget Sound steelhead is not optimistic. While harvest and hatchery production of steelhead in Puget Sound are currently at low levels and are not likely to increase substantially in the foreseeable future, some recent environmental trends not favorable to Puget Sound steelhead survival and production are expected to continue.	• Continued de habitat • Widespread d despite signifi • Threats to div hatchery stee • Declining dive uncertain but fish • A reduction in • Reduced habi • Urbanization • Dikes, harden channelizatio
Upper Columbia River steelhead	Threatened 01/05/2006 (71 FR 834)	UCSRB 2007	NWFSC 2015	This DPS comprises four independent populations. Three populations are at high risk of extinction while 1 population is at moderate risk. Upper Columbia River steelhead populations have increased relative to the low levels observed in the 1990s, but natural-origin abundance and productivity remain well below viability thresholds for three out of the four populations. The status of the Wenatchee River steelhead population continued to improve based on the additional year's information available for the most recent review. The abundance and productivity viability rating for	• Adverse effec Columbia Riv • Impaired tribu • Degraded floo function, char riparian areas recruitment, • Hatchery-rela • Predation and • Harvest-relate

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				the Wenatchee River exceeds the minimum threshold for 5% extinction risk. However, the overall DPS status remains unchanged from the prior review, remaining at high risk driven by low abundance and productivity relative to viability objectives and diversity concerns.	
Middle Columbia River steelhead	Threatened 01/05/2006 (71 FR 834)	NMFS 2009	NWFSC 2015	This DPS comprises 17 extant populations. The DPS does not currently include steelhead that are designated as part of an experimental population above the Pelton Round Butte Hydroelectric Project. 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 DPS is not currently meeting the viability criteria in the MCR steelhead recovery plan. In general, the majority of population level viability ratings remained unchanged from prior reviews for each major population group within the DPS.	• Degraded fres • Mainstem Col related impac • Degraded est habitat • Hatchery-rela • Harvest-relate • Effects of pre disease
Lower Columbia River Chinook salmon	Threatened 06/28/2005 (70 FR 37160)	NMFS 2013d	NWFSC 2015	This ESU comprises 32 independent populations. Twenty-seven populations are at very high risk, 2 populations are at high risk, one population is at moderate risk, and 2 populations are at very low risk. Overall, there was little change since the last status review in the biological status of this ESU, although there are some positive trends. Increases in abundance were noted in about 70% of the fall-run populations and decreases in hatchery contribution were noted for several populations. Relative to baseline VSP levels identified in the recovery plan, there has been an overall improvement in the status of a number of fall-run populations, although most are still far from the recovery plan goals.	• Reduced acce habitat • Hatchery-rela • Harvest-relate salmon • An altered flo plume • Reduced acce habitat • Reduced proc sediment and the estuary • Contaminant
Lower Columbia River coho salmon	Threatened 06/28/2005 (70 FR 37160)	NMFS 2013d	NWFSC 2015	Of the 24 populations that make up this ESU, 21 populations are at very high risk, 1 population is at high risk, and 2 populations are at moderate risk. Recent recovery efforts may have contributed to the observed natural production, but in the absence of longer term data sets it is not possible to parse out these effects. Populations with longer term data sets exhibit stable or slightly positive abundance trends. Some trap and haul programs appear to be operating at or near replacement, although other programs still are far from that threshold and require supplementation with additional hatchery-origin spawners .Initiation of or improvement in the downstream juvenile facilities at Cowlitz Falls, Merwin, and North Fork Dam are likely to further improve the	• Degraded est habitat • Fish passage b • Degraded fres related effect • Harvest-relate • An altered flo plume • Reduced acce habitat in the • Reduced proc sediment and the estuary • Juvenile fish v • Contaminants

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				status of the associated upstream populations. While these and other recovery efforts have likely improved the status of a number of coho salmon populations, abundances are still at low levels and the majority of the populations remain at moderate or high risk. For the Lower Columbia River region land development and increasing human population pressures will likely continue to degrade habitat, especially in lowland areas. Although populations in this ESU have generally improved, especially in the 2013/14 and 2014/15 return years, recent poor ocean conditions suggest that population declines might occur in the upcoming return years	
Lower Columbia River steelhead	Threatened 01/05/2006 (71 FR 834)	NMFS 2013d	NWFSC 2015	This DPS comprises 23 historical populations, 17 winter-run populations and six summer-run populations. Nine populations are at very high risk, 7 populations are at high risk, 6 populations are at moderate risk, and 1 population is at low risk. The majority of winter-run steelhead populations in this DPS continue to persist at low abundances. Hatchery interactions remain a concern in select basins, but the overall situation is somewhat improved compared to prior reviews. Summer-run steelhead populations were similarly stable, but at low abundance levels. The decline in the Wind River summer-run population is a source of concern, given that this population has been considered one of the healthiest of the summer-runs; however, the most recent abundance estimates suggest that the decline was a single year aberration. Passage programs in the Cowlitz and Lewis basins have the potential to provide considerable improvements in abundance and spatial structure, but have not produced self-sustaining populations to date. Even with modest improvements in the status of several winter-run DIPs, none of the populations appear to be at fully viable status, and similarly none of the MPGs meet the criteria for viability.	• Degraded est habitat • Degraded fres • Reduced acce habitat • Avian and ma • Hatchery-rela • An altered flo plume • Reduced acce habitat in the • Reduced proc sediment and the estuary • Juvenile fish v • Contaminants
Columbia River chum salmon	Threatened 06/28/2005 (70 FR 37160)	NMFS 2013d	NWFSC 2015	Overall, the status of most chum salmon populations is unchanged from the baseline VSP scores estimated in the recovery plan. A total of 3 of 17 populations are at or near their recovery viability goals, although under the recovery plan scenario these populations have very low recovery goals of 0. The remaining populations generally require a higher level of viability and most require substantial improvements to reach their viability goals. Even with the improvements observed during the last five years, the majority of populations in this ESU	• Degraded est habitat • Degraded fres • Degraded stre hydropower a • Reduced wate • Current or po • An altered flo plume • Reduced acce habitat in the

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				remain at a high or very high risk category and considerable progress remains to be made to achieve the recovery goals.	• Reduced proc sediment and the estuary • Juvenile fish v • Contaminants
Upper Willamette River Chinook salmon	Threatened 06/28/2005 (70 FR 37160)	ODFW and NMFS 2011	NWFSC 2015	This ESU comprises seven populations. Five populations are at very high risk, one population is at moderate risk (Clackamas River) and one population is at low risk (McKenzie River). Consideration of data collected since the last status review in 2010 indicates the fraction of hatchery-origin fish in all populations remains high (even in Clackamas and McKenzie populations). The proportion of natural-origin spawners improved in the North and South Santiam basins, but is still well below identified recovery goals. Abundance levels for five of the seven populations remain well below their recovery goals. Of these, the Calapooia River may be functionally extinct and the Molalla River remains critically low. Abundances in the North and South Santiam rivers have risen since the 2010 review, but still range only in the high hundreds of fish. The Clackamas and McKenzie populations have previously been viewed as natural population strongholds, but have both experienced declines in abundance despite having access to much of their historical spawning habitat. Overall, populations appear to be at either moderate or high risk, there has been likely little net change in the VSP score for the ESU since the last review, so the ESU remains at moderate risk.	• Degraded fres • Degraded wat • Increased dis • Altered strea • Reduced acce habitats • Altered food v microdetritus • Predation by including hat • Competition r and steelhead • Altered popul and bycatch
Upper Willamette River steelhead	Threatened 01/05/2006 (71 FR 834)	ODFW and NMFS 2011	NWFSC 2015	This DPS has four demographically independent populations. Three populations are at low risk and one population is at moderate risk. Declines in abundance noted in the last status review continued through the period from 2010-2015. While rates of decline appear moderate, the DPS continues to demonstrate the overall low abundance pattern that was of concern during the last status review. The causes of these declines are not well understood, although much accessible habitat is degraded and under continued development pressure. 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 and a source of competition for the DPS. While the collective risk to the persistence of the DPS has not changed significantly in recent years, continued declines and potential negative impacts from	• Degraded fres • Degraded wat • Increased dis • Altered strea • Reduced acce habitats due t • Altered food v of microdetrit • Predation by including hat • Competition r and steelhead • Altered popul interbreeding

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				climate change may cause increased risk in the near future.	
Southern Oregon/ Northern California Coast coho salmon	Threatened 06/28/2005 (70 FR 37160)	NMFS 2014b	Williams et al. 2016	This ESU comprises 31 independent, 9 independent, and 5 ephemeral populations all grouped into 7 diversity strata. Of the 31 independent populations, 24 are at high risk of extinction and 6 are at moderate risk of extinction. The extinction risk of an ESU depends upon the extinction risk of its constituent independent populations; because the population abundance of most independent populations are below their depensation threshold, the SONCC coho salmon ESU is at high risk of extinction and is not viable	• Lack of floodp • Impaired wat • Altered hydro • Impaired estu • Degraded ripa • Altered sedim • Increased dis • Barriers to mi • Fishery-relate • Hatchery-rela
Northern California steelhead	Threatened 6/7/2000 (65 FR 36074)	NMFS 2016b	NMFS 2016e	This DPS historically comprised 42 independent populations of winter-run steelhead (19 functionally independent and 23 potentially independent), and up to 10 independent populations (all functionally independent) of summer-run steelhead, with more than 65 dependent populations of winter-run steelhead in small coastal watersheds, and Eel river tributaries. Many populations are considered to be extant. Significant gaps in information exist for the Lower Interior and North Mountain Interior diversity strata. All winter-run populations are currently well below viability targets, with most at 5-13% of these goals. Mixed population trends arise depending on time series length; thus, there is no strong evidence to indicate conditions for winter-run populations have worsened appreciably since the last status review. Summer-run populations are of concern. While one run is near the viability target, others are very small or there is a lack of data. Overall, available information for winter- and summer-run populations do not suggest an appreciable increase or decrease in extinction risk since the last status review.	• Dams and oth • Logging • Agriculture • Ranching • Fishery-relate • Hatchery-rela
California Coastal Chinook salmon	Threatened 09/16/1999 (64 FR 50394)	NMFS 2016b	Williams et al. 2016	This ESU historically supported 16 Independent populations of fall-run Chinook salmon (11 Functionally Independent and five potentially Independent), six populations of spring-run Chinook salmon, and an unknown number of dependent populations. Based on the data available, eight of the 16 populations were classified as data deficient, one population was classified as being at a Moderate/High risk of extirpation, and six populations were classified as being at a High risk of extirpation. There has been a mix in population trends, with some population escapement numbers increasing and others decreasing. Overall, there is a lack of compelling evidence to suggest that the status	• Logging and r substrate con load, and redu • Estuarine alte complexity an diking • Dams and bar habitats throu gravel recruit • Climate chang • Urbanization water quality agricultural ru

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				of these populations has improved or deteriorated appreciably since the previous status review.	• Gravel mining stranding of a spawning in p • Alien species • Small hatcher monitoring th on wild spawn
Sacramento River winter-run Chinook salmon	Endangered 09/16/1999 (64 FR 50394)	NMFS 2014c	Williams et al. 2016	This ESU historically supported 18 or 19 Independent populations, with some smaller dependent populations, and four diversity groups. Only three populations are extant (Mill, Deer, and Butte creeks on the upper Sacramento River) which only represent one diversity group (Northern Sierra Nevada). Spatial diversity is increasing with presence (at low numbers in some cases) in all diversity groups. Recolonization of the Battle Creek population with increasing abundance of the Clear Creek population is benefiting ESU viability. The reappearance of phenotypic spring-run to the San Joaquin River tributaries may be the beginning of natural recolonization processes in once extirpated rivers. Active reintroduction efforts on the Yuba and San Joaquin rivers show promise. The ESU is trending positively towards achieving at least two populations in each of the four historical diversity groups necessary for recovery.	• Dams block ac spawning and with altering temperatures • Diversions • Urbanization • Logging • Grazing • Agriculture • Mining – histo California Gol • Estuarine mo reducing deve juvenile salmo • Fisheries • Hatcheries • 'Natural' facto
Central Valley spring-run Chinook salmon	Threatened 09/16/1999 (64 FR 50394)	NMFS 2014c	Williams et al. 2016	This ESU historically supported 18 or 19 Independent populations, with some smaller dependent populations, and four diversity groups. Only three populations are extant (Mill, Deer, and Butte creeks on the upper Sacramento River) which only represent one diversity group (Northern Sierra Nevada). Spatial diversity is increasing with presence (at low numbers in some cases) in all diversity groups. Recolonization of the Battle Creek population with increasing abundance of the Clear Creek population is benefiting ESU viability. The reappearance of phenotypic spring-run to the San Joaquin River tributaries may be the beginning of natural recolonization processes in once extirpated rivers. Active reintroduction efforts on the Yuba and San Joaquin rivers show promise. The ESU is trending positively towards achieving at least two populations in each of the four historical diversity groups necessary for recovery.	• Dams block ac spawning and with altering temperatures • Diversions • Urbanization • Logging • Grazing • Agriculture • Mining – histo California Gol • Estuarine mo reducing deve juvenile salmo • Fisheries • Hatcheries • 'Natural' facto
California Central Valley steelhead	Threatened 3/19/1998 (63 FR 13347)	NMFS 2014c	Williams et al. 2016	Steelhead are present throughout most of the watersheds in the Central Valley, but often in low numbers, especially in the San Joaquin River tributaries. The status of this DPS appears to have changed little since the 2011 status review	• Major dams • Water diversi • Barriers • Levees and ba • Dredging and

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				stating the DPS was in danger of extinction. There is still a paucity of data on the status of wild populations. There are some encouraging signs of increased returns over the last few years. However, the catch of unmarked (wild) steelhead at Chipps Island is still less than 5 percent of the total smolt catch, which indicates natural production of steelhead throughout the Central Valley remains at very low levels. Despite a positive trend on Clear Creek and encouraging signs from Mill Creek, all other concerns raised in the previous status review remain.	• Mining • Contaminants • Alien species • Fishery-relate • Hatchery-rela
Central California Coast coho salmon	Endangered 04/02/2012 (77 FR 19552) 06/28/2005 (70 FR 37160) Threatened 10/31/1996 (61 FR 56138)	NMFS 2012d	Williams et al. 2016	This ESU comprises approximately 76 populations that are mostly dependent populations. Historically, the ESU had 11 functionally independent populations and one potentially independent population organized into four stratum. Most independent populations remain at critically low levels, with those in the southern Santa Cruz Mountains strata likely extirpated. Data suggests some populations show a slight positive trend in annual escapement, but the improvement is not statistically significant. Overall, all populations remain, at best, a slight fraction of their recovery target levels, and, aside from the Santa Cruz Mountains strata, the continued extirpation of dependent populations continues to threaten the ESU's future survival and recovery.	• Logging • Agriculture • Mining • Urbanization • Stream modif stream bank a elevated wate and rearing h impaired grav upstream sou lost riparian v erosion into s • Dams • Wetland loss • Water withdr diversions for
Central California Coast steelhead	Threatened 8/18/1997 (62 FR 43937)	NMFS 2016b	Williams et al. 2016	Both adult and juvenile abundance data are limited for this DPS. It was historically comprised of 37 independent populations (11 functionally independent and 26 potentially independent) and perhaps 30 or more dependent populations of winter-run steelhead. Most of the coastal populations are assumed to be extant with other populations (Coastal San Francisco Bay and Interior San Francisco Bay) likely at high risk of extirpation. While data availability for this DPS remains poor, there is little new evidence to suggest that the extinction risk for this DPS has changed appreciably in either direction since the last status review.	• Dams and oth • Stream habita • Estuarine hab • Hatchery-rela
South-Central California Coast steelhead	Threatened 8/18/1997 (62 FR 43937)	NMFS 2013a	Williams et al. 2016	Currently, nearly half of this DPS reside in the Carmel River. Most other streams and rivers have small populations that can be stochastically driven to extirpation. The ability to fully assess the status of individual populations and the DPS as whole has been limited. There is little new evidence to indicate that the status of the S-CCC Steelhead DPS has changed appreciably since the last status	• Hydrological r water dive • Agricultural a other pass • Flood control, • Alien species • Estuarine hab • Marine enviro • Natural enviro

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				review, though the Carmel River runs have shown a long term decline. Threats to the DPS identified during initial listing have remained largely unchanged, though some fish passage barriers have been removed. Threats to this DPS are likely to exacerbate the factors affecting the continued existence of the DPS. S-CCC steelhead recovery will require reducing threats, maintaining interconnected populations across their native range, and preserving the diversity of life history strategies.	• Pesticide cont
Southern California Steelhead	Endangered 8/18/1997 (62 FR 43937)	NMFS 2012b	Williams et al. 2916	This DPS includes steelhead populations along the coast of California from the Santa Maria River system to the border between the U.S. and Mexico. In this area there we have counted only a very small number of fish—typically fewer than 12 adults per year on average in recent years—but we note that there are enduring annual runs. It remains to be seen how these small runs are able to persist. Some populations in different basins are connected by relatively frequent straying. More recent genetic data show a large amount of introgression and extirpation of native fish in the southern portion of this area. There has been progress in removing fish passage barriers and in constructing fish passage in some watersheds. Recovery projects also include plant restoration and removal of non-native species. However, anthropogenic effects are overall unchanged, and impacts from climate change are expected to intensify the threats this species faces.	• Loss and degr • Dams • Urban Develo • Mining, agricu • Predation by native spec • Disease • More frequen closures • Inadequate re • Climate chang variability
Southern DPS (sDPS) of eulachon	Threatened 03/18/2010 (75 FR 13012)	NMFS 2017b	Gustafson et al. 2016	The Southern DPS 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. Sub populations for this species include the Fraser River, Columbia River, British Columbia and the Klamath River. In the early 1990s, there was an abrupt decline in the abundance of eulachon returning to the Columbia River. Despite a brief period of improved returns in 2001-2003, the returns and associated commercial landings eventually declined to the low levels observed in the mid-1990s. Although eulachon abundance in monitored rivers has generally improved, especially in the 2013-2015 return years, recent poor ocean conditions and the likelihood that these conditions will persist into the near future suggest that population declines may be widespread in the upcoming return years	• Changes in oc change, partic of the species trends may be may alter pre success. • Climate-induc habitats • Bycatch of eu • Adverse effec diversions • Water quality • Shoreline con • Over harvest • Predation