NATIONAL MARINE FISHERIES SERVICE
ENDANGERED SPECIES ACT SECTION 7
BIOLOGICAL OPINION

Title	Biological Opinion on the National Science Foundation and Lamont-Doherty Earth Observatory's Marine Geophysical Survey by the Research Vessel *Marcus G. Langseth* of the Queen Charlotte Fault in the Northeast Pacific Ocean and the National Marine Fisheries Service Permits and Conservation Division's Issuance of an Incidental Harassment Authorization pursuant to Section 101(a)(5)(D) of the Marine Mammal Protection Act
Consultation Conducted By:	Endangered Species Act Interagency Cooperation Division, Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce
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1 INTRODUCTION

The Endangered Species Act of 1973, as amended (ESA; 16 U.S.C. 1531 et seq.) establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat they depend on. Section 7(a)(2) of the ESA requires Federal agencies to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their designated critical habitat. Federal agencies must do so in consultation with the National Marine Fisheries Service (NMFS) for threatened or endangered species (ESA-listed), or designated critical habitat that may be affected by the action that are under NMFS jurisdiction (50 C.F.R. §402.14(a)). If a Federal action agency determines that an action "may affect, but is not likely to adversely affect" endangered species, threatened species, or designated critical habitat and NMFS concurs with that determination for species under NMFS jurisdiction, consultation concludes informally (50 C.F.R. §402.14(b)).

Section 7(b)(3) of the ESA requires that at the conclusion of consultation, NMFS provides an opinion stating whether the Federal agency's action is likely to jeopardize ESA-listed species or destroy or adversely modify designated critical habitat. If NMFS determines that the action is likely to jeopardize listed species or destroy or adversely modify critical habitat, NMFS provides a reasonable and prudent alternative (RPA) that allows the action to proceed in compliance with section 7(a)(2) of the ESA. If an incidental take is expected, section 7(b)(4) requires NMFS to provide an incidental take statement that specifies the impact of any incidental taking and includes reasonable and prudent measures (RPMs) to minimize such impacts and terms and conditions to implement the RPMs.

The action agencies for this consultation are the National Science Foundation and NMFS's Permits and Conservation Division. Two federal actions are considered in this biological opinion (opinion). The first is the National Science Foundation's proposal to fund a seismic survey along the Queen Charlotte Fault in the Northeast Pacific Ocean from July to August 2021, in support of a National Science Foundation-funded collaborative research project, led by Columbia University's Lamont-Doherty Earth Observatory. The second is the NMFS Permits and Conservation Division's proposal to issue an incidental harassment authorization (IHA) authorizing non-lethal "takes" by Level A and Level B harassment (as defined by the Marine Mammal Protection Act [MMPA]) of marine mammals incidental to the planned seismic survey, pursuant to section 101(a)(5)(D) of the MMPA, 16 U.S.C. § 1371(a)(5)(D).

This consultation, opinion, and incidental take statement, were completed in accordance with section 7(a)(2) of the statute (16 U.S.C. 1536 (a)(2)), associated implementing regulations (50 C.F.R. §§402.01-402.16), and agency policy and guidance. This opinion and incidental take statement were prepared by the NMFS Office of Protected Resources Endangered Species Act Interagency Cooperation Division (NMFS ESA Interagency Cooperation Division; hereafter referred to as "we") in accordance with section 7(b) of the ESA and implementing regulations at 50 C.F.R. Part 402.

This document represents the NMFS ESA Interagency Cooperation Division's opinion on the effects of the proposed actions on endangered and threatened marine mammals, sea turtles, fishes, and designated critical habitat for those species. A complete record of this consultation is on file at the NMFS Office of Protected Resources in Silver Spring, Maryland.

1.1 Background

The National Science Foundation was established by Congress with the National Science Foundation Act of 1950 (Public Law 810507, as amended) and is the only federal agency dedicated to the support of fundamental research and education in all scientific and engineering disciplines. The National Science Foundation has a continuing need to fund seismic surveys that enable scientists to collect data essential to understanding the complex Earth processes beneath the ocean floor.

The National Science Foundation is proposing to fund and conduct a marine seismic survey, for scientific research purposes and data collection, of the Queen Charlotte Fault in the Northeast Pacific Ocean in July 2021, off the coasts of Southeast Alaska and northern British Columbia. In conjunction with this action, the NMFS Permits and Conservation Division is proposing the issuance of an IHA under the MMPA for incidental take of marine mammals that could occur during the National Science Foundation's seismic survey. This document represents the NMFS ESA Interagency Cooperation Division's opinion on the effects of the two proposed federal actions on threatened and endangered species, and has been prepared in accordance with section 7 of the ESA. Both the National Science Foundation and the NMFS Permits and Conservation Division have conducted similar actions in the past that have been the subject of ESA section 7 consultations. Recent previous opinions for the National Science Foundation's seismic surveys and their associated issuance of IHAs in the vicinity of the proposed action area include NMFS (2017b), NMFS (2018a), NMFS (2019b), (NMFS 2019c), and NMFS (2021). The opinions for each of these actions determined that the authorized activities were not likely to jeopardize the continued existence of ESA-listed species, or result in the destruction or adverse modification of designated critical habitat.

1.2 Consultation History

This opinion is based on information provided in the National Science Foundation's draft environmental assessment (EA) prepared pursuant to the National Environmental Policy Act (NSF and LDEO 2020), the National Science Foundation and Lamont-Doherty Earth Observatory's MMPA IHA application (NSF and L-DEO 2020), the NMFS Permits and Conservation Division's notice of a proposed IHA prepared pursuant to the MMPA (86 FR 30006), monitoring reports from similar activities, published and unpublished scientific information on threatened and endangered species and their surrogates, scientific and commercial information such as reports from government agencies and peer-reviewed literature, biological opinions on similar activities, and other sources of information. Our communication with the National Science Foundation and NMFS Permits and Conservation Division regarding this consultation is summarized as follows:

- On October 2, 2019, the National Science Foundation requested a list of ESA-listed species and designated critical habitat that may occur in the proposed action area in the Northeast Pacific as well as recommended data sources for marine mammal and sea turtle abundances and densities in the action area.
- On October 17, 2019, NMFS responded to the National Science Foundation's request and provided a list of ESA-listed species and designated critical habitat that may occur in the action area in the Northeast Pacific as well as recommended data sources for marine mammal and sea turtle abundances and densities in the action area.
- On December 3, 2019, NMFS received a request from National Science Foundation for ESA section 7 consultation for a proposed seismic survey to be undertaken in the Northeast Pacific Ocean from July 2020 to August 2020. The National Science Foundation provided a letter and draft EA pursuant to the National Environmental Protection Act, which included information necessary for a biological assessment, in support of the request. NMFS provided comments on the draft EA on December 18, 2019 and NMFS' Alaska Regional Office submitted additional comments on January 9, 2020.
- On January 10, 2020, the National Science Foundation provided responses to NMFS' Alaska Regional Office's comments.
- On January 13, 2020, the National Science Foundation provided responses to our comments.
- On January 15, 2020, we determined the request for consultation included enough information to initiate ESA Section 7 consultation with the National Science Foundation on the proposed Queen Charlotte Survey, and initiated consultation.
- On February 25, 2020, NMFS' Permits and Conservation Division conducted an Early Review Team meeting to resolve issues related to take estimates for several MMPA and ESA-listed species likely to be adversely affected by the survey.
- On April 10, 2020, the National Science Foundation notified NMFS that they postponed their proposed 2020 seismic survey of the Queen Charlotte Fault to the summer of 2021 due to Covid-19. As a result, the consultation was paused.
- On October 15, 2020, the National Science Foundation submitted a revised draft EA of the Queen Charlotte Fault Survey to NMFS. Additional revisions to the EA were sent to NMFS on October 29, 2020. The revised EA included minimal updates to the proposed action comprised of small revisions to the survey tracklines.
- On November 3, 2020 NMFS sent the National Science Foundation comments on the revised EA.
- On December 16, 2020, the National Science Foundation submitted a revised draft EA of the Queen Charlotte Fault Survey to NMFS.

- On June 1, 2021, the Permits Division submitted their initiation package to the ESA Interagency Cooperation Division for review. The ESA Interagency Cooperation Division reviewed the package, determined it was complete, and initiated consultation on the same date.
- On June 28, 2021, the National Science Foundation submitted a final EA of the Queen Charlotte Fault Survey to NMFS.

2 THE ASSESSMENT FRAMEWORK

Section 7(a)(2) of the ESA requires Federal agencies, in consultation with NMFS, to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species; or adversely modify or destroy their designated critical habitat.

"Jeopardize the continued existence of" means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of an ESA-listed species in the wild by reducing the reproduction, numbers, or distribution of that species." 50 C.F.R. §402.02.

"Destruction or adverse modification" means a direct or indirect alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species." 50 C.F.R. §402.02.

An ESA section 7 assessment involves the following steps:

Description of the Proposed Action (Section 3): We describe the proposed action and those aspects (or stressors) of the proposed action that may have effects on the physical, chemical, and biotic environment. This section also includes the avoidance and minimization measures that have been incorporated into the project to reduce the effects to ESA-listed species.

Action Area (Section 4): Is defined as "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action." 50 C.F.R. §402.02. We describe the action area with the spatial extent of those effects and associated stressors.

Potential Stressors (Section 5): We identify the stressors that could occur as a result of the proposed action and affect ESA-listed species and designated critical habitat.

Endangered Species Act Resources That May be Affected (Section 6): We identify the ESA-listed species and designated critical habitat under NMFS jurisdiction that may occur within the action area that may be affected by the proposed action.

Species and Critical Habitat Not Likely to be Adversely Affected (Section 7): We identify the ESA-listed species and designated critical habitat that are not likely to be adversely affected by the proposed action.

Status of the Species and Critical Habitat Likely to be Adversely Affected (Section 8): During the ESA section 7 consultation process, we identify the ESA-listed species and designated critical habitat that are anticipated to co-occur with the effects and stressors caused by the proposed action in space and time, and may be adversely affected. We then evaluate the status of those species and habitat.

*Environmental Baseline (*Section 9): We describe the environmental baseline in the action area as the condition of the listed species and 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 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process. The consequences to listed species from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline.

Effects of the Action (Section 10): 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 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. These are broken into analyses of exposure, response, and risk, as described below for the species that are likely to be adversely affected by the action.

Cumulative Effects (Section 11): Cumulative effects are the effects to ESA-listed species and designated critical habitat of future state or private activities that are reasonably certain to occur within the action area (50 C.F.R. §402.02). Effects from future Federal actions that are unrelated to the proposed action are not considered because they require separate ESA section 7 compliance.

Integration and Synthesis (Section 12): In this section, we complete our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. We add the effects of the action (Section 10) to the environmental baseline (Section 9) and the cumulative effects (Section 11), taking into account the status of the species and critical habitat (Section 8), to formulate the agency's biological opinion and conclusion of the effects of the action on listed resources. With full consideration of the status of the species and the designated critical habitat, the effects of the action within the action area on populations or subpopulations and on essential features of designated critical habitat when added to the environmental baseline and the cumulative effects to determine whether the action could reasonably be expected to:

- Reduce appreciably the likelihood of survival and recovery of ESA-listed species in the wild by reducing its numbers, reproduction, or distribution, and state our conclusion as to whether the action is likely to jeopardize the continued existence of such species; or

Appreciably diminish the value of designated critical habitat as a whole for the conservation of an ESA-listed species, and state our conclusion as to whether the action is likely to destroy or adversely modify designated critical habitat.

Conclusion (Section 0): The conclusion section summarizes the results of our jeopardy and destruction or adverse modification analyses.

If, in completing the last step in the analysis, we determine that the action under consultation is likely to jeopardize the continued existence of ESA-listed species or destroy or adversely modify designated critical habitat, then we must identify RPA(s) to the action, if any, or indicate that to the best of our knowledge there are no RPAs (50 C.F.R. §402.14).

In addition, we include an *Incidental Take Statement* (Section 13) that specifies the impact of the take, RPMs to minimize the impact of the take, and terms and conditions to implement the RPMs. ESA section 7 (b)(4); 50 C.F.R. §402.14(i). We also provide discretionary *Conservation Recommendations* that may be implemented by the action agency (Section 14) (50 C.F.R. §402.14(j)). Finally, we identify the circumstances in which *Reinitiation of Consultation* is required (Section 15) (50 C.F.R. §402.16).

To comply with our obligation to use the best scientific and commercial data available (16 U.S.C. § 1536(a)(2); 50 C.F.R. §402.14), we collected information identified through searches of *Google Scholar*, and literature cited sections of peer reviewed articles, species listing documentation, and reports published by government and private entities. This opinion is based on our review and analysis of various information sources, including:

- Information submitted by the National Science Foundation, Lamont-Doherty Earth Observatory of Columbia University, and NMFS Permits and Conservation Division;
- Government reports (including NMFS biological opinions and stock assessment reports);
- National Oceanic and Atmospheric Administration (NOAA) technical memorandums;
- Monitoring reports; and
- Peer-reviewed scientific literature.

These resources were used to identify information relevant to the potential effects and associated stressors and responses of ESA-listed species and designated critical habitat under NMFS' jurisdiction that may be affected by the proposed actions to draw conclusions on risks the action may pose to the continued existence of these species and the value of designated critical habitat for the conservation of ESA-listed species.

3 Description of the Proposed Actions

"Action" is defined as all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies in the United States or upon the high seas (50 C.F.R. §402.02).

Two federal actions were evaluated during this consultation. The first proposed action for this consultation is the National Science Foundation and Lamont Doherty Earth Observatory's (along with researchers from the University of New Mexico and Western Washington University) proposal to sponsor and conduct a high-energy marine seismic survey on the Research Vessel (R/V) *Marcus G. Langseth* (RV *Langseth*) in the Northeast Pacific Ocean over the Queen Charlotte Fault from July to August 2021. The R/V *Langseth* is operated by the Lamont-Doherty Earth Observatory of Columbia University under an existing cooperative agreement. The second proposed action for this consultation is NMFS' Permits and Conservation Division's proposed issuance of an IHA authorizing non-lethal "takes" by MMPA Level A and B harassment (ESA harassment and harm) pursuant to section 101(a)(5)(D) of the MMPA for the National Science Foundation's high-energy marine seismic survey in the Northeast Pacific Ocean. While this consultation evaluated two federal actions, the two actions and the analysis of them are interrelated, and therefore this opinion may alternatively refer to either plural "proposed actions" or a singular "proposed action" that includes the entire scope of collective activities.

The information presented here is based primarily upon information in the consultation initiation packages submitted to us by the National Science Foundation and NMFS' Permits and Conservation Division.

3.1 National Science Foundation's and Lamont-Doherty Earth Observatory's Proposed Activities

The proposed action includes a two-dimensional 36-airgun array high-energy seismic survey in the Exclusive Economic Zones (EEZ) of the United States (U.S) and Canada, including in U.S. state waters and the Territorial Waters of Canada. The survey will focus on the Queen Charlotte Fault in the Northeast Pacific Ocean. It will provide data necessary to characterize the crustal and uppermost mantle velocity structure, fault zone architecture and rheology, and seismicity of the Queen Charlotte Fault. These data would provide essential constraints for earthquake and tsunami hazard assessment in the region.

3.1.1 Seismic Survey Objectives

Researchers from the University of New Mexico and Western Washington University have proposed seismic surveys using the R/V *Langseth* in the Northeast Pacific Ocean. The main goal of the seismic program proposed by the University of New Mexico and University of Western Washington is to characterize the crustal and uppermost mantle velocity structure, fault zone architecture and rheology, and seismicity of the Queen Charlotte Fault. To achieve the project goals, the Principal Investigators (PIs) Drs. L. Worthington (University of New Mexico) and E. Roland (Western Washington University) propose to utilize long-offset two-dimensional seismic reflection and wide-angle reflection-refraction capabilities of the R/V *Langseth* and a combined U.S.-Canadian broadband ocean-bottom seismometers array. Although not funded through the National Science Foundation, collaborators Dr. M. Nedimovic (Dalhousie University), the Geological Survey of Canada, and the United States Geological Survey (Dr. M. Walton and collaborators), would work with the PIs to achieve the research goals, providing assistance, such as through logistical support (e.g., Ocean Bottom Seismometers (OBSs); land seismometers), partial funding for a support vessel (the R/V *Tully*), and data acquisition and exchange.

The Queen Charlotte Fault system is an approximately 1200-kilometer long onshore-offshore transform system connecting the Cascadia and Alaska-Aleutian subduction zones. The Queen Charlotte Fault is an approximately 900 kilometer-long offshore component of the transform system, and the fault accommodates >50 millimeters per year of dextral strike-slip motion between the Pacific and North American tectonic plates. This project would characterize an approximately 450-kilometer segment of the fault that encompasses systematic variations in key parameters in space and time. These parameters include: 1) changes in fault obliquity relative to Pacific-North American plate motion leading to increased convergence from north to south; 2) Pacific plate age and theoretical mechanical thickness decrease from north to south; and 3) a shift in Pacific plate motion at approximately 12 to six million years ago that may have increased convergence along the entire length of the fault, possibly initiating underthrusting in the southern portion of the study area. Current understanding of how these variations are expressed through seismicity, crustal-scale deformation, and lithospheric structure and dynamics is limited due to lack of instrumentation and modern seismic imaging. The research effort would capitalize on the R/V *Langseth's* proposed marine-based activities and would vastly expand the geophysical dataset available for analysis for the region.

3.1.2 Seismic Survey Overview

The National Science Foundation will use a conventional seismic survey methodology and the procedures will be similar to those used during previous seismic surveys. The survey would involve one source vessel, the R/V *Langseth*, which would tow a 36-airgun array at a depth of 12 meters. The receiving system would consist of a 15-kilometer long hydrophone streamer and up to 60 short term OBSs, which would be deployed at 123 sites in multiple phases from a second vessel, the Canadian Coast Guard R/V *John P. Tully* (*Tully*). The airguns would fire at a shot interval of approximately 23 seconds (50 meters) during multi-channel seismic (MCS) surveys with the hydrophone streamer and approximately 69-second (150 meters) intervals during refraction surveys to OBSs. Airguns would also fire at a shot interval of approximately one minute (130 meters) during turns between transects.

The surveys are proposed to occur within the EEZs of the U.S. and Canada, as well as in U.S. state waters and Canadian Territorial Waters ranging in depth from 50 to 2,800 meters. The proposed surveys are expected to last for 36 days, including approximately 27 days of seismic operations, two days of transit to and from the survey area, three days for equipment deployment/recovery, and four days of contingency. The R/V *Langseth* and R/V *Tully* would likely leave out of and return to the port in Ketchikan, Alaska, during July or August 2021. The proposed survey tracklines are shown in Figure 1. The location of the survey lines could shift from what is currently depicted depending on factors such as science drivers, poor data quality, and weather.

The R/V *Tully* would deploy short-period OBSs first along five OBS refraction lines. Two OBS lines run parallel to the coast, and three are perpendicular to the coast. One perpendicular line is located off Southeast Alaska, one is off Haida Gwaii, and another is located in Dixon Entrance (See Figure 1). Following refraction shooting of a single line, short-period instruments on that line would be recovered, serviced, and redeployed on a subsequent refraction line while MCS data would be acquired by the *Langseth.* MCS lines would be acquired off Southeast Alaska, Haida Gwaii, and the Dixon Entrance (see Figure 1). The coast-parallel OBS refraction transect nearest to shore (see Figure 1) would only be surveyed once at OBS shot spacing. The other coast-parallel OBS refraction transect (on the ocean side; see Figure 1) would be acquired twice, once during refraction and once during reflection surveys. In addition, portions of the three coast-perpendicular OBS refraction lines would also be surveyed twice, once for OBS shot spacing and once for MCS shot spacing. The coincident reflection/refraction profiles that run parallel to the coast would be acquired in multiple segments to ensure straight-line geometry. Sawtooth transits during which seismic data would be acquired would take place between transect lines when possible; otherwise, boxcar turns would be performed to save time. Both reflection and refraction surveys would use the same airgun array with the same discharge volume of 108,154.6 cubic centimeters (6,600 cubic inches).

As the airgun arrays are towed along the survey lines, the OBSs would receive and store the returning acoustic signals internally for later analysis, and the hydrophone streamer would transfer the data to the on-board processing system. Approximately 4,250 kilometers of transect lines would be surveyed; however, there could be additional seismic operations associated with turns, airgun testing, and repeat coverage of any areas where initial data quality is sub-standard. This additional work is factored into our effects analysis (see Section 10). Most of the survey (69 percent) would occur in deep water (>1000 meters), 30 percent would occur in intermediate water (100–1000 meters deep), and one percent would take place in shallow water (<100 meters deep). Approximately 16 percent of the transect lines (680 kilometers) would be undertaken in Canadian Territorial Waters, with most effort in intermediate waters.

In addition, a multibeam echosounder, sub-bottom profiler, and acoustic Doppler current profiler would be operated from the R/V *Langseth* continuously during the seismic surveys, but not during transit to and from the survey area. Further, ocean-bottom seismometers would collect data. To retrieve the ocean-bottom seismometers, an acoustic release transponder (pinger) is used to interrogate the instrument. All planned geophysical data acquisition activities would be conducted by Lamont-Doherty Earth Observatory with on-board assistance by the scientists who have proposed the studies. The vessel would be self-contained, and the crew would live aboard the vessel.

3.1.3 Source Vessel Specifications

The seismic survey will involve one source vessel, the U.S.-flagged R/V *Langseth*. The R/V *Langseth* is owned by the National Science Foundation and operated by Columbia University's Lamont-Doherty Earth Observatory under an existing Cooperative Agreement. The R/V

Langseth has a length of 72 meters (235 feet), a beam of 17 meters (56 feet), and a maximum draft of 5.9 meters (19.4 feet). It is 2,842 gross tons. Its propulsion system consists of two diesel Bergen BRG-6 engines, each producing 3,550 horsepower, and an 800 horsepower bow thruster. The R/V *Langseth*'s design is that of a seismic research vessel, with a particularly quiet propulsion system to avoid interference with the seismic signals. The vessel speed during seismic operations would be approximately 4.2 knots (7.8 kilometers) per hour during the 2-D survey. When not towing seismic survey gear, the R/V *Langseth* typically cruises at 18.5 kilometers (10 knots) per hour and has a range of approximately 13,500 kilometers (7,289.4 nautical miles). During transits, the ship may travel at 11 knots (20.37 kilometers) per hour. The R/V *Langseth* will also serve as the platform from which vessel-based protected species observers (PSOs) (acoustic and visual) will listen and watch for animals (e.g., marine mammals and sea turtles).

The proposed seismic survey will also use a second vessel, the R/V *Tully*, to deploy OBSs. The vessel has a length of 69 meters, a beam of 14.5 meters, and a draft of 4.5 meters. The ship is powered by two Deutz 628 geared diesel engines, producing 3697 horsepower, which drives the controllable-pitch propeller. The vessel also has stern and bow thrusters. The cruising speed is 10 knots, and the range is approximately 22,224 nautical miles (41,159 kilometers) with an endurance of 50 days. Other specifications of the R/V *Tully* are located in Table 1 below.

Table 1. R/V *Tully* Vessel Specifications.

Owner:	Canadian Coast Guard
Operator:	Canadian Coast Guard
Flag:	Canada
Date Built:	1985
Gross Tonnage:	2,021
Accommodation Capacity:	41 including ~20 scientists

3.1.4 Airgun Array and Acoustic Receivers Description

During the seismic survey, the R/V *Langseth* will deploy an airgun array (i.e., a certain number of airguns of varying sizes in a certain arrangement) as an energy source. An airgun is a device used to emit acoustic energy pulses downward through the water column and into the seafloor, and generally consists of a steel cylinder that is charged with high-pressure air. Release of the compressed air into the water column generates a signal that reflects (or refracts) off the seafloor and/or sub-surface layers having acoustic impedance contrast. When fired, a brief (approximately 0.1 second) pulse of sound is emitted by all airguns nearly simultaneously. The airguns are silent during the intervening periods with the array typically fired on a fixed distance (or shot point) interval. The return signal is recorded by a listening device (e.g., receiving system) and later analyzed with computer interpretation and mapping systems used to depict the sub-surface.

The airgun array for the two-dimensional seismic survey will consist of 36 bolt airguns (plus four spares) with a total discharge volume of 108,154.6 cubic centimeters (6,600 cubic inches) (Table 2). The airguns will be configured as four identical linear arrays or "strings". The four airgun strings will be towed behind the R/V *Langseth* and will be distributed across an area approximately 24 meters (78.7 feet) by 16 meters (52.5 feet). The shot interval will be approximately 16 to 17 seconds (approximately 37.5 meter [123 feet]). The firing pressure of the airgun array will be approximately 1,900 pounds per square inch (psi) (plus or minus 100 psi). The four airgun strings will be towed approximately 30 meters (98 feet) behind the vessel at a tow depth of 12 meters (39.4 feet).

It is expected that the airgun array will be active 24 hours per day during the seismic survey. Airguns will operate continually during the seismic survey period except for unscheduled shut downs.

Table 2. Source array and survey specifications for the proposed two-dimensional seismic survey over the Queen Charlotte Fault in the Northeast Pacific Ocean.

Source array specifications	
Energy source	36 Bolt 40 to 360-cubic inch air guns 4 strings
Source output (downward)-36 air gun array	Zero to peak = 258 dB re 1 μPa-m Peak to peak = 264 dB re 1 μPa-m
Air discharge volume	~ 6,600-cubic inch
Pulse duration	0.1 second
Shot interval	50 meters- multi-channel seismic survey 150 meters- refraction surveys to OBSs 130 meters- turns/transits between transects
Dominant frequency components	2 to 188 hertz
Tow depth	12-meters
Sound source velocity (tow speed)	4.2 knots (7.8 kilometers per hour)

dB re 1 μPa-m = For underwater sounds the reference pressure $p_{reference}$ is an rms pressure of 1 μPascal. Units for decibels are given as "dB re1 μPa-m" indicating that the reference pressure is 1 μPa rms at 1 meter.

As stated in Section 3.1.2, the receiving system would consist of a 15-kilometer-long hydrophone streamer and up to 60 OBSs, which would be deployed from a second vessel, the R/V *Tully*. Past surveys in the 1980s and 1990s used much shorter streamers (2.6 to four kilometers long), which provided rather poor quality data. A longer hydrophone streamer, like the one proposed for this action, provides opportunities to suppress unwanted energy that interferes with imaging targets, allows for accurate measurements of seismic velocities, and provides a large amount of data redundancy for enhancing seismic images during data processing. As the airgun array is towed along the tracklines, the hydrophone streamer receives the returning acoustic signals and transfers the data to the onboard processing system. The OBSs receives and stores the returning acoustic signals internally for later analysis.

The seismometers would consist of approximately 60 short-period OBSs and 28 broadband instruments that would be deployed prior to or during the survey. Along OBS refraction lines, the R/V *Tully* would deploy short-period OBSs at approximately ten-kilometer intervals, with a spacing of approximately five kilometers over the central 40 kilometers of the fault zone for fault-normal crossings. Following refraction shooting of a single line, short-period instruments on that line would be recovered, serviced, and redeployed on a subsequent refraction line while MCS data are acquired. The OBSs have a height and diameter of approximately one meter and an anchor weighing approximately 80 kilograms. OBS sample rates would be set at 100 hertz and 200 hertz for the broadband and short-period OBSs, respectively, so that all instruments can be used for refraction imaging and earthquake analysis. The lower sample rate for the broadband OBSs is desirable, as the instruments would be deployed for an extended period. All OBSs would be recovered upon conclusion of the survey; however, the broadband OBSs would be deployed for approximately 12 months before recovery.

3.1.5 Multibeam Echosounder and Sub-bottom Profiler

Along with the airgun operations, two additional acoustical data acquisition systems would be operated during the seismic survey. The ocean floor would be mapped with a Kongsberg EM 122 multi-beam echosounder and a Knudsen 3260 sub-bottom profiler. The multi-beam echosounder and sub-bottom profiler sound sources will operate simultaneously with the airgun array, but not during transit to and from the seismic survey area.

3.1.5.1 Multi-Beam Echosounder

The Kongsberg EM122 multi-beam echosounder operates at 10.5–13 (usually 12) kilohertz and is hull-mounted on the R/V *Langseth*. The transmitting beamwidth is one or two degrees fore–aft and 150 degrees athwartship. The maximum source level is 242 re: 1µPa. Each ping consists of eight (in water >1,000 meters [3,281 feet] deep) or four (2,600 meters [8,530 feet] successive fan-shaped transmissions, each ensonifying a sector that extends one degree fore–aft. Continuous-wave signals increase from two to 15 milliseconds long in water depths up to 2,600 meters (8,530 feet), and FM chirp signals up to 100 milliseconds long are used in water >2,600 meters (8,530 feet). The successive transmissions span an overall cross-track angular extent of about 150 degrees, with two-millisecond gaps between the pings for successive sectors.

3.1.5.2 Sub-bottom Profiler

The ocean floor will also be mapped with the Knudsen 3260 sub-bottom profiler. The sub-bottom profiler is normally operated to provide information about the near seafloor sedimentary features and the bottom topography that is mapped simultaneously by the multi-beam echosounder. The beam is transmitted as a 27-degree cone, which is directed downward by a 3.5 kilohertz transducer in the hull of the R/V *Langseth*. The nominal power output is 10 kilowatts, but the actual maximum radiated power is three kilowatts or 222 dB re: 1 µPa at 1 meter root mean squared (rms). The ping duration is up to 64 milliseconds, and the ping interval is one second. A common mode of operation is to broadcast five pulses at one-second intervals followed by a five second pause. The sub-bottom profiler is capable of reaching depths of 10,000 meters (32,808.4 feet).

3.1.6 Mitigation and Monitoring

The National Science Foundation and Lamont-Doherty Earth Observatory are obligated under the MMPA to implement measures such that their action results in the least practicable adverse impact on marine mammal species or stocks and, under the ESA, to reduce the likelihood of adverse effects to ESA-listed marine species or adverse effects on their designated critical habitats. Monitoring is used to observe or check the progress of the mitigation required by the IHA over time and to ensure that any measures implemented to reduce or avoid adverse effects on ESA-listed species are successful.

NMFS Permits and Conservation Division will require and the National Science Foundation and Lamont-Doherty Earth Observatory will implement the mitigation and monitoring measures listed below. These mitigation and monitoring measures are required during the seismic survey to reduce potential for injury or harassment to marine mammals, sea turtles, and fishes. Additional details of each mitigation and monitoring measure are described in subsequent sections of this opinion:

- Proposed exclusion zones;
- Power-down procedures;
- Shut down procedures;
- Ramp-up procedures;
- Visual monitoring by NMFS-approved PSOs;
- Passive acoustic monitoring; and
- Vessel strike avoidance measures

Additional details on the other required MMPA mitigation and monitoring measures (e.g., power-down, shut down, and ramp-up procedures) can be found in Appendix A.

3.1.6.1 Proposed Exclusion and Buffer Zones-Ensonified Area

The NMFS Permits and Conservation Division will require, and the National Science Foundation and Lamont-Doherty Earth Observatory will implement exclusion zones around the R/V *Langseth* to minimize any potential adverse effects of the sound from the airgun array on MMPA and ESA-listed species. The exclusion zones are areas within which occurrence of a marine mammal and sea turtle triggers a power-down or shut down of the airgun array to reduce exposure of marine mammals and sea turtles to sound levels expected to have adverse effects on the species or their habitat. These exclusion zones are based upon modeled sound levels at various distances from the R/V *Langseth*, and correspond to the respective species' sound thresholds for temporary and permanent effects, including behavioral effects.

Ensonified Area

Lamont-Doherty Earth Observatory model results were used to determine the 160 dB re: 1 µPa (rms) radius[1] for the single 40 cubic inch airgun array and the 36 airgun array in shallow (less than 100 meters [328 feet] deep), intermediate (100 to 1,000 meters deep), and deep water (greater than 1,000 meters [3,280.8 feet]). Received sound levels were predicted by Lamont-Doherty Earth Observatory's model (Diebold et al. 2010), which uses ray tracing for the direct wave traveling from the airgun array to the receiver and its associated source ghost (i.e., reflection at the air-water interface in the vicinity of the airgun array), in a constant-velocity half-space (infinite homogeneous ocean layer, unbounded by a seafloor). In 2003, empirical data concerning 190, 180, and 160 dB re: 1 µPa (rms) distances were acquired during the acoustic calibration study of the R/V *Maurice Ewing*'s airgun array in a variety of configurations in the northern Gulf of Mexico (Tolstoy 2004). In addition, propagation measurements of pulses from the R/V *Langseth*'s 36 airgun array at a tow depth of six meters (19.7 feet) have been reported in deep water (approximately 1,600 meters [5,249.3 feet]), intermediate water depth on the slope (approximately 600 to 1,100 meters [1,968.5 to 3,608.9 feet]), and shallow water (approximately 50 meters [164 feet]) in the Gulf of Mexico in 2007 through 2008 (Tolstoy et al. 2009; Diebold et al. 2010). Results of the propagation measurements (Tolstoy et al. 2009) showed that radii around the airguns for different received levels varied with water depth. However, the depth of the airgun array was different in the Gulf of Mexico calibration study (six meters [19.7 feet]) from in the proposed seismic survey activities (10 to 12 meters [32.8 to 39.4 feet]). Because propagation varies with airgun array depth, correction factors have been applied to the distances reported by Tolstoy et al. (2009), as explained below.

For deep and intermediate water depth cases, the field measurements in the Gulf of Mexico cannot be used readily to derive harm and harassment (MMPA Level A and Level B harassment) isopleths, as at those sites the calibration hydrophone was located at a roughly constant depth of 350 to 500 meters (1,148.3 to 1,640.4 feet), which may not intersect all the sound pressure level isopleths at their widest point from the sea surface down to the maximum relevant water depth for marine mammals of approximately 2,000 meters (6,561.7 feet). At short ranges, where the direct arrivals dominate and the effects of seafloor interactions are minimal, the data recorded at the deep and slope sites are suitable for comparison with modeled levels at the depth of the calibration hydrophone. At longer ranges, the comparison with the model, constructed from the maximum sound pressure level through the entire water column at varying distances from the airgun array, is the most relevant. This is explained in more detail below.

In deep and intermediate water depths, comparisons at short ranges between sound levels for direct arrivals recorded by the calibration hydrophone and model results from the same airgun array tow depth are in good agreement. Consequently, isopleths falling within this domain can be

[1] For Level B harassment under the MMPA, and behavioral responses under the ESA, NMFS has historically relied on an acoustic threshold for 160 dB re: 1 µPa (rms)

predicted reliably by the Lamont-Doherty Earth Observatory model, although they may be imperfectly sampled by measurements recorded at a single depth. At greater distances, the calibration data show that seafloor-reflected and sub-seafloor-refracted arrivals dominate, whereas the direct arrivals become weak and/or incoherent. Aside from local topography effects, the region around the critical distance is where the observed levels rise closest to the model curve. However, the observed sound levels are found to fall almost entirely below the model curve. Thus, analysis of the Gulf of Mexico calibration measurements demonstrates that although simple, the Lamont-Doherty Earth Observatory model is a robust tool for conservatively estimating isopleths. For deep water depths (greater than 1,000 meters [3,280.8 feet]), Lamont-Doherty Earth Observatory used the deep water radii obtained from model results down to a maximum water depth of 2,000 meters (6,561.7 feet).

For shallow and intermediate depth waters, Lamont-Doherty Earth Observatory was able to use site-specific data to calculate the 160 dB and 175 dB re: 1 μPa (rms) isopleths[2] for behavioral harassment of marine mammals and sea turtles, respectively. This is based on Crone et al. (2014), empirical data collected on the Cascadia Margin in 2012 during the COAST Survey.

To estimate 160 dB and 175 dB radii in shallow and intermediate water depths, Lamont-Doherty Earth Observatory used the received levels from multichannel seismic data collected by the R/V *Langseth* during the COAST survey detailed in Crone et al. (2014). Streamer data in shallow water collected in 2012 have the advantage of including the effects of local and complex subsurface geology, seafloor topography and water column properties and thus allow us to establish mitigation radii more confidently than by using the data from calibration experiments in the Gulf of Mexico (Tolstoy et al. 2009; Diebold et al. 2010).

Measurements have not been reported for the single 40 cubic inch airgun array that is proposed for this action. Lamont-Doherty Earth Observatory model results are used to determine the 160 dB re: 1 μPa (rms) radius for the single 40 cubic inch airgun array at a tow depth of 12 meters (39.4 feet) in shallow, intermediate, and deep water. The estimated distances to the 160 and 175 dB re: 1 μPa (rms) isopleths for the single 40 cubic inch airgun array and 36 airgun array are in Table 3 and Table 4.

The National Science Foundation will implement an exclusion zone for sea turtles of 100 meter (328 feet). This distance is practicable for PSOs to implement shut downs, and is sufficiently large to prevent sea turtles from being exposed to sound levels that could result in Permanent Threshold Shift (PTS)[3]. This is discussed further in Section 10.3.3.

Table 3. Predicted distances to which sound levels of 160 dB re: 1 μPa (rms) for Marine Mammal Protection Act Level B harassment for impulsive sources will be received from the single 40 cubic

[2] The 175 dB re: 1 μPa (rms) isopleth represents our best understanding of the threshold at which sea turtles exhibit behavioral responses to seismic airgun arrays (see Table 4).
[3] PTS is a permanent increase in the threshold of hearing (minimum intensity needed to hear a sound) at a specific frequency above a previously established reference level (DOSITS 2021).

inch airgun and the 36-airgun array in shallow, intermediate, and deep water depths for marine mammals during the proposed seismic survey in the Northeast Pacific Ocean.

Source	Volume (in^3)	Water Depth (meters)	Predicted Distance to Threshold (160 dB re: 1 µPa [rms]) (meters)
1 Airgun	40	<100	1,041
		100 to 1,000	647
		>1,000	431
36 Airguns	6,600	<100	12,650
		100 to 1,000	9,648
		>1,000	6,733

in^3=cubic inches
m=meters

Table 4. Predicted distances to which sound levels of 175 dB re: 1 µPa (rms) will be received from the single 40 cubic inch airgun and the 36-airgun array in shallow, intermediate, and deep water depths for sea turtles during the proposed seismic survey in the Northeast Pacific Ocean.

Source	Volume (in^3)	Water Depth (meters)	Predicted Distance to Threshold (175 dB re: 1 µPa [rms]) (meters)
1 Airgun	40	<100	170
		100 to 1,000	116
		>1,000	77
36 Airguns	6,600	<100	3,924
		100 to 1,000	2,542
		>1,000	1,864

in^3=cubic inches
m=meters

Establishment of Proposed Exclusion and Buffer Zones

An exclusion zone is a defined area within which occurrence of a marine mammal or sea turtle triggers mitigation action intended to reduce the potential for certain outcomes (e.g., auditory injury, disruption of critical behaviors). The buffer zone means an area beyond the exclusion zone to be monitored for the presence of marine mammals and sea turtles that may enter the exclusion zone.

For marine mammals, PSOs will establish a default (minimum) exclusion zone with a 500-meter (1,640.4 feet) radius for visual monitoring for the 36 airgun array. The 500-meter (1,640.4 feet) exclusion zone will be based on the radial distance from any element of the airgun array (rather than being based on the center of the airgun array or around the vessel itself). With certain exceptions (described below), if a marine mammal appears within, enters, or appears on course to enter this zone, the airgun array will be powered-down or shut down, depending on the circumstance.

The 500 meter (1,640.4 feet) exclusion zone is intended to be precautionary in the sense that it will be expected to contain sound exceeding the injury criteria for all cetacean hearing groups (based on the dual criteria of SEL_{cum} and SPL_{peak}[4]), while also providing a consistent, reasonably observable zone within which PSOs will typically be able to conduct effective observations. Additionally, a 500 meter exclusion zone (1,640.4 feet) is expected to minimize the likelihood that marine mammals will be exposed to levels likely to result in more severe behavioral responses. Although significantly greater distances may be observed from an elevated platform under good conditions, the NMFS Permits and Conservation Division believes that 500 meters (1,640.4 feet) is likely regularly attainable for PSOs using the naked eye during typical conditions.

The buffer zone for marine mammals encompasses the area at and below the sea surface from the edge of the 0 to 500 meter (0 to 1,640.4 feet) exclusion zone, out to a radius of 1,000 meters (3,280.8 feet) from the edges of the airgun array (500 to 1,000 meters [1,640.4 to 3,280.8 feet]).

For sea turtles, as stated earlier, the National Science Foundation will establish an exclusion zone of 100 meters (328 feet), with the buffer zone corresponding to the distance to the 175 dB threshold. This is discussed further in Section 10.3.3.

The National Science Foundation's draft EA and Lamont-Doherty Earth Observatory's IHA application have a detailed description of the modeling for the R/V *Langseth*'s airgun array as well as the resulting isopleths to thresholds for the various marine mammal hearing groups and sea turtles (Table 3 and Table 4). Predicted distances to harm (MMPA Level A harassment) isopleths, which vary based on marine mammal hearing groups, were calculated by Lamont-Doherty Earth Observatory using the NUCLEUS software program and the NMFS User Spreadsheet (NOAA 2018; see Table 5).

[4] Notes: SEL_{cum} = Cumulative sound exposure level (decibel referenced to 1 micropascal squared seconds [dB re 1 μPa2-s]), SPL_{peak} = Peak sound pressure level (decibel referenced to 1 micropascal [dB re 1 μPa]), > indicates that the given effect would occur above the reported threshold.

Table 5. Predicted distances to PTS in hearing criteria for impulsive sources for various marine mammal hearing groups that could be received from the single airgun as well as the 36-airgun arrays during the proposed seismic survey in the Northeast Pacific Ocean.

Threshold	Low Frequency Cetaceans (meters)	Mid Frequency Cetaceans (meters)	High Frequency Cetaceans (meters)	Phocid Pinnipeds (meters)	Otariid Pinnipeds (meters)
Source – 1 Airgun					
SEL_{cum}	0.5	0	0	0	0
Peak SPL_{flat}	1.76	0.51	12.5	1.98	0.4
Source – 36 Airgun Array					
SEL_{cum}	426.9	0	1.3	13.9	0
Peak SPL_{flat}	38.9	13.6	268.3	43.7	10.6

m=meters

3.1.6.2 Shut down and Power Down Procedures

The shut down of the airgun array requires the immediate de-activation of all individual elements of the airgun array while a power-down of the airgun array requires the immediate de-activation of all individual elements of the airgun array except the single 40 cubic inch airgun. Any PSO on duty will have the authority to delay the start of seismic survey activities or to call for shut down or power-down of the airgun array if a marine mammal or sea turtle is detected within the applicable exclusion zone. The operator must also establish and maintain clear lines of communication directly between PSOs on duty and crew controlling the airgun array to ensure that shut down and power-down commands are conveyed swiftly while allowing PSOs to maintain watch. When both visual and acoustic PSOs are on duty, all detections will be immediately communicated to the remainder of the on-duty PSO team for potential verification of visual observations by the acoustic PSO or of acoustic detections by visual PSOs. When the airgun array is active (i.e., anytime one or more airgun is active, including during ramp-up and power-down) and: (1) a marine mammal or sea turtle appears within or enters the applicable exclusion zone and/or (2) a marine mammal (other than delphinids) is detected acoustically and localized within the applicable exclusion zone; the airgun array will be shut down. When a PSO calls for shut down, the airgun array will be immediately deactivated and any dispute resolved only following deactivation. Additionally, shut down will occur whenever passive acoustic monitoring alone (without visual sighting), confirms presence of marine mammal(s) in the exclusion zone. If the acoustic PSO cannot confirm presence within the exclusion zone, visual PSOs will be notified but shut down is not required.

Following a shut down, airgun array activity will not resume until the marine mammal has cleared the 500-meter (1,640.4 feet) exclusion zone. The animal will be considered to have cleared the 500-meter (1,640.4 feet) exclusion zone if it is visually observed to have departed the 500-meter (1,640.4 feet) exclusion zone, or it has not been seen within the 500-meter (1,640.4 feet) exclusion zone for 15 minutes in the case of small odontocetes and pinnipeds, or 30 minutes in the case of mysticetes and all other odontocetes, including sperm whales, beaked whales, killer whales, and Risso's dolphins. For sea turtles, the animal is considered to have cleared the 100-meter exclusion zone if it is visually observed to have departed the 100-meter exclusion zone, or it has not been seen in the 100-meter exclusion zone for 15 minutes.

Power-down conditions will be maintained (except for small delphinids for which shut down is waived) until marine mammals are no longer observed within the 500-meter exclusion zone, or sea turtles are no longer observed within the 100-meter exclusion zone, following which full-power operations may be resumed without ramp-up.

A large body of anecdotal evidence indicates that small delphinids commonly approach vessels and/or towed airgun arrays during active sound production for purposes of bow riding, with no apparent effect observed in those delphinids (Barkaszi et al. 2012a). The potential for increased shut downs resulting from such a measure will require the R/V *Langseth* to revisit the missed trackline to re-acquire data, resulting in an overall increase in the total sound energy input to the marine environment and an increase in the total duration over which the seismic survey activities are active in a given area. Although other species with mid-frequency hearing ranges (e.g., large delphinids) are no more likely to incur auditory injury than are small delphinids, they are much less likely to approach vessels. Therefore, retaining a power-down and/or shut down requirement for large delphinids will not have similar impacts in terms of either practicability for the applicant or corollary increase in sound energy output and time on the water. The NMFS Permits and Conservation Division anticipates some benefit for a power-down and/or shut down requirement for large delphinids in that it simplifies the total range of decision-making for PSOs. It may also preclude any potential for non-auditory physiological effects as well as some more severe behavioral reactions for any such animals in close proximity to the sound source vessel.

Visual PSOs will use best professional judgement in making the decision to call for a shut down if there is uncertainty regarding identification (i.e., whether the observed marine mammal[s] belongs to one of the delphinid genera for which shut down is waived or one of the species with a larger exclusion zone). If PSOs observe any behaviors in a small delphinid for which shut down is waived that indicate an adverse reaction, then power-down will be initiated immediately.

In addition to the shut down and power-down procedures described above, the NMFS Permits and Conservation Division's MMPA IHA will require shut downs if any of the following are observed at any distance:

- Any large whale (defined as a sperm whale or any mysticete [baleen whale]) species with a calf (defined as an animal less than two-thirds the body size of an adult observed to be in close association with an adult);

- An aggregation of six or more large whales; and/or
- A North Pacific right whale.

3.1.6.3 Pre-Clearance and Ramp-Up Procedures

Ramp-up (sometimes referred to as "soft-start") means the gradual and systematic increase of emitted sound levels from an airgun array. Ramp-up begins by first activating a single airgun of the smallest volume, followed by doubling the number of active elements in stages until the full complement of an airgun array is active. Each stage will be approximately the same duration, and the total duration will not be less than approximately 20 minutes. The intent of pre-clearance observation (30 minutes) is to ensure no protected species are observed within the buffer zone prior to the beginning of ramp-up. During pre-clearance is the only time observations of protected species in the buffer zone will prevent operations (i.e., the beginning of ramp-up). The intent of ramp-up is to warn protected species of pending seismic survey activities and to allow sufficient time for those animals to leave the immediate vicinity. A ramp-up procedure, involving a step-wise increase in the number of airguns firing and total airgun array volume until all operational airguns are activated and the full volume is achieved, is required at all times as part of the activation of the airgun array. All operators must adhere to the following pre-clearance and ramp-up requirements:

- The operator must notify a designated PSO of the planned start of ramp-up as agreed upon with the lead PSO; the notification time will not be less than 60 minutes prior to the planned ramp-up in order to allow the PSO time to monitor the exclusion and buffer zones for 30 minutes prior to the initiation of ramp-up (pre-clearance);
- Ramp-ups will be scheduled so as to minimize the time spent with the airgun array activated prior to reaching the designated run-in;
- One of the PSOs conducting pre-clearance observations must be notified again immediately prior to initiating ramp-up procedures and the operator must receive confirmation from the PSO to proceed;
- Ramp-up may not be initiated if any marine mammal or sea turtle is within the applicable exclusion or buffer zone. If a marine mammal or sea turtle is observed within the applicable exclusion zone or the buffer zone during the 30-minute pre-clearance period, ramp-up may not begin until the animal(s) has been observed exiting the zones or until an additional time period has elapsed with no further sightings (15 minutes for small odontocetes, sea turtles, and pinnipeds and 30 minutes for mysticetes and all other odontocetes, including sperm whales, beaked whales, killer whales, and Risso's dolphins).
- Ramp-up will begin by activating a single airgun array of the smallest volume in the airgun array and will continue in stages by doubling the number of active elements at the commencement of each stage, with each stage of approximately the same duration. Duration will not be less than 20 minutes. The operator must provide information to the PSO documenting that appropriate procedures were followed;

- PSOs must monitor the exclusion and buffer zones during ramp-up, and ramp-up must cease and the airgun array must be shut down upon observation of marine mammals and sea turtles within the applicable exclusion zone. Once ramp-up has begun, observations of marine mammals and sea turtles within the buffer zone do not require shut down or power-down, but such observation will be communicated to the operator to prepare for the potential shut down or power-down;
- Ramp-up may occur at times of poor visibility, including nighttime, if appropriate acoustic monitoring has occurred with no detections in the 30 minutes prior to beginning ramp-up. Airgun array activation may only occur at times of poor visibility where operational planning cannot reasonably avoid such circumstances;
- If the airgun array is shut down for brief periods (i.e., less than 30 minutes) for reasons other than that described for shut down and power-down (e.g., mechanical difficulty), it may be activated again without ramp-up if PSOs have maintained constant visual and/or passive acoustic monitoring and no visual or acoustic detections of marine mammals have occurred within the applicable exclusion zone. For any longer shut down, pre-clearance observation and ramp-ups are required. For any shut down at night or in periods of poor visibility (e.g., Beaufort sea state four or greater), ramp-up is required, but if the shut down period was brief and constant observation was maintained, a pre-clearance watch of 30 minutes is not required; and
- Testing of the airgun array involving all elements requires ramp-up. Testing limited to individual elements or strings of the airgun array does not require ramp-up but does require pre-clearance of 30 minutes.

3.1.6.4 Vessel-Based Visual Mitigation Monitoring

Visual monitoring requires the use of trained PSOs to scan the ocean surface visually for the presence of marine mammals. The area to be scanned visually includes primarily the exclusion zone (0 to 500 meters), but also the buffer zone (500 to 1,000 meters). As described above, the buffer zone is an area beyond the exclusion zone to be monitored for the presence of marine mammals and sea turtles that may enter the exclusion zone. During pre-clearance monitoring (i.e., before ramp-up begins), the buffer zone also acts as an extension of the exclusion zone in that observations of marine mammals within the buffer zone will also prevent airgun array operations from beginning (i.e., ramp-up). Visual monitoring of the exclusion zone and adjacent waters is intended to establish and, when visual conditions allow, maintain zones around the sound source that are clear of marine mammals and sea turtles, thereby reducing or eliminating the potential for injury and minimizing the potential for more severe behavioral reactions for animals close to the vessel. Visual monitoring of the buffer zone is intended to: (1) provide additional protection to marine mammals that may be in the area during pre-clearance; and (2) during use of the airgun array, aid in establishing and maintaining the exclusion zone by alerting the visual PSO and crew of marine mammals and sea turtles that are outside of, but may approach and enter, the exclusion zone.

The National Science Foundation and Lamont-Doherty Earth Observatory must use at least five dedicated, trained, NMFS-approved PSOs. The PSOs must have no tasks other than to conduct observational effort, record observational data, and communicate with and instruct relevant vessel crew with regard to the presence of marine mammals and mitigation requirements. PSO resumes shall be provided to NMFS for approval prior to the survey.

At least one of the visual and two of the acoustic PSOs aboard the vessel must have a minimum of 90 days at-sea experience working in the role during a deep penetration (i.e., high-energy) seismic survey, with no more than 18 months elapsed since the conclusion of the at-sea experience. One visual PSO with such experience shall be designated as the lead for the entire PSO team. The lead PSO shall serve as the primary point of contact for the vessel operator and ensure all PSO requirements per the MMPA IHA are met. To the maximum extent practicable, the experienced PSOs will be scheduled to be on duty with those PSOs with appropriate training but who have not yet gained relevant at-sea experience.

During seismic survey activities (e.g., any day on which use of the airgun array is planned to occur, and whenever the airgun array is in the water, whether activated or not), a minimum of two visual PSOs must be on duty and conducting visual observations at all times during daylight hours (i.e., from 30 minutes prior to sunrise through 30 minutes following sunset) and 30 minutes prior to and during nighttime ramp-ups of the airgun array. Visual monitoring of the exclusion and buffer zones must begin no less than 30 minutes prior to ramp-up and must continue until one hour after use of the airgun array ceases or until 30 minutes past sunset. Visual PSOs shall coordinate to ensure 360-degree visual coverage around the vessel from the most appropriate observation posts, and shall conduct visual observations using binoculars and the naked eye while free from distractions and in a consistent, systematic, and diligent manner.

PSOs will establish and monitor the buffer and exclusion zones. The buffer and exclusion zones will be based upon the radial distance from the edges of the airgun array (rather than being based on the center of the airgun array or around the vessel itself). During use of the airgun array (i.e., anytime the airgun array is active, including ramp-up), occurrences of marine mammals and sea turtles within the buffer zone (but outside the exclusion zone) will be communicated to the operator to prepare for the potential shut down or power-down for the airgun array.

During use of the airgun array (i.e., anytime the airgun array is active, including ramp-up), occurrences of marine mammals within the buffer zone (but outside the exclusion zone) will be communicated to the operator to prepare for the potential shut down or power-down of the airgun array. Visual PSOs will immediately communicate all observations to the on-duty acoustic PSO(s), including any determination by the PSO regarding species identification, distance, and bearing, and the degree of confidence in the determination. Any observations of marine mammals and sea turtles by crewmembers will be relayed to the PSO team. During good conditions (e.g., daylight hours, Beaufort sea state three or less), visual PSOs will conduct observations when the airgun array is not operating for comparison of sighting rates and behavior with and without use of the airgun array and between acquisition periods, to the maximum extent practicable. Visual PSOs may be on watch for a maximum of four consecutive hours followed by a break of at least one hour between watches and may conduct a maximum of 12 hours of observation per 24-hour period. Combined observational duties (visual and acoustic, but not at the same time) may not exceed 12 hours per 24-hour period for any individual PSO.

3.1.6.5 Passive Acoustic Monitoring

Passive acoustic monitoring means the use of trained operators, herein referred to as acoustic PSOs, to operate passive acoustic monitoring equipment to acoustically detect the presence of marine mammals. Passive acoustic monitoring involves acoustically detecting marine mammals, regardless of distance from the airgun array, as localization of animals may not always be possible. Passive acoustic monitoring is intended to further support visual monitoring (during daylight hours) in maintaining an exclusion zone around the airgun array that is clear of marine mammals. In cases where visual monitoring is not effective (e.g., due to weather, nighttime), passive acoustic monitoring may be used to allow certain activities to occur, as further detailed below.

Passive acoustic monitoring will take place in addition to the visual monitoring program. Visual monitoring typically is not effective during periods of poor visibility or at night, and even with good visibility, is unable to detect marine mammals when they are below the surface or beyond visual range. Passive acoustic monitoring can be used in addition to visual observations to improve detection, identification, and localization of marine mammals. The passive acoustic monitoring will serve to alert visual PSOs (if on duty) when vocalizing cetaceans are detected. It is only useful when marine mammals call, but it can be effective by either day or night, and does not depend on good visibility. It will be monitored in real time so that the visual PSOs can be advised when cetaceans are detected.

The R/V *Langseth* will use a towed passive acoustic monitoring system, which must be monitored by a minimum of one on duty acoustic PSO beginning at least 30 minutes prior to ramp-up and at all times during use of the airgun array. Acoustic PSOs may be on watch for a maximum of four consecutive hours followed by a break of at least one hour between watches and may conduct a maximum of 12 hours of observation per 24-hour period for any individual PSO.

Seismic survey activities may continue for 30 minutes when the passive acoustic monitoring system malfunctions or is damaged, while the passive acoustic monitoring operator diagnoses the issue. If the diagnosis indicates that the passive acoustic monitoring system must be repaired to solve the problem, operations may continue for an additional two hours without passive acoustic monitoring during daylight hours only under the following conditions:

- Beaufort sea state is less than or equal to four;
- No marine mammals (excluding delphinids) detected solely by passive acoustic monitoring in the applicable exclusion zone in the previous two hours;

- NMFS is notified via email as soon as practicable with the time and location in which operations began occurring without an active passive acoustic monitoring system; and
- Operations with an active airgun array, but without an operating passive acoustic monitoring system, do not exceed a cumulative total of four hours in any 24-hour period.

3.1.6.6 Vessel Strike Avoidance

Vessel strike avoidance measures are intended to minimize the potential for collisions with marine mammals and sea turtles. The vessel strike avoidance measures apply to all vessels associated with the planned seismic survey activities. NMFS Permits and Conservation Division notes that these requirements do not apply in any case where compliance will create an imminent and serious threat to a person or vessel or to the extent that a vessel is restricted in its ability to maneuver and, because of the restriction, cannot comply. These measures include the following:

- The vessel operator and crew will maintain a vigilant watch during daylight hours for all marine mammals and sea turtles and slow down or stop or alter course of the vessel, as appropriate and regardless of vessel size, to avoid striking any marine mammal and sea turtle during seismic survey activities as well as transits. A single marine mammal at the surface may indicate the presence of submerged animals near the vessel; therefore, precautionary measures should be exercised when an animal is observed. A visual observer aboard the vessel will monitor a vessel strike avoidance zone around the vessel (specific distances detailed below) to ensure the potential for vessel strike is minimized, according to the parameters stated below. Visual observers monitoring the vessel strike avoidance zone can be either third-party PSOs or crew members, but crew members responsible for these duties will be provided sufficient training to distinguish marine mammals and sea turtles from other phenomena and broadly to identify a marine mammal and sea turtles to broad taxonomic group (e.g., as a large whale or other marine mammal).
- Vessel speeds must be reduced to 18.5 kilometers per hour (10 knots) or less when mother/calf pairs, pods, or large assemblages of marine mammals and sea turtles are observed near the vessel.
- The vessel will maintain a minimum separation distance of 100 meter (328.1 feet) from large whales (i.e., all baleen whales and sperm whales).
- The vessel will maintain a minimum separation distance of 50 meter (164 feet) from all other marine mammals and sea turtles, with an exception made for animals that approach the vessel.
- When marine mammals and sea turtles are sighted while a vessel is underway, the vessel must take action as necessary to avoid violating the relevant separation distance. If marine mammals are sighted within the relevant separation distance, the vessel must reduce speed and shift the engine to neutral, not engaging the engines until animals are clear of the area. This recommendation does not apply to any vessel towing gear.

3.2 National Marine Fisheries Service's Proposed Activities

On December 3, 2019, NMFS Permits and Conservation Division received a request from the National Science Foundation and Lamont-Doherty Earth Observatory for an IHA to take marine mammals incidental to conducting a high-energy marine seismic survey along the Queen Charlotte Fault in the Northeast Pacific Ocean. On December 16, 2021, NMFS Permits and Conservation Division deemed the National Science Foundation and Lamont-Doherty Earth Observatory's application for an IHA to be adequate and complete. The National Science Foundation and Lamont-Doherty Earth Observatory's request is for take of a small number of 21 species of marine mammals by MMPA Level B harassment. In addition, NMFS proposes to authorize take by MMPA Level A harassment for seven of these species. Neither the National Science Foundation, Lamont-Doherty Earth Observatory, nor NMFS Permits and Conservation Division expects serious injury or mortality to result from the proposed activities, therefore, an IHA is appropriate. The planned seismic survey is not expected to exceed one year; hence, the NMFS Permits and Conservation Division does not expect subsequent MMPA IHAs would be issued for this proposed action. The IHA would be valid for a period of one year from the date of issuance. The NMFS Permits and Conservation Division proposes to issue the IHA prior to the start of the proposed seismic survey activities.

3.2.1 National Marine Fisheries Service's Proposed IHA

The NMFS Permits and Conservation Division's IHA would authorize the incidental harassment of the following threatened and endangered marine mammal species: blue whale (*Balaenoptera musculus*), fin whale (*Balaenoptera physalus*), North Pacific right whale (*Eubalaena japonica),* the Mexico DPS of humpback whale (*Megaptera novaeangliae*), the Western North Pacific DPS of gray whale (*Eschrichtius robustus*), sei whale (*Balaenoptera borealis*), sperm whale (*Physeter macrocephalus*), and the Western DPS of Steller sea lion (*Eumetopias jubatus*). The proposed IHA identifies requirements that the National Science Foundation must comply with as part of its authorization. The NMFS Permits and Conservation Division does not expect the National Science Foundation's planned seismic survey to exceed one year and does not expect subsequent MMPA IHAs would be issued for this particular specified activity.

On June 4, 2021, NMFS Permits and Conservation published a notice of proposed IHA and request for comments on proposed IHA and possible renewal in the *Federal Register* (86 FR 30006). The public comment period closed on July 6, 2021. Appendix A (Section 17) contains the proposed IHA. The text in Appendix A was taken directly from the proposed IHA provided to us in the consultation initiation package from NMFS' Permits and Conservation Division.

3.2.2 National Marine Fisheries Service's Revisions to Proposed IHA

The NMFS Permits and Conservation Division has made revisions to the proposed IHA since the notice was published in the *Federal Register* on June 4, 2021 (86 FR 30006). Recent sightings data from the Canadian Department of Fisheries documented an individual North Pacific right whale off the coast of Haida Gwaii on June 15, 2021 (Kloster 2021). The revisions to the proposed IHA include modifications to the incidental take estimates for North Pacific right whale. Due to recent sightings data, the NMFS Permits and Conservation Division added two authorized take of North Pacific right whale to its IHA.

4 Action Area

Action area means all areas affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 C.F.R. §402.02).

The proposed survey would occur within approximately 52–57 degrees North and approximately 131–137 degrees West. Representative survey tracklines are shown in Figure 1. The surveys are proposed to occur within the EEZ of the U.S. and Canada, as well as in U.S. state waters and Canadian Territorial Waters ranging in depth from 50 to 2800 meters. As described earlier in this document, some deviation in actual tracklines, including the order of survey operations, could be necessary for reasons such as science drivers, poor data quality, inclement weather, or mechanical issues with the research vessel and/or equipment. However, deviations in tracklines are expected to be limited and would have minimal effect on the ensuing analysis. Thus, for the surveys, the tracklines could occur anywhere within the coordinates noted above, which is the proposed action area for the consultation. The proposed action area includes all areas where effects from the survey could occur (including all areas ensonified by sound from the proposed activities and transit routes).

Canadian Territorial Seas and the Action Area

Canada considers its territorial seas to extend out 12 nautical miles. A nation's territorial seas are the sovereign territory of that country. According to the draft EA that the National Science Foundation prepared for this action, most of the survey lines will take place outside the 12 nautical mile line. NMFS' jurisdiction under the ESA and MMPA only applies to the portions of the seismic survey which occur outside the 12 nautical mile boundary.

The fact that portions of the proposed actions fall both inside and outside of the 12 nautical mile boundary (the high seas) presents us with a complexity. For ESA section 7 consultations, we are required to examine the effects of the action throughout the entire action area in making our jeopardy and/or destruction and adverse modification determinations. However, we do not have authority under the ESA to authorize incidental take within the sovereign territory of Canada (i.e., within 12 nautical miles of Canada's coast).

Although portions of the tracklines do not occur in the high seas (where NMFS has jurisdiction), we are obligated to consider the effects of the action throughout the entire action area. Therefore, we must consider the 12 nautical mile boundary in relation to:

- The location of the tracklines, and
- The extent of the ensonified area.

By using GIS software, the Lamont-Doherty Earth Observatory calculated the amount of survey tracklines and ensonified areas that were inside Canadian territorial waters. They then calculated take both inside Canadian territorial waters and for the entire action area (see Section 10.3).

This opinion considers two exposure scenarios to fulfill our requirements under the ESA:

1. Estimate exposure and response to determine the effects of the proposed actions throughout the entire action area (inside and outside the 12 nautical mile boundary) to reach the jeopardy determination, and
2. Estimate exposure and response in the portions of the action area where NMFS has jurisdiction under the ESA (to estimate numbers of allowed take for an incidental take statement).

To make our jeopardy determination, we will consider the effects of the action in the total survey area, and we will use the area calculated outside the Canadian territorial seas to estimate the amount or extent of take for an incidental take statement.

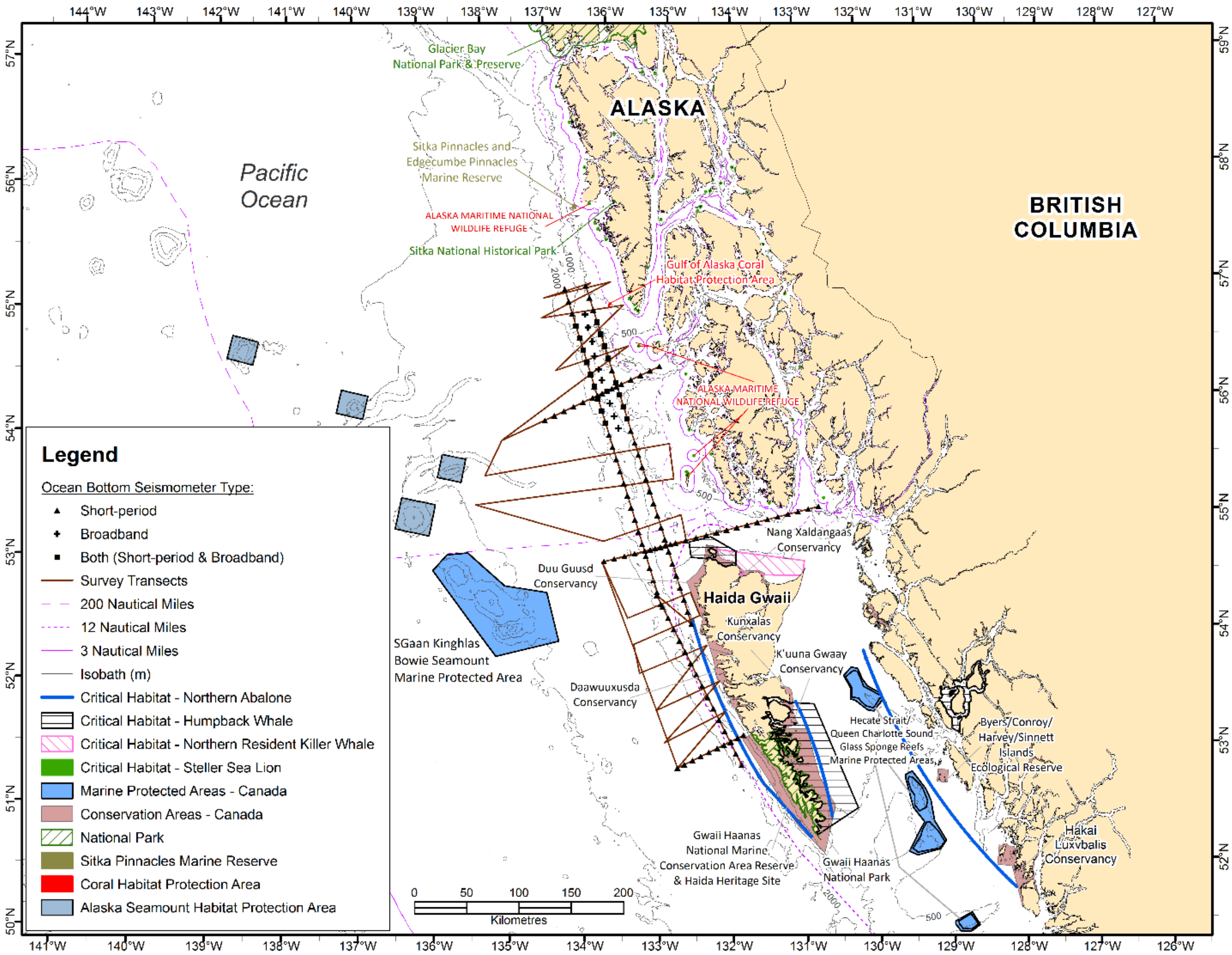

Figure 1. Location of the proposed seismic surveys in the Northeast Pacific Ocean off the coasts of Southeast Alaska and northern British Columbia.

5 Potential Stressors

The proposed action involves multiple activities, each of which can create stressors. Stressors are any physical, chemical, or biological entity that may directly or indirectly induce a response in either an ESA-listed species or their designated critical habitat. During consultation, we deconstructed the proposed action to identify stressors that are reasonably certain to result from the proposed activities. These can be categorized as pollution (e.g., fuel, oil, trash), vessel strikes, acoustic and visual disturbance (research vessels, multi-beam echosounders, sub-bottom profilers, acoustic Doppler current profilers, and seismic airgun array), and entanglement in towed seismic equipment. These stressors and their potential effects to ESA-listed species and designated critical habitat are introduced in the subsections that follow. Detailed information on the effects of these potential stressors can be found in Section 7.1 and our effects analysis in Section 10. The proposed action includes several conservation (monitoring and mitigation) measures described in Section 3.1.6 that are designed to minimize effects that may result from some of these potential stressors. While we consider all of these measures important and expect them to be effective in minimizing the effects of potential stressors, they do not completely eliminate the identified stressors. Nevertheless, we treat them as part of the proposed action and fully consider them when evaluating the effects of the proposed action.

5.1 Pollution

The operation of the R/V *Langseth* and R/V *Tully* as a result of the proposed action may result in pollution from fuel, oil, trash, and other debris.

5.1.1 Marine Debris

The release of marine debris such as paper, plastic, wood, glass, and metal associated with vessel operations can have adverse effects on marine species most commonly through entanglement or ingestion (Gall and Thompson 2015).While lethal and non-lethal effects to air breathing marine animals such sea turtles, birds, and marine mammals are well documented, marine debris also adversely affects marine fish (Gall and Thompson 2015).

5.1.2 Pollution by Oil or Fuel Leakage

Research vessels used in National Science Foundation-funded seismic surveys have spill prevention plans, which allow a rapid response to a spill in the event one occurs. In the event that a leak should occur, the amount of fuel and oil onboard the R/V *Langseth* and R/V *Tully* is unlikely to cause widespread, high-dose contamination (excluding the remote possibility of severe damage to the vessel) that will impact ESA-listed species directly or pose hazards to their food sources.

5.2 Vessel Strikes

Seismic surveys necessarily involve vessel traffic within the marine environment, and the transit of any vessel in waters inhabited by ESA-listed species carries the risk of a vessel strike. Vessel strikes are known to adversely affect ESA-listed sea turtles, fishes, and marine mammals (Laist et al. 2001; Douglas et al. 2008; NMFS and USFWS 2008; Brown and Murphy 2010; Work et al. 2010; Rockwood et al. 2017). If an animal is struck by a vessel, it may experience minor, non-lethal injuries, serious injuries, or death.

Vessel traffic associated with the proposed action carries the risk of vessel strikes of protected species. The probability of a vessel collision depends on the number, size, and speed of vessels, as well as the distribution, abundance, life stage and behavior of the species (Laist et al. 2001; Jensen and Silber 2004; Hazel et al. 2007; Vanderlaan and Taggart 2007; Conn and Silber 2013a). The R/V *Langseth* has a length of 72 meters (235 feet) and the proposed operating speed during seismic data acquisition is approximately 8.3 kilometers per hour (4.5 knots). The R/V *Tully* has a length of 69 meters (226 feet) and a proposed operating speed of 18.5 kilometers per hour (10 knots). When not towing seismic survey gear, the R/V *Langseth* typically cruises at 18.5 kilometers per hour (10 knots). The majority of vessel strikes of large whales occur when vessels are traveling at speeds greater than approximately 18.5 kilometers per hour (10 knots), with faster travel, especially of large vessels (80 meters [262.5 feet] or greater), being more likely to cause serious injury or death (Laist et al. 2001; Jensen and Silber 2004; Vanderlaan and Taggart 2007; Conn and Silber 2013a).

Several conservation measures proposed by the NMFS Permits and Conservation Division and/or National Science Foundation would minimize the risk of vessel strike (e.g., use of PSOs, vessel strike avoidance measures [Section 3.1.6]). The R/V *Langseth* and R/V *Tully* will be traveling at generally slow speeds, reducing the probability of a vessel strike (Kite-Powell et al. 2007; Vanderlaan and Taggart 2007). In addition, the overall level of vessel activity associated with the proposed action is low relative to the large size of the action area, further reducing the likelihood of a vessel strike of an ESA-listed species. While vessel strikes of marine mammals during seismic survey activities are possible, we are not aware of any definitive case of a marine mammal being struck by a vessel associated with seismic surveys. The R/V *Langseth* has traveled hundreds of thousands of kilometers without a vessel strike (Holst and Smultea 2008b; Hauser and Holst 2009; Holst 2010).

5.3 Acoustic Noise, Vessel Noise, and Visual Disturbance

The proposed action would produce a variety of sounds, including those associated with vessel operations, and the use of a multi-beam echosounders, acoustic Doppler current profilers, sub-bottom profilers, and airgun arrays that may produce an acoustic disturbance or otherwise affect ESA-listed species. The presence of the survey vessel and the survey gear can also produce a visual disturbance that may affect ESA-listed marine species.

The visual or auditory disturbances associated with the proposed action could disrupt behavior of ESA-listed species that spend time near the surface. Studies have shown that vessel operation can result in changes in the behavior of marine mammals and sea turtles (Patenaude et al. 2002; Richter et al. 2003; Hazel et al. 2007; Smultea et al. 2008; Holt et al. 2009; Luksenburg and Parsons 2009; Noren et al. 2009). Numerous studies of interactions between surface vessels and marine mammals have demonstrated that free-ranging marine mammals engage in avoidance behavior when surface vessels move toward them. It is not clear whether these responses are caused by the physical presence of a surface vessel, the underwater noise generated by the vessel, or an interaction between the two (Bryant et al. 1984; Bauer 1986; Watkins 1986; Corkeron 1995; Wursig et al. 1998; Bejder et al. 1999; Au and Green 2000; Félix 2001; Nowacek et al. 2001; Erbe 2002b; Magalhaes et al. 2002; Williams et al. 2002; Lusseau 2003; Richter et al. 2003; Goodwin and Cotton 2004; Scheidat et al. 2004; Amaral and Carlson 2005; Simmonds 2005; Bain et al. 2006; Lemon et al. 2006; Lusseau 2006; Bejder and Lusseau. 2008; Bejder et al. 2009). Animals may not even differentiate between visual and acoustic disturbances created by vessels at close distances and may simply respond to the combined disturbance. In cases when responses are observed at great distances, it is thought that animals are likely responding to sound more than the visual presence of vessels (Evans et al. 1992; Blane and Jaakson 1994a; Evans et al. 1994). Several authors suggest that the noise generated during motion is probably an important factor (Evans et al. 1992; Blane and Jaakson 1994b; Evans et al.

1994). These studies suggest that the behavioral responses of marine mammals to surface vessels are similar to their behavioral responses to predators.

Unlike vessels, which produce sound as a byproduct of their operations, survey equipment such as OBSs, multi-beam echosounders, acoustic Doppler current profilers, sub-bottom profilers, and seismic airgun arrays are designed to actively produce deliberate and controlled sound. Depending on the circumstances, exposure to these anthropogenic sound sources may result in auditory injury, changes in hearing ability, masking of important sounds, behavioral responses, as well as other physical and physiological responses.

5.4 Gear Entanglement

The towed seismic equipment associated with the proposed seismic surveys may pose a risk of entanglement to ESA-listed species. Entanglement can result in death or injury of marine mammals and sea turtles (Moore et al. 2009; Van der Hoop et al. 2013; Duncan et al. 2017). Marine mammal and sea turtle entanglement is a global problem that every year results in the death of hundreds of thousands of animals worldwide, particularly due to entanglement in fishing gear, or bycatch. Entangled marine mammals and sea turtles may drown or starve due to being restricted by gear, suffer physical trauma and systemic infections, and/or be hit by vessels due to an inability to avoid them.

The towed hydrophone streamer is rigid and as such should not encircle, wrap around, or in any other way entangle any of the ESA-listed species considered in this consultation.

6 Endangered Species Act Resources That May Be Affected

This section identifies the ESA-listed species and designated critical habitat under NMFS jurisdiction that may occur within the action area that may be affected by the proposed action (Table 6). The following section (Section 7) identifies the species and designated critical habitat that may be affected, but are not likely to be adversely affected by the proposed action. The remaining species and designated critical habitat deemed likely to be adversely affected by the proposed action (See Section 7.3) are then carried forward through the remainder of this opinion.

Table 6. Endangered Species Act-listed threatened and endangered species and critical habitat potentially occurring in the action area that may be affected

Species	ESA Status	Critical Habitat	Recovery Plan
Marine Mammals – Cetaceans			
Blue Whale (*Balaenoptera musculus)*	E – 35 FR 18319	-- --	07/1998 11/2020
Fin Whale (*Balaenoptera physalus)*	E – 35 FR 18319	-- --	75 FR 47538 07/2010
Gray Whale (*Eschrichtius robustus*) Western North Pacific Population	E – 35 FR 18319	-- --	-- --

Species	ESA Status	Critical Habitat	Recovery Plan
Humpback Whale (*Megaptera novaeangliae*) – Mexico DPS	T – 81 FR 62259	86 FR 21082	11/1991
Killer Whale (*Orcinus orca*) – Southern Resident DPS	E – 70 FR 69903 Amendment 80 FR 7380	71 FR 69054 84 FR 99214 (Proposed)	73 FR 4176 01/2008
North Pacific Right Whale (*Eubalaena japonica*)	E – 73 FR 12024	73 FR 19000	78 FR 34347 06/2013
Sei Whale (*Balaenoptera borealis*)	E – 35 FR 18319	-- --	12/2011
Sperm Whale (*Physeter macrocephalus*)	E – 35 FR 18319	-- --	75 FR 81584 12/2010
Marine Mammals—Pinnipeds			
Guadalupe Fur Seal (*Artocephalus townsendi*)	T – 50 FR 51252	-- --	-- --
Steller Sea Lion (*Eumetopias jubatus*) – Western DPS	E – 55 FR 49204	58 FR 45269	73 FR 11872 2008
Marine Reptiles			
Green Turtle (*Chelonia mydas*) – East Pacific DPS	T – 81 FR 20057	-- --	63 FR 28359 01/1998
Leatherback Turtle (*Dermochelys coriacea*)	E – 35 FR 8491	44 FR 17710 and 77 FR 4170	10/1991 – U.S. Caribbean, Atlantic, and Gulf of Mexico 63 FR 28359 05/1998 – U.S. Pacific
Loggerhead Turtle (*Caretta caretta*) – North Pacific Ocean DPS	E – 76 FR 58868	-- --	63 FR 28359
Olive Ridley Turtle (*Lepidochelys olivacea*) All Other Areas	T – 43 FR 32800	-- --	-- --
Olive Ridley Turtle (*Lepidochelys olivacea*) Mexico's Pacific Coast Breeding Colonies	E – 43 FR 32800	-- --	63 FR 28359
Fishes			
Chinook Salmon (*Oncorhynchus tshawytscha)* – California Coastal ESU	T – 70 FR 37160	70 FR 52488	81 FR 70666
Chinook Salmon (*Oncorhynchus tshawytscha)* – Central Valley Spring-Run ESU	T – 70 FR 37160	70 FR 52488	79 FR 42504
Chinook Salmon (*Oncorhynchus tshawytscha)* – Lower Columbia River ESU	T – 70 FR 37160	70 FR 52629	78 FR 41911

Species	ESA Status	Critical Habitat	Recovery Plan
Chinook Salmon (*Oncorhynchus tshawytscha)* – Puget Sound ESU	T – 70 FR 37160	70 FR 52629	72 FR 2493
Chinook Salmon (*Oncorhynchus tshawytscha)* – Sacramento River Winter-Run ESU	E – 70 FR 37160	58 FR 33212	79 FR 42504
Chinook Salmon (*Oncorhynchus tshawytscha)* – Snake River Fall-Run ESU	T – 70 FR 37160	58 FR 68543	80 FR 67386 (Draft)
Chinook Salmon (*Oncorhynchus tshawytscha)* – Snake River Spring/Summer Run ESU	T – 70 FR 37160	64 FR 57399	81 FR 74770 (Draft) 11-2017-Final
Chinook Salmon (*Oncorhynchus tshawytscha)* – Upper Columbia River Spring-Run ESU	E – 70 FR 37160	70 FR 52629	72 FR 57303
Chinook Salmon (*Oncorhynchus tshawytscha)* – Upper Willamette River ESU	T – 70 FR 37160	70 FR 52629	76 FR 52317
Chum Salmon (*Oncorhynchus keta*) – Columbia River ESU	T – 70 FR 37160	70 FR 52629	78 FR 41911
Chum Salmon (*Oncorhynchus keta*) – Hood Canal Summer-Run ESU	T – 70 FR 37160	70 FR 52629	72 FR 29121
Coho Salmon (*Oncorhynchus kisutch*) – Central California Coast ESU	E – 70 FR 37160	64 FR 24049	77 FR 54565
Coho Salmon (*Oncorhynchus kisutch*) – Lower Columbia River ESU	T – 70 FR 37160	81 FR 9251	78 FR 41911
Coho Salmon (*Oncorhynchus kisutch*) – Oregon Coast ESU	T – 73 FR 7816	73 FR 7816	81 FR 90780
Coho Salmon (*Oncorhynchus kisutch*) – Southern Oregon and Northern California Coasts ESU	T – 70 FR 37160	64 FR 24049	79 FR 58750
Eulachon (*Thaleichthys pacificus*) –Southern DPS	T – 75 FR 13012	76 FR 65323	9/2017
Green Sturgeon (*Acipenser medirostris*) – Southern DPS	T – 71 FR 17757	74 FR 52300	2010 (Outline) 8/2018- Final
Sockeye Salmon (*Oncorhynchus nerka*) – Ozette Lake ESU	T – 70 FR 37160	70 FR 52630	74 FR 25706
Sockeye Salmon (*Oncorhynchus nerka*) – Snake River ESU	E – 70 FR 37160	58 FR 68543	80 FR 32365
Steelhead Trout (*Oncorhynchus mykiss*) – California Central Valley DPS	T – 71 FR 834	70 FR 52487	79 FR 42504
Steelhead Trout (*Oncorhynchus mykiss*) – Central California Coast DPS	T – 71 FR 834	70 FR 52487	81 FR 70666

Species	ESA Status	Critical Habitat	Recovery Plan
Steelhead Trout (*Oncorhynchus mykiss*) – Lower Columbia River DPS	T – 71 FR 834	70 FR 52629	78 FR 41911
Steelhead Trout (*Oncorhynchus mykiss*) – Middle Columbia River DPS	T – 71 FR 834	70 FR 52629	74 FR 50165
Steelhead Trout (*Oncorhynchus mykiss*) – Northern California DPS	T – 71 FR 834	70 FR 52487	81 FR 70666
Steelhead Trout (*Oncorhynchus mykiss*) – Puget Sound DPS	T – 72 FR 26722	81 FR 9251	84 FR 71379
Steelhead Trout (*Oncorhynchus mykiss*) – Snake River Basin DPS	T – 71 FR 834	70 FR 52629	81 FR 74770 (Draft) 11-2017-Final
Steelhead Trout (*Oncorhynchus mykiss*) – South-Central California Coast DPS	T – 71 FR 834	70 FR 52487	78 FR 77430
Steelhead Trout (*Oncorhynchus mykiss*) – Southern California DPS	E – 71 FR 834	70 FR 52487	77 FR 1669
Steelhead Trout (*Oncorhynchus mykiss*) – Upper Columbia River DPS	T – 71 FR 834	70 FR 52629	72 FR 57303
Steelhead Trout (*Oncorhynchus mykiss*) – Upper Willamette River DPS	T – 71 FR 834	70 FR 52629	76 FR 52317

7 Species and Critical Habitat Not Likely to be Adversely Affected

NMFS uses two criteria to identify the ESA-listed species or critical habitat that are not likely to be adversely affected by the proposed action, as well as the effects of activities that are consequences of the Federal agency's proposed action. The first criterion is exposure, or some reasonable expectation of a co-occurrence, between one or more potential stressors associated with the proposed activities and ESA-listed species or designated critical habitat. If we conclude that an ESA-listed species or designated critical habitat is not likely to be exposed to the proposed activities, we must also conclude that the species or critical habitat is not likely to be adversely affected by those activities.

The second criterion is the probability of a response given exposure. ESA-listed species or designated critical habitat that is exposed to a potential stressor but is likely to be unaffected by the exposure is also not likely to be adversely affected by the proposed action. We applied these criteria to the ESA-listed species and designated critical habitat in Section 6 and we summarize our results below.

An action warrants a "may affect, not likely to be adversely affected" determination when effects on listed species or critical habitat are expected to be *discountable, insignificant, or wholly beneficial*. *Beneficial* effects have an immediate positive effect without any adverse effects to the species or habitat.

Insignificant effects relate to the size or severity of the impact and include those effects that are undetectable, not measurable, or so minor that they cannot be meaningfully evaluated. Insignificant is the appropriate effect conclusion when plausible effects are going to happen, but will not rise to the level of constituting an adverse effect.

Discountable applies to those consequences that are extremely unlikely to occur to the listed species or critical habitat. For an effect to be discountable, there must be a plausible adverse effect (i.e., a credible effect that could result from the action and that would be an adverse effect if it did impact a listed species or critical habitat), but it is very unlikely to occur.

In this section, we evaluate effects from the proposed action's stressors (Section 5) to numerous ESA-listed species and designated critical habitat that may be affected, but are not likely to be adversely affected by the proposed action (Section 7.1). For ESA-listed species, we focus specifically on the stressors associated with the National Science Foundation-funded seismic research activities and the NMFS Permits and Conservation Division's proposed action of issuance of an IHA for ESA-listed marine mammals and other non-listed marine mammals and their effects on these species. We consider several of these stressors not likely to adversely affect species, and provide our rationale in the sections below.

We also identify ESA-listed species (Section 7.2) and designated critical habitat (Section 7.3) that are not likely to be adversely affected by the proposed action. The effects of other stressors associated with the proposed action, which are likely to adversely affect ESA-listed species, are evaluated in Section 10.

7.1 Stressors Not Likely to Adversely Affect Species

7.1.1 Pollution

Pollution in the form of vessel exhaust, fuel, oil spills, leaks, trash, or other debris as a result of the proposed action could result in impacts to ESA-listed marine mammals, sea turtles, and fishes. Vessel exhaust (i.e., air pollution) would occur during the entirety of the proposed action, during all vessel transit and operations, and could affect air-breathing ESA-listed species such as marine mammals and sea turtles. It is unlikely that vessel exhaust resulting from the operation of the R/V *Langseth* or R/V *Tully* would have a measurable impact on ESA-listed marine mammals or sea turtles given the relatively short duration of the proposed action (approximately 36 days), and the various regulations to minimize air pollution from vessel exhaust, such as the National Science Foundation's compliance with the Act to Prevent Pollution from Ships. For these reasons, the effects that may result from vessel exhaust on ESA-listed marine mammals and sea turtles are considered insignificant.

Discharges into the water from research vessels (the R/V *Langseth* and the R/V *Tully*) in the form of leakages of fuel or oil are possible, though effects of any spills to ESA-listed marine mammals, sea turtles, and fishes considered in this opinion would be minimal, if they occur at all. Wastewater from the vessels would be treated in accordance with U.S. Coast Guard standards. An oil or fuel leak could pose a significant risk to the vessel and its crew and actions to correct a leak should occur immediately to the extent possible. In the event that a leak should occur, the amount of fuel and oil onboard the vessels is unlikely to cause widespread, high dose contamination (excluding the remote possibility of severe damage to the vessels) that will affect ESA-listed species directly or pose hazards to their food sources. In addition, the research vessel used during the National Science Foundation-funded seismic survey has spill-prevention plans, which will allow a rapid response to a spill in the event one occurred. Because the potential for oil or fuel leakage is extremely unlikely to occur and there have been no recorded incidents of spills requiring a response during previous surveys, we find that the effect from this potential stressor on ESA-listed marine mammals, sea turtles, and fishes is discountable.

Trash or other debris resulting from the proposed action may affect ESA-listed marine mammals, sea turtles, and fishes. Any marine debris (e.g., plastic, paper, wood, metal, glass) that might be released would be accidental. The National Science Foundation proposes to include guidance on the handling and disposal of marine trash and debris during the seismic survey. The gear used in the proposed action may also result in marine debris. The OBSs would be released from the attached anchor and float to the surface for retrieval, leaving the anchor behind as debris on the ocean floor. There would be 60 ocean bottom seismometer anchors left behind. Although these anchors can be considered debris, we do not believe them to pose an entanglement risk or other hazards for ESA-listed marine mammals, sea turtles, or fishes. Because the potential for accidental release of trash is extremely unlikely to occur, and the marine debris created by the OBSs is minor, we find that the effects from this potential stressor on ESA-listed marine mammals, sea turtles, and fishes are insignificant and discountable, respectively.

Therefore, we conclude that pollution by vessel exhaust, fuel or oil spills or leaks, and trash or other debris may affect, but is not likely adversely affect ESA-listed species.

7.1.2 Vessel Strikes

Vessel traffic associated with the proposed action carries the risk of vessel strikes of ESA-listed marine mammals, sea turtles, and fishes. In general, the probability of a vessel collision and the associated response depends, in part, on size and speed of the vessel. The R/V *Langseth* has a length of 235 feet (72 meters) and the operating speed during seismic data acquisition is typically approximately 9.3 kilometers per hour (5 knots). When not towing seismic survey gear, the R/V *Langseth* typically transits at 18.5 kilometers per hour (10 knots). The R/V *Tully* is 226 feet (69 meters) in length, and cruises up to 18.52 kilometers per hour (10 knots). During the deployment and retrieval of OBSs, the R/V *Tully* will be traveling at a much slower speed. The majority of vessel strikes of large whales occur when vessels are traveling at speeds greater than approximately 18.5 kilometers per hour (10 knots), with faster travel, especially of large vessels (80 meters [262.5 feet] or greater), being more likely to cause serious injury or death (Laist et al. 2001; Jensen and Silber 2004; Vanderlaan and Taggart 2007; Conn and Silber 2013a).

Much less is known about vessel strike risk for sea turtles, but it is considered an important injury and mortality risk within the action area (Lutcavage et al. 1997). Based on behavioral observations of sea turtle avoidance of small vessels, green turtles may be susceptible to vessel strikes at speeds as low as 3.7 kilometers per hour (2 knots) (Hazel et al. 2007). If an animal is struck by a vessel, responses can include death, serious injury, and/or minor, non-lethal injuries, with the associated response depending on the size and speed of the vessel, among other factors (Laist et al. 2001; Jensen and Silber 2004; Vanderlaan and Taggart 2007; Conn and Silber 2013b).

Each of the ESA-listed fish species considered in this opinion are thought to spend at least some time in the upper portions of the water column where they may be susceptible to vessel strike. However, fish behavior in the vicinity of a vessel can be variable, depending on several factors such as life stage, life history, and environmental parameters. The potential responses of fishes to a physical strike may include physical injury or mortality, physiological stress, or behavioral changes such as avoidance, altered swimming speed and swimming orientation (direction). Fish are able to use a combination of sensory cues to detect approaching vessels, such as sight, hearing, and their lateral line (for nearby changes in water motion). A study on fish behavioral responses to vessels showed that most adults exhibit avoidance responses to engine noise, sonar, depth finders, and fish finders (Jørgensen et al. 2004), reducing the potential for vessel strikes. Misund (1997) found that fish ahead of a ship showed avoidance reactions at ranges of 50 to 350 meters (160 to 490 feet). When the vessel passed over them, some fish responded with sudden escape responses that included movement away from the vessel laterally or through downward compression of the school. In an early study conducted by Chapman and Hawkins (1973), the authors observed avoidance responses of herring from the low-frequency sounds of large vessels or accelerating small vessels. Avoidance responses quickly ended within ten seconds after the vessel departed. Conversely, Rostad (2006) observed that some fish are attracted to different types of vessels (e.g., research vessels, commercial vessels) of varying sizes, noise levels, and habitat locations.

Several conservation measures proposed by the NMFS Permits and Conservation Division and/or National Science Foundation and Lamont-Doherty Earth Observatory will minimize the risk of vessel strike for the ESA-listed marine mammals and sea turtles considered in this opinion, such as the use of PSOs, and ship crew keeping watch while in transit. Measures meant to be protective of mammals and turtles are also expected to lead to protection of fish species. In addition, the overall level of vessel activity associated with the proposed action is low relative to the large size of the action area, further reducing the likelihood of a vessel strike of an ESA-listed species.

While vessel strikes of marine mammals, sea turtles, and fishes during seismic survey activities are possible, we are not aware of any definitive case of a marine mammal, sea turtle, or fish being struck by a vessel associated with seismic surveys. The R/V *Langseth* and RV *Tully* will be traveling at generally low speeds, reducing the probability of a vessel strike (Kite-Powell et al. 2007; Vanderlaan and Taggart 2007). Both vessels will maintain watches while in transit. Our expectation is that vessel strike is unlikely, due to the hundreds of thousands of kilometers the R/V *Langseth* has traveled without a vessel strike, general expected movement of marine mammals away from or parallel to the R/V *Langseth*, as well as the generally slow movement of the R/V *Langseth* during most of its travels (Holst and Smultea 2008b; Hauser and Holst 2009; Holst 2010). In addition, adherence to observation and avoidance procedures is also expected to avoid vessel strikes. All factors considered, we have concluded the potential for vessel strike of ESA-listed species considered in this opinion from the research vessels participating in the proposed action is highly improbable. Because the potential for vessel strike is extremely unlikely to occur, we find that the risk from this potential stressor is discountable for ESA-listed marine mammals, sea turtles and fishes. Therefore, we conclude that vessel strike may affect, but is not likely to adversely affect ESA-listed species.

7.1.3 Operational Noise and Visual Disturbance of Vessels and Equipment

The research vessels associated with the proposed action may cause visual or auditory disturbances to ESA-listed species that spend time near the surface or in the upper parts of the water column, such as marine mammals, sea turtles, and fishes that could disrupt their normal behaviors. Studies have shown that vessel operations can result in changes in the behavior of marine mammals, sea turtles, and fishes (Patenaude et al. 2002; Richter et al. 2003; Hazel et al. 2007; Smultea et al. 2008; Holt et al. 2009; Luksenburg and Parsons 2009; Noren et al. 2009). In many cases, particularly when responses are observed at great distances, it is thought that animals likely respond to sound more than the visual presence of vessels (Evans et al. 1992; Blane and Jaakson 1994a; Evans et al. 1994). Nonetheless, it is generally not possible to distinguish responses to the visual presence of vessels from those to the sounds associated with those vessels. Moreover, at close distances animals may not even differentiate between visual and acoustic disturbances created by vessels and simply respond to the combined disturbance.

Unlike vessels, which produce sound as a byproduct of their operations, the equipment such as multi-beam echosounders, sub-bottom profilers, acoustic Doppler current profilers, acoustic release transponders, OBSs, and airgun arrays are designed to actively produce sound, and as such, the characteristics of these sound sources are deliberate and under control. The ocean bottom seismometers have an acoustic release transponder that transmits a signal to the instrument at a frequency of eight to 11 kilohertz and a response is received at a frequency of 11.5 to 13 kilohertz (operator selectable), to activate and release the instrument. The transmitting beam pattern is 55 degrees. The sound source level is approximately 93 decibels.

Assessing whether these sounds may adversely affect ESA-listed species involves understanding the characteristics of the acoustic sources, the species that may be present in the vicinity of the sound, and the effects that sound may have on the physiology and behavior of those species. Although it is known that sound is important for marine mammal communication, navigation, and foraging (NRC 2003b; NRC 2005), there are many unknowns in assessing impacts of sound, such as the potential interaction of different effects and the significance of responses by marine mammals to sound exposures (Nowacek et al. 2007; Southall et al. 2007a).

Numerous studies of interactions between surface vessels and marine mammals have demonstrated that free-ranging marine mammals engage in avoidance behavior when surface vessels move toward them. It is not clear whether these responses are caused by the physical presence of a surface vessel, the underwater noise generated by the vessel or an interaction between the two (Bryant et al. 1984; Bauer 1986; Watkins 1986; Corkeron 1995; Wursig et al. 1998; Bejder et al. 1999; Au and Green 2000; Félix 2001; Nowacek et al. 2001; Erbe 2002b; Magalhaes et al. 2002; Williams et al. 2002; Lusseau 2003; Richter et al. 2003; Goodwin and Cotton 2004; Scheidat et al. 2004; Amaral and Carlson 2005; Simmonds 2005; Bain et al. 2006; Lemon et al. 2006; Lusseau 2006; Bejder and Lusseau. 2008; Bejder et al. 2009). However, several authors suggest that the noise generated during motion is probably an important factor (Evans et al. 1992; Blane and Jaakson 1994b; Evans et al. 1994). These studies suggest that the behavioral responses of marine mammals to surface vessels are similar to their behavioral responses to predators.

Less is understood about the hearing sensitivities to anthropogenic sounds for other non-marine mammal ESA-listed species such as sea turtles and fishes. Given that much less is known about how they use sound, the impacts of anthropogenic sound are difficult to assess (Popper et al. 2014b; Nelms et al. 2016). Nonetheless, depending on the circumstances, exposure to anthropogenic sounds may result in auditory injury, changes in hearing ability, masking of important sounds, behavioral responses, as well as other physical and physiological responses (see Section 10.3.5).

The functional hearing ranges of ESA-listed sea turtles are not well understood and vary by species. Piniak et al. (2016) found green and hawksbill turtle juveniles capable of hearing underwater sounds at frequencies of 50 hertz to 1,600 hertz (maximum sensitivity at 200 to 400 hertz). Loggerhead sea turtles are thought to have a functional hearing range of 250 to 750 hertz (Bartol et al. 1999), and Kemp's ridley sea turtles a range of 100 to 500 hertz. Piniak (2012) measured hearing of leatherback sea turtle hatchlings in water and in air, and observed reactions to low frequency sounds, with responses to stimuli occurring between 50 hertz and 1.6 kilohertz in air and between 50 hertz and 1.2 kilohertz in water (lowest sensitivity recorded was 93 dB re: 1 μPa at 300 hertz).

The research vessels may cause auditory disturbance to ESA-listed marine mammals and sea turtles, and more generally disrupt their behavior. In addition to the active sound sources mentioned above, we expect the R/V *Langseth* and R/V *Tully* will add to the local noise environment in the action area due to the vessels' propulsion and other noise characteristics of the vessels' machinery.

Sounds emitted by large vessels can be characterized as low-frequency, continuous, or tonal, and sound pressure levels at a source will vary according to speed, burden, capacity, and length (Richardson et al. 1995b; Kipple and Gabriele 2007; McKenna et al. 2012). Source levels for 593 container ship transits were estimated from long-term acoustic recording received levels in the Santa Barbara shipping channel, and a simple transmission loss model using Automatic Identification System data for source-receiver range (McKenna et al. 2013). Vessel noise levels for a single ship could vary five to 10 dB depending on transit conditions. Given the sound propagation of low frequency sounds, a large vessel in this sound range can be heard 139 to 463 kilometers (75.1 to 250 nautical miles) away (Polefka 2004). Hatch et al. (2008) measured commercial ship underwater noise levels and reported average source level estimates (71 to 141 hertz, re: 1 μPa [rms] ± standard error) for individual vessels ranged from 158 ± 2 dB (research vessel) to 186 ± 2 dB (oil tanker). McKenna et al (2012) in a study off Southern California documented different acoustic levels and spectral shapes observed from different modern vessel-types, illustrating the variety of possible noise levels created by the diversity of vessels that may be present.

Very little research exists on sea turtle responses to vessel noise disturbance. Currently, there is nothing in the available literature specifically aimed at studying and quantifying sea turtle response to vessel noise. However, a study examining vessel strike risk to green sea turtles suggests that sea turtles may habituate to vessel sound and may be more likely to respond to the sight of a vessel rather than the sound of a vessel, although both may play a role in prompting reactions (Hazel et al. 2007). Regardless of the specific stressor associated with vessels to which turtles are responding, they only appear to show responses (i.e., avoidance behavior) at approximately 10 meters (32.8 feet) or closer (Hazel et al. 2007). Therefore, the noise from vessels is not likely to affect sea turtles from further distances, and disturbance may only occur if a sea turtle hears a vessel nearby or sees it as it approaches. These responses appear limited to non-injurious, minor changes in behavior based on the limited information available on sea turtle response to vessel noise.

All fish species can detect vessel noise due to its low-frequency content and their hearing capabilities. Therefore, ESA-listed fishes could be exposed to a range of vessel noises, depending on the source and context of the exposure. Because of the characteristics of vessel noise, sound produced from seismic research vessels are unlikely to result in direct injury, hearing impairment, or other trauma to fishes. Moreover, in the near field, fish are able to detect water motion as well as visually locate an oncoming vessel. In these cases, most fishes located in close proximity that detect the vessel either visually, or via sound and motion in the water would be capable of avoiding the vessel or move away from the area affected by vessel sound. Thus, fish are more likely to react to vessel noise at close range than to vessel noise emanating from a greater distance away. These reactions may include physiological stress responses, or avoidance behaviors.

The contribution of vessel noise by the R/V *Langseth* and the R/V *Tully* is likely small in the overall regional sound field. The R/V *Tully* and the R/V *Langseth*'s passage past an ESA-listed marine mammal, sea turtle, or fish will be brief and not likely to be significant in impacting any individual's ability to feed, reproduce, or avoid predators. Brief interruptions in communication via masking are possible, but unlikely given the habits of marine mammals and fish to move away from vessels, either as a result of engine noise, the physical presence of the vessel, or both (Mitson and Knudsen 2003; Lusseau 2006). Also, as stated sea turtles are most likely to habituate and are shown to be less affected by vessel noise at distances greater than 10 meters

(32.8 feet) (Hazel et al. 2007). In addition, during research operations, the R/V *Langseth* and R/V *Tully* will be traveling at slow speeds, reducing the amount of noise produced by the propulsion system (Kite-Powell et al. 2007; Vanderlaan and Taggart 2007). The distance between the research vessel and observed marine mammals and sea turtles, per avoidance protocols, will also minimize the potential for acoustic disturbance from engine noise. The potential effects to ESA-listed species within the action area due to sounds fields produced by the proposed seismic survey equipment are evaluated in Section 10.

Because the potential acoustic interference from engine noise will be so minor that it cannot be meaningfully evaluated, we find that the risk from this potential stressor is insignificant. Therefore, we conclude that acoustic interference from engine noise may affect, but is not likely to adversely affect ESA-listed marine mammals, sea turtles, or fishes.

7.1.4 Gear Interaction

There is a variety of gear planned for use during the proposed action that might entangle, strike, or otherwise interact with ESA-listed species in the action area. Towed gear from the seismic survey activities pose a risk of entanglement to ESA-listed marine mammals, sea turtles, and fishes. The towed hydrophone streamer could come in direct contact with ESA-listed species. Sea turtle entanglements have occurred in towed gear from seismic survey vessels. Leatherback sea turtles (*Dermochelys coriacea*) are the most common species of sea turtle in the action area and we are not aware of any cases of leatherback sea turtle entanglement from seismic gear. However, a National Science Foundation-funded seismic survey off the coast of Costa Rica during 2011 recovered a dead olive ridley turtle (*Lepidochelys olivacea*) in the foil of towed seismic equipment; it is unclear whether the sea turtle became lodged in the foil pre- or post mortem (Spring 2011). Nevertheless, entanglement is highly unlikely due to the towed hydrophone streamer's inflexible design as well as observations of sea turtles investigating the towed hydrophone streamer and not becoming entangled including when operating in regions of high sea turtle density without entanglements (Holst et al. 2005b; Holst et al. 2005a; Hauser 2008; Holst and Smultea 2008a). The towed hydrophone streamer is rigid and as such will not encircle, wrap around, or in any other way entangle any of the large whales considered during this consultation. We expect the taut cables will prevent entanglement. Furthermore, mysticetes (baleen whales) and sperm whales are expected to avoid areas where the airgun array is actively being used, meaning they will also avoid towed gear. We are not aware of any entanglement events with ESA-listed marine mammals with the towed gear proposed for use in this action.

Ocean bottom seismometers pose a risk to ESA-listed marine mammals and sea turtles as they are being deployed, and when they drop to the ocean floor. We expect ESA-listed marine mammals, sea turtles, and fishes to be able to detect OBSs and move out of the way.

ESA-listed fish species in the action area (e.g., green sturgeon, salmon, steelhead, and eulachon) could be entangled or struck by equipment used during the seismic survey. ESA-listed salmon, steelhead, and eulachon are distributed throughout the water column, while green sturgeon, in coastal Pacific environments, are mostly found at depths of 20–60 meters (Huff et al. 2011). The ocean bottom seismometers will operate at or near the ocean floor. The towed hydrophone array, the passive acoustic monitoring (PAM) hydrophone (both towed near the surface), and the towed airgun array (towed at 12 meters below the surface) pose similar risks to ESA-listed fishes. However, we consider the possibility of equipment entanglement or strike to be remote because of fishes' ability to detect the equipment moving through the water and move out of the way. Fish are able to use a combination of sensory cues to detect equipment, such as sight, hearing, and their lateral line (for nearby changes in water motion).

Although the towed hydrophone streamer or passive acoustic monitoring array could come in direct contact with an ESA-listed species, entanglements are highly unlikely and thus considered discountable. Based upon extensive deployment of this type of equipment with no reported entanglement and the nature of the gear that is likely to prevent it from occurring, we find the probability of adverse effects to ESA-listed species to be discountable, and therefore, these effects may affect, but are not likely to adversely affect any ESA-listed species.

7.1.5 Multibeam Echosounder, Sub-bottom Profiler, Acoustic Doppler Profiler, and Acoustic Release Transponder

Multi-beam echosounders, sub-bottom profilers, acoustic Doppler current profilers, and acoustic release transponder are four additional active acoustic systems that will operate during the proposed seismic survey on the R/V *Langseth*. These systems have the potential to expose ESA-listed marine mammal species, sea turtles, and fishes to sound levels above the 160 dB re: 1 μPa (rms) and 175 dB re: 1 μPa (rms) thresholds, respectively, but generally operate at higher frequencies than airgun array operations (10 to 13.5 [usually 12] kilohertz for the multi-beam echosounder, 3.5 kilohertz for the sub-bottom profiler, 75 kilohertz for the acoustic Doppler current profiler, and eight to 13 kilohertz for the acoustic release transponder). As such, the frequencies will attenuate more rapidly than those from airgun array sound sources. For these reasons, ESA-listed marine mammals, sea turtles, and fishes will likely experience higher levels of sound from the airgun array well before these other acoustic sources of equal amplitude because these other sounds will drop off faster than those from the airgun arrays.

We rule out high-level ensonification exposure for ESA-listed species (approximate sound source levels: 242 dB re: 1 μPa [rms] for multi-beam echosounders, 222 dB re: 1 μPa [rms] for sub-bottom profilers, 224 dB re: 1 μPa [rms] for acoustic Doppler current profilers, 93 dB re: 1 μPa [rms] for acoustic release transponder), because it presents a low risk for auditory or other damage to occur, which is similarly concluded by Boebel et al. (2006) and Lurton and DeRuiter (2011). To be susceptible to temporary threshold shift (TTS)[5], a marine mammal, sea turtle, or fish will have to pass at very close range and match the vessel's speed and direction. This is due to the narrow acoustic beam-width of these devices (See Figure 2 in Lurton and DeRuiter (2011)). As a result, we expect a very small probability of TTS during the proposed seismic

[5] Temporary threshold shift is a temporary increase in the threshold of hearing (minimum intensity needed to hear a sound) at a specific frequency that returns to its pre-exposure level over time (DOSITS 2021).

surveys. An individual would have to be located well within 100 meters (328.1 feet) of the vessel to experience a pulse from these acoustic sources that could result in TTS (LGL Ltd. 2008). It is possible that a small number of ESA-listed marine mammals, sea turtles, and fishes could experience low-level exposure to the multi-beam echosounders, sub-bottom profilers, acoustic Doppler current profilers, and acoustic release transponder. However, these devices will not be operated while the vessel is in transit. These devices (excluding the acoustic release transponder when retrieving OBSs) will only be used during the seismic survey, and we expect that because the sound from the airguns is greater than that produced by these devices, the noise from these devices will be completely subsumed. Thus, the effects of these sounds on ESA-listed marine mammals, sea turtles, and fishes during the survey will be insignificant. As a result, we conclude that the effects of these sounds may affect, but are not likely to adversely affect any ESA-listed species.

7.1.6 Stressors Considered Further

The only potential stressor of the proposed action that is likely to adversely to affect some of the ESA-listed species within the action area is sound levels within the sound fields produced by the seismic airgun array. This stressor may adversely affect certain ESA-listed marine mammals, leatherback sea turtles, and salmonids. The effects on these species are further analyzed and evaluated in Section 10.

7.2 Species Not Likely to be Adversely Affected

7.2.1 Southern Resident Killer Whale

The killer whale is cosmopolitan and globally fairly abundant; it has been observed in all oceans of the world Ford (2014). It is very common in temperate waters and also frequents tropical waters, at least seasonally (Heyning and Dahlheim 1988). Killer whales are segregated socially, genetically, and ecologically into three distinct ecotypes: residents, transients, and offshore animals. Killer whales occur in inshore inlets, along the coast, over the continental shelf, and in offshore waters (Ford et al. 2018).

There are eight killer whale stocks recognized in the Pacific U.S. with Southern Residents being the only ESA-listed population (Carretta et al. 2020a; Muto et al. 2020). Although possible, it is unlikely that individuals from the Southern Resident stock would be encountered during the proposed survey. Southern Resident killer whales primarily occur in the southern Strait of Georgia, Strait of Juan de Fuca, Puget Sound, and the southern half of the west coast of Vancouver Island (Carretta et al. 2020a); however, their range may extend into Southeast Alaska (Carretta et al. 2020a). In June 2007, whales from L-pod were sighted off Chatham Strait, Alaska, the farthest north they have ever been documented (Carretta et al. 2020a). In the fall, this population is known to occur in Puget Sound, and during the winter, they occur along the outer coast and do not spend a lot of time in critical habitat areas (Ford 2014). However, during the summer, Southern Resident killer whales typically spend their time within the inland waters of Washington and British Columbia outside of the proposed survey area (See Figure 2 below).

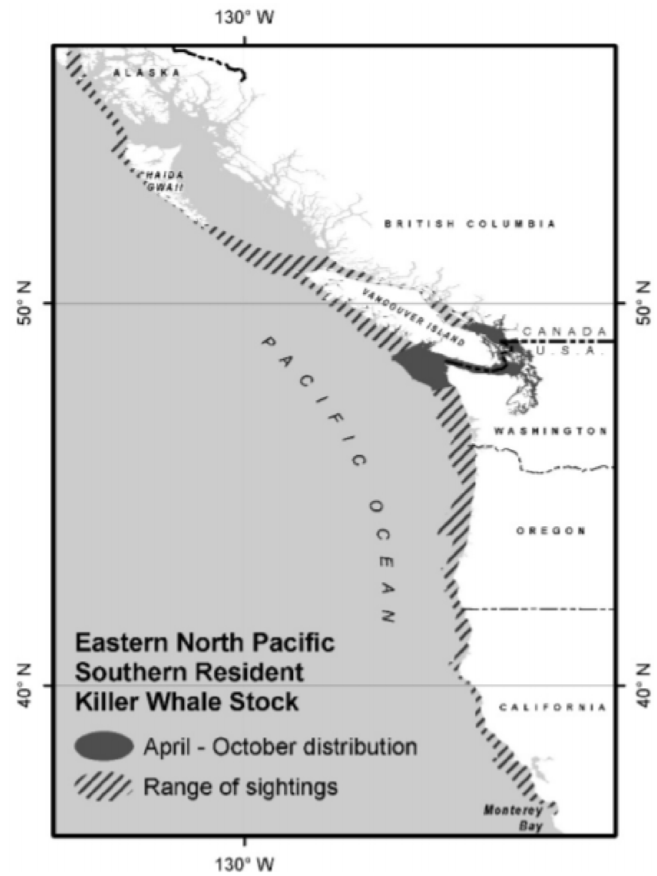

Figure 2. Approximate April - October distribution of the Eastern North Pacific Southern Resident killer whale stock (shaded area) and range of sightings (diagonal lines) (Carretta et al. 2020a).

Based on the seasonal information presented above, there is a very low probability of encountering this species anywhere in the coastal and offshore waters in the action area during the scheduled timeframe for the survey (July to August). As a result, potential acoustic noise from the proposed seismic airgun activities on Southern Resident killer whales is discountable. Therefore, we conclude that the acoustic effects of the National Science Foundation and Lamont-Doherty Earth Observatory's seismic airgun activities may affect, but are not likely to adversely affect ESA-listed Southern Resident killer whales.

7.2.2 Guadalupe Fur Seal

Guadalupe fur seals pup and breed mainly at Isla Guadalupe, Mexico. In 1997, a second rookery was discovered at Isla Benito del Este, Baja California and a pup was born at San Miguel Island, California (Carretta et al. 2020a). A few Guadalupe fur seals are known to occur at California sea lion rookeries in the Channel Islands, primarily San Nicolas and San Miguel islands, and sightings have also been made at Santa Barbara and San Clemente islands (Carretta et al. 2020a). Guadalupe fur seals prefer rocky habitat for breeding and hauling out. They generally haul out at the base of towering cliffs on shores characterized by solid rock and large lava blocks

(Bartholomew Jr. 1950; Peterson et al. 1968), although they can also inhabit caves and recesses (Belcher and T.E. Lee 2002). While at sea, this species usually is solitary but typically gathers in the hundreds to thousands at breeding sites.

During the summer breeding season, most adults occur at rookeries in Mexico (Carretta et al. 2020a). Following the breeding season, adult males tend to move northward to forage. Females have been observed feeding south of Guadalupe Island, making an average round trip of 2,375 kilometers (Ronald and Gots 2003). Several rehabilitated Guadalupe fur seals that were satellite tagged and released in central California traveled as far north as British Columbia (Norris and Elorriaga-Verplancken 2019). Fur seals younger than two years old are more likely to travel to more northerly, offshore areas than older fur seals (Norris and Elorriaga-Verplancken 2019). Stranding data also indicates that fur seals younger than two years are more likely to occur in the proposed survey area, as this age class was most frequently reported (Norris and Elorriaga-Verplancken 2019).

Despite the reports of young fur seals, there is an extremely low number of sightings of Guadalupe fur seals in the northern extent of their range (i.e., Washington and British Columbia); thus, this species is considered extremely rare in the action area. Based on this information, there is a very low probability of encountering this species anywhere in the coastal and offshore waters in the action area. As a result, potential acoustic noise from the proposed seismic survey activities on Guadalupe fur seals is discountable. Therefore, we conclude that the acoustic effects of the National Science Foundation and Lamont-Doherty Earth Observatory's seismic survey activities may affect, but are not likely to adversely affect the ESA-listed Guadalupe fur seal.

7.2.3 Endangered Species Act-Listed Sea Turtles

ESA-listed sea turtles (Eastern DPS of green, hawksbill, North Pacific DPS of loggerhead, and Mexico's Pacific coast breeding colonies population of olive ridley turtles) may occur in the action area (leatherback sea turtles are considered in Sections 8 and 10) and be affected by acoustic noise generated by the airgun array of the National Science Foundation and Lamont-Doherty Earth Observatory's proposed seismic survey activities. Hawksbill and olive ridley turtles range broadly throughout the Pacific Ocean; however, both species have a circumtropical distribution restricted by ocean temperature, with southern California being the northern limit of their distribution. East Pacific DPS of green, North Pacific DPS of loggerhead, and Mexico's Pacific coast breeding colonies of olive ridley turtles have been documented off the coast of Oregon, Washington, and/or British Columbia, but these occurrences are considered extralimital as they are generally warm-water species (WDFW 2012). Strandings of turtles have increased in recent years, particularly for olive ridley turtles, possibly due to warmer ocean conditions or El Niño (Boyer 2017).

The rarity of reports from the waters of the Northeast Pacific Ocean and extralimital portion of their range suggests that the East Pacific DPS of green, hawksbill, North Pacific DPS of loggerhead, and Mexico's Pacific coast breeding colonies of olive ridley turtles are not reasonably likely to be exposed to potential acoustic noise from seismic survey activities considered in this opinion. Therefore, we conclude that acoustic noise generated by the airgun array during the National Science Foundation and Lamont-Doherty Earth Observatory's seismic airgun activities may affect, but are not likely to adversely affect ESA-listed Eastern DPS of green, hawksbill, North Pacific DPS of loggerhead and Mexico's Pacific coast breeding colonies population of olive ridley turtles.

7.2.4 Pacific Salmonids

The ESA-listed salmonid DPSs and Evolutionary Significant Units (ESUs) considered in this opinion originate from estuarine systems in the lower continental U.S. (i.e.; Washington, Oregon and California), which are a significant distance away from the proposed survey area in Southeast Alaska and Canada. However, many ESA-listed salmonids found within Southeast Alaska migrate from the Columbia River (Van Doornik et al. 2019). Although ESA-listed salmonids may overlap in time and space with the survey activities (see Section 8), several ESUs and DPSs of Chinook and coho salmon are not expected to overlap with the action area due to their migration patterns. Based on coded wire tag data presented in Figure 2 of Weitkamp and Neely (2002), the Central California Coast ESU, Lower Columbia River ESU, Oregon Coast ESU, and Southern Oregon and Northern California Coast ESU of coho salmon have a distribution that is south of the proposed action area. The farthest north that these ESUs are shown to be found is Vancouver Island, Canada which is far south of the proposed action area.

In addition to ESA-listed ESUs of coho salmon, there are several ESUs of Chinook salmon whose ranges are south of the action area. Based on coded wire tag data from Shelton et al. (2019) and Weitkamp (2010), the California Coastal ESU, Central Valley Spring-Run ESU, and Sacramento River Winter-Run ESU of Chinook salmon have a distribution that is south of the proposed action area. The farthest north that these ESUs are shown to be found is Puget Sound, Washington, which is far south of the proposed action area.

Due to the distribution of the ESA-listed ESUs of coho and Chinook salmon mentioned above, there is a very low probability of encountering these populations anywhere in the coastal and offshore waters of the action area. As a result, potential acoustic noise effects from the proposed seismic survey activities on the Central California Coast ESU, Lower Columbia River ESU, Oregon Coast ESU, and Southern Oregon and Northern California Coast ESU of coho salmon; and the California Coastal ESU, Central Valley Spring-Run ESU, and Sacramento River Winter-Run ESU of Chinook salmon are discountable. Therefore, we conclude that acoustic noise generated by the airgun array during the National Science Foundation and Lamont-Doherty Earth Observatory's seismic airgun activities may affect, but are not likely to adversely affect the ESA-listed Central California Coast ESU, Lower Columbia River ESU, Oregon Coast ESU, and Southern Oregon and Northern California Coast ESU of coho salmon; and the California Coastal ESU, Central Valley Spring-Run ESU, and Sacramento River Winter-Run ESU of Chinook salmon.

7.2.5 Southern DPS Eulachon

On March 18, 2010, the National Marine Fisheries Service (NMFS) published a final rule in the Federal Register (75 FR 13012) to list the southern distinct population segment (DPS) of eulachon (*Thaleichthys pacificus*) as threatened under the ESA (NMFS 2010). This listing encompassed all subpopulations of eulachon within the states of Washington, Oregon, and California and extended from the Skeena River in British Columbia south to the Mad River in Northern California.

Southern DPS eulachon are genetically distinct from eulachon in the northern parts of its range (i.e., Alaska). Recent genetic analysis indicates that the Southern DPS exhibits a regional population structure, with a three-population southern Columbia-Fraser group, coming from the Cowlitz, Columbia, and Fraser rivers (Candy et al. 2015; Gustafson 2016).

Adult and juvenile Southern DPS eulachon can be found in the Pacific Ocean, along the continental shelf, in waters from 50 to 200 meters deep (Gustafson 2016). Adults are most frequently found in the Columbia River and its tributaries (e.g., Cowlitz River, Sandy River), and sometimes in the Klamath River, California.

Due to the range of Southern DPS eulachon, this population is considered rare in the action area. Based on this information, there is a very low probability of encountering Southern DPS eulachon anywhere in the coastal and offshore waters in the action area. As a result, potential acoustic effects from the proposed seismic survey activities on Southern DPS eulachon are discountable. Therefore, we conclude that the effects of the National Science Foundation and Lamont-Doherty Earth Observatory's seismic airgun activities may affect, but are not likely to adversely affect the ESA-listed southern DPS eulachon.

7.2.6 Southern DPS Green Sturgeon

NMFS listed the southern DPS of green sturgeon as threatened under the ESA in 2006 due to loss of spawning habitat, overharvest, and entrainment threats (71 FR 17757; April 7, 2006). Juvenile green sturgeon spend one to four years in fresh and estuarine waters before they leave for saltwater (Lindley et al. 2008). They then disperse widely in the ocean. Subadult and adult movements in the ocean are not well known, but green sturgeon have been captured in marine waters from Baja California to the Bering Sea. They typically remain in waters less than 100 meters deep (Lindley et al. 2008). Due to this, the species is not likely to overlap with the National Science Foundation's proposed seismic airgun activities which will mostly occur in deeper waters (i.e., 99 percent of the cruise will occur in waters >100 meters).

North American green sturgeon make a long-distance seasonal migration along the continental shelf of North America (Lindley et al. 2008). This includes a northward migration in fall, overwintering north of Vancouver Island, British Columbia, and south of Southeast Alaska, and southward return in the spring. NMFS (2018b) discussed that green sturgeon are long-lived and show spawning site fidelity in natal streams (Poytress et al. 2009; Poytress et al. 2010). After maturity is reached at about 15 years of age, adults of the Southern DPS typically return to spawn in their natal streams every three to four years (NMFS 2018b). These sturgeon do not spawn in Alaska (NMFS 2018b).

NMFS (2015e) discussed that anecdotal sightings and fisheries observer data indicate green sturgeon are observed infrequently in Alaskan waters and noted that telemetry data and genetic analyses suggested that Southern DPS green sturgeon generally occur seasonally (overwintering) south from Graves Harbor, Alaska. Lindley et al. (2008) tagged 213 sub-adult and adult Northern and Southern DPS green sturgeon from Oregon, Washington, and California and observed only one tagged green sturgeon taken in a commercial gillnet fishery in southeast Alaska, providing further evidence that green sturgeon occur infrequently in Alaskan waters. The tagged green sturgeon was later confirmed as belonging to the Southern DPS (NMFS 2015e).

Green sturgeon occur infrequently in Alaskan waters. It is, therefore, very unlikely that these fish would experience adverse effects from the National Science Foundation's proposed seismic airgun activities. In addition, given that green sturgeon are mostly found in coastal Pacific environments at depths of 20–60 meters (Huff et al. 2011), it is highly unlikely that exposure will occur. As a result, effects of the proposed action on the Southern DPS of green sturgeon are discountable. Therefore, we conclude that the effects of the National Science Foundation and Lamont-Doherty Earth Observatory's seismic survey activities may affect, but are not likely to adversely affect the ESA-listed southern DPS green sturgeon.

7.3 Designated Critical Habitat Not Likely to be Adversely Affected

The proposed action will take place along the Queen Charlotte Fault within the area of approximately 52 to 57 degrees North and approximately 131 to 137 degrees West. This action area includes designated critical habitat for the Western DPS of Steller sea lions (58 FR 45269; Aug. 27, 1993).

7.3.1 Steller Sea Lion - Western DPS Critical Habitat

In 1993, NMFS designated critical habitat for the Steller sea lion. The Steller sea lion eastern DPS was delisted on November 4, 2013 (78 FR 66139); therefore, this DPS will not be considered in this opinion. However, this change in listing status does not affect the designated critical habitat for Steller sea lions (58 FR 45269), because "removing the eastern DPS from the List of Endangered and Threatened Wildlife does not remove or modify that designation" (78 FR 66162). Steller sea lion designated critical habitat remains in place until a separate rulemaking amends the designation.

The critical habitat includes specific rookeries, haulouts, and associated areas, as well as three foraging areas that are considered essential for the health, continued survival, and recovery of the species. Within the action area, critical habitat is located on islands off the coast of Southeast Alaska (e.g., Sitka, Coronation Island, Noyes Island, and Forrester Island).

In Southeast Alaska, major Steller sea lion rookeries, associated air, and aquatic zones are designated as critical habitat. Critical habitat includes an air zone extending 3,000 feet (0.9

kilometers) above rookery areas historically occupied by sea lions. Critical habitat also includes an aquatic zone extending 3,000 feet (0.9 kilometers) seaward. These sites are located near Steller sea lion abundance centers and include important foraging areas, large concentrations of prey, and host large commercial fisheries that often interact with the species.

The physical and biological features (PBFs) identified for the aquatic areas of Steller sea lion designated critical habitat that occur within the action area are those that support foraging, such as adequate prey resources and available foraging habitat (58 FR 45269). While Steller sea lions do rest in aquatic habitat, there was insufficient information available at the time critical habitat was designated to include aquatic resting sites as part of the critical habitat designation (58 FR 45269).

The components of the proposed action that may impact Steller sea lion critical habitat would be the sound from the airgun array affecting the prey resources and available foraging habitat. The proposed seismic survey tracklines do not overlap with any areas of Steller sea lion critical habitat; however the extent of the ensonified area from the airguns will overlap with units of Steller sea lion critical habitat in Southeast Alaska. The R/V *Langseth* will travel at a speed of 4.2 knots (7.8 kilometers) per hour during the survey, and we expect that the critical habitat units will only be exposed for a few hours. Therefore, the short duration of the potential exposure leads us to conclude that effects to the Steller lion critical habitat from the proposed seismic activities will be insignificant.

The effects of all other stressors analyzed, including vessel traffic, pollution, and sound associated with the proposed seismic activities, on the PBFs were found to be insignificant and not likely to reduce the conservation value of Steller sea lion critical habitat. Further, we expect that the disruption of Steller sea lion rookeries and effects to the prey species from the seismic airgun array would be insignificant, and would not affect the conservation value of the critical habitat. Therefore, we conclude that the proposed action may affect, but is not likely to adversely affect Steller sea lion critical habitat.

8 Status of Species Likely to be Adversely Affected

This section identifies and examines the status of each species that is expected to be adversely affected by the seismic airgun activities during the proposed action. The status includes the existing level of risk that the ESA-listed species face, based on parameters considered in documents such as recovery plans, status reviews, and ESA-listing decisions. The species' status section helps to inform the description of the species' current "reproduction, numbers, or distribution," which is part of the jeopardy determination as described in 50 C.F.R. §402.02. More detailed information on the status and trends of these ESA-listed species, and their biology and ecology can be found in the listing regulations and critical habitat designations published in the *Federal Register*, status reviews, recovery plans, and on the following NMFS website: https://www.fisheries.noaa.gov/species-directory, among others.

One factor affecting the rangewide status of marine mammals, sea turtles, fishes, and aquatic habitat at large is climate change. Climate change interrelates with threats such as habitat loss and overharvesting to further exacerbate species declines. The decline of species and ecosystems can then accelerate climate change, creating a feedback loop that further exacerbates the situation. The impacts of climate change on even the smallest species can undermine biological systems and different species across a food web. For instance, expanded sea-ice melt and ocean acidification in the Arctic Ocean is lessening krill populaces, compromising the endurance of marine mammals that rely upon krill as an essential food source. Because basal species are usually affected by climate change, the full impacts of species loss may not be seen for decades (Foden et al. 2016). Climate change will be discussed in further detail the *Environmental Baseline* section (Section 9) of this opinion.

8.1 Blue Whale

The blue whale is a widely distributed baleen whale found in all major oceans (Figure 3).

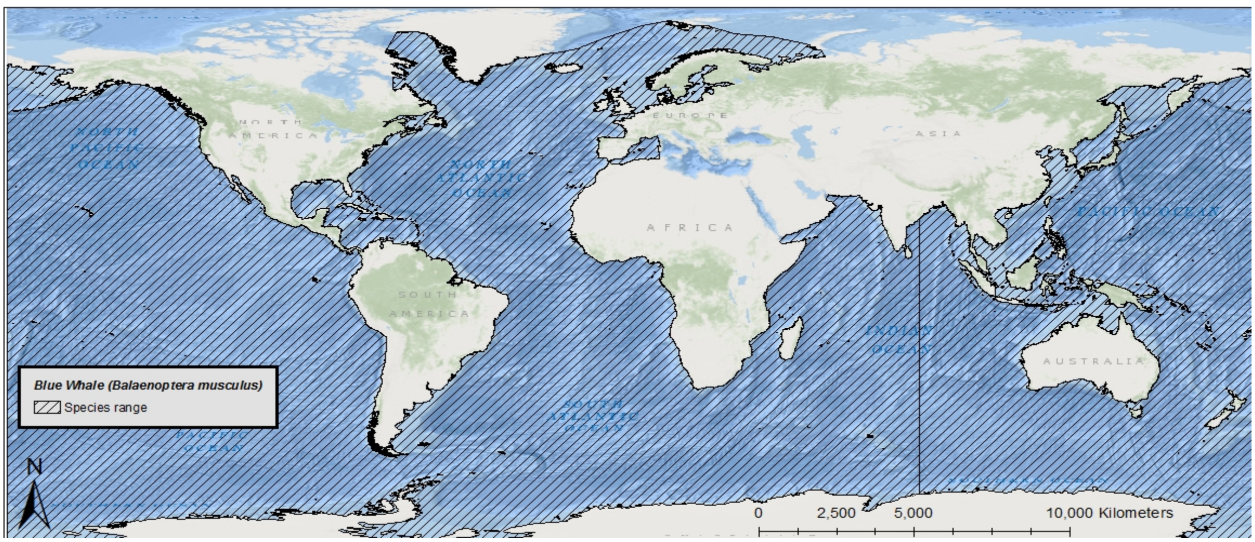

Figure 3. Map identifying the range of the endangered blue whale.

Blue whales are the largest animal on earth and distinguishable from other whales by a long-body and comparatively slender shape, a broad, flat "rostrum" when viewed from above, proportionally smaller dorsal fin, and a mottled gray color that appears light blue when seen through the water. Most experts recognize at least three subspecies of blue whale, *B. m. musculus*, which occurs in the Northern Hemisphere, *B. m. intermedia*, which occurs in the Southern Ocean, and *B. m. brevicauda*, a pygmy species found in the Indian Ocean and South Pacific Ocean. The blue whale was originally listed as endangered on December 2, 1970.

Information available from the recovery plan (NMFS 2020b), recent stock assessment reports (Carretta 2019a; Carretta 2019b), and recent scientific publications were used to summarize the life history, population dynamics, and status of the species as follows.

Life History

The average life span of blue whales is 80 to 90 years. They have a gestation period of ten to 12 months, and calves nurse for six to seven months. Blue whales reach sexual maturity between five and 15 years of age with an average calving interval of two to three years. They winter at low latitudes, where they mate, calve and nurse, and summer at high latitudes, where they feed. Blue whales forage almost exclusively on krill and can eat approximately 3,600 kilograms (7,936.6 pounds) daily. Feeding aggregations are often found at the continental shelf edge, where upwelling produces concentrations of krill at depths of 90 to 120 meters (295.3 to 393.7 feet).

Population Dynamics

The global, pre-exploitation estimate for blue whales is approximately 181,200 (IWC 2007b). Current estimates indicate approximately 5,000 to 12,000 blue whales globally (IWC 2007b). Blue whales are separated into populations by ocean basin in the North Atlantic Ocean, North Pacific Ocean, and Southern Hemisphere. There are three stocks of blue whales designated in United States waters: the Eastern North Pacific Ocean, Central North Pacific Ocean, and Western North Atlantic Ocean. Due to the location of the action, the Eastern North Pacific stock of blue whales is most likely to be in the action area. The minimum population size for eastern North Pacific Ocean blue whales is 1,050; the more recent abundance estimate is 1,496 whales (Carretta 2019a).

Current estimates indicate a growth rate of just under three percent per year for the eastern North Pacific stock (Calambokidis 2009).

Little genetic data exist on blue whales globally. Data on genetic diversity of blue whales in the Northern Hemisphere are currently unavailable. However, genetic diversity information for similar cetacean population sizes can be applied. Stocks that have a total population size of 2,000 to 2,500 individuals or greater provide for maintenance of genetic diversity resulting in long-term persistence and protection from substantial environmental variance and catastrophes. Stocks that have a total population of 500 individuals or less may be at a greater risk of extinction due to genetic risks resulting from inbreeding. Stock population at low densities (less than 100) are more likely to suffer from the 'Allee' effect, where inbreeding and the heightened difficulty of finding mates reduces the population growth rate in proportion with reducing density.

In general, distribution is driven largely by food requirements; blue whales are more likely to occur in waters with dense concentrations of their primary food source, krill. While they can be found in coastal waters, they are thought to prefer waters further offshore; in Canadian Pacific waters, blue whale habitat includes the continental shelf break, continental slope, and offshore waters beyond the shelf break (Canada 2017). Off California, they are associated with areas of upwelling, off the continental slope, likely due to high concentrations of zooplankton there (Nichol 2011). Data from satellite telemetry research indicate that blue whales in U.S. West Coast waters spend about five months outside the U.S. EEZ, from November to March (Hazen et al. 2017). In the North Pacific Ocean, blue whales range from Kamchatka to southern Japan in the west and from the Gulf of Alaska and California to Costa Rica in the east. They primarily occur off the Aleutian Islands and the Bering Sea.

Vocalization and Hearing

Blue whale vocalizations tend to be long (greater than 20 seconds), low frequency (less than 100 hertz) signals (Richardson et al. 1995b), with a range of 12 to 400 hertz and dominant energy in the infrasonic range of 12 to 25 hertz (McDonald et al. 1995; Ketten 1998; Mcdonald et al. 2001; Mellinger and Clark 2003). Vocalizations are predominantly songs and calls.

Calls are short-duration sounds (two to five seconds) that are transient and frequency-modulated, having a higher frequency range and shorter duration than song units and often sweep down in frequency (20 to 80 hertz), with seasonally variable occurrence. Blue whale calls have high acoustic energy, with reports of source levels ranging from 180 to 195 dB re: 1 μPa at 1 meter (Cummings and Thompson 1971b; Aburto et al. 1997; Ketten 1998; Mcdonald et al. 2001; Clark and Gagnon 2004; Berchok et al. 2006; Samaran et al. 2010). Calling rates of blue whales tend to vary based on feeding behavior. For example, blue whales make seasonal migrations to areas of high productivity to feed, and vocalize less at the feeding grounds then during migration (Burtenshaw et al. 2004). Stafford et al. (2005) recorded the highest calling rates when blue whale prey was closest to the surface during its vertical migration. Wiggins et al. (2005) reported the same trend of reduced vocalization during daytime foraging followed by an increase at dusk as prey moved up into the water column and dispersed. Oleson et al. (2007c) reported higher calling rates in shallow diving (less than 30 meters [98.4 feet] whales), while deeper diving whales (greater than 50 meters [154 feet]) were likely feeding and calling less.

Although general characteristics of blue whale calls are shared in distinct regions (Thompson et al. 1996; Mcdonald et al. 2001; Mellinger and Clark 2003; Rankin et al. 2005), some variability appears to exist among different geographic areas (Rivers 1997). Sounds in the North Atlantic Ocean have been confirmed to have different characteristics (i.e., frequency, duration, and repetition) than those recorded in other parts of the world (Mellinger and Clark 2003; Berchok et al. 2006; Samaran et al. 2010). Clear differences in call structure suggestive of separate populations for the western and eastern regions of the North Pacific Ocean have also been reported (Stafford et al. 2001); however, some overlap in calls from the geographically distinct regions have been observed, indicating that the whales may have the ability to mimic calls (Stafford and Moore 2005). In Southern California, blue whales produce three known call types: Type A, B, and D. B calls are stereotypic of blue whale population found in the eastern North Pacific (McDonald et al. 2006b) and are produced exclusively by males and associated with mating behavior (Oleson et al. 2007a). These calls have long durations (20 seconds) and low frequencies (10 to 100 hertz); they are produced either as repetitive sequences (song) or as singular calls. The B call has a set of harmonic tonals, and may be paired with a pulsed Type A call. D calls are produced in highest numbers during the late spring and early summer and in diminished numbers during the fall, when A-B songs dominate blue whale calling (Oleson et al. 2007c; Hildebrand et al. 2011; Hildebrand et al. 2012).

Blue whale songs consist of repetitively patterned vocalizations produced over time spans of minutes to hours or even days (Cummings and Thompson 1971b; Mcdonald et al. 2001). The songs are divided into pulsed/tonal units, which are continuous segments of sound, and phrases, repeated in combinations of one to five units (Payne and Mcvay 1971; Mellinger and Clark 2003). Songs can be detected for hundreds, and even thousands of kilometers (Stafford et al. 1998), and have only been attributed to males (Mcdonald et al. 2001; Oleson et al. 2007a). Worldwide, songs are showing a downward shift in frequency (McDonald et al. 2009). For example, a comparison of recording from November 2003 and November 1964 and 1965 reveals a long-term shift in the frequency of blue whale calling near San Nicolas Island. In 2003, the spectral energy peak was 16 hertz compared to approximately 22.5 hertz in 1964 and 1965, illustrating a more than 30 percent shift in call frequency over four decades (McDonald et al. 2006b). McDonald et al. (2009) observed a 31 percent downward frequency shift in blue whale calls off the coast of California, and also noted lower frequencies in seven of the world's ten known blue whale songs originating in the Atlantic, Pacific, Southern, and Indian Oceans. Many possible explanations for the shifts exist but none have emerged as the probable cause.

As with other baleen whale vocalizations, blue whale vocalization function is unknown, although numerous hypotheses exist (maintaining spacing between individuals, recognition, socialization, navigation, contextual information transmission, and location of prey resources) (Payne and Webb. 1971; Thompson et al. 1992; Edds-Walton 1997; Oleson et al. 2007b). Intense bouts of long, patterned sounds are common from fall through spring in low latitudes, but these also occur less frequently while in summer high-latitude feeding areas. Short, rapid sequences of 30 to 90 hertz calls are associated with socialization and may be displays by males based upon call seasonality and structure. The low frequency sounds produced by blue whales can, in theory, travel long distances, and it is possible that such long distance communication occurs (Payne and Webb. 1971; Edds-Walton 1997). The long-range sounds may also be used for echolocation in orientation or navigation (Tyack 1999).

Direct studies of blue whale hearing have not been conducted, but it is assumed that blue whales can hear the same frequencies that they produce (low frequency) and are likely most sensitive to this frequency range (Richardson et al. 1995c; Ketten 1997). Based on vocalizations and anatomy, blue whales are assumed to predominantly hear low-frequency sounds below 400 hertz (Croll et al. 2001; Stafford and Moore 2005; Oleson et al. 2007c). In terms of functional hearing capability, blue whales belong to the low frequency group, which have a hearing range of seven hertz to 35 kilohertz (NOAA 2018).

Status

The blue whale is endangered as a result of past commercial whaling. In the North Atlantic Ocean, at least 11,000 blue whales were killed from the late 19th to mid-20th centuries. In the North Pacific Ocean, at least 9,500 whales were killed between 1910 and 1965. Commercial whaling no longer occurs, but blue whales are affected by anthropogenic noise, threatened by ship strikes, entanglement in fishing gear, pollution, harassment due to whale watching, and reduced prey abundance and habitat degradation due to climate change. Because populations appear to be increasing in size, the species appears to be somewhat resilient to current threats; however, the species has not recovered to pre-exploitation levels.

Critical Habitat

No critical habitat has been designated for the blue whale.

Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover blue whale populations. These threats will be discussed in further detail in the *Environmental Baseline* section (Section 9) of this opinion. See the 2020 Final Recovery Plan for the Blue Whale (NMFS 2020b) for complete downlisting/delisting criteria for each of the following recovery plan goals:

1. Determine stock structure of blue whale populations occurring in U.S. waters and elsewhere.
2. Estimate the size and monitor trends in abundance of blue whale populations.
3. Identify and protect habitat essential to the survival and recovery of blue whale populations.
4. Reduce or eliminate human-caused injury and mortality of blue whales.
5. Minimize detrimental effects of directed vessel interactions with blue whales.
6. Maximize efforts to acquire scientific information from dead, stranded, and entangled blue whales.
7. Coordinate state, federal, and international efforts to implement recovery actions for blue whales.
8. Establish criteria for deciding whether to delist or downlist blue whales.

8.2 Fin Whale

The fin whale is a large, widely distributed baleen whale found in all major oceans and comprised of three subspecies: *B. p. physalus* in the Northern Hemisphere, and *B. p. quoyi* and *B. p. patachaonica* (a pygmy form) in the Southern Hemisphere (Figure 4). Within the action area, fin whales occur year round off the coasts of Oregon and Washington (Carretta 2019b), as well as in the waters of British Columbia throughout the year (DFO 2017b).

Fin whales are distinguishable from other whales by a sleek, streamlined body, with a V-shaped head, a tall falcate dorsal fin, and a distinctive color pattern of a black or dark brownish-gray body and sides with a white ventral surface. The lower jaw is gray or black on the left side and creamy white on the right side. The fin whale was originally listed as endangered on December 2, 1970.

Information available from the recovery plan (NMFS 2010b), recent stock assessment reports (Carretta 2019a; Carretta 2019b), and status review (NMFS 2011c) were used to summarize the life history, population dynamics and status of the species as follows.

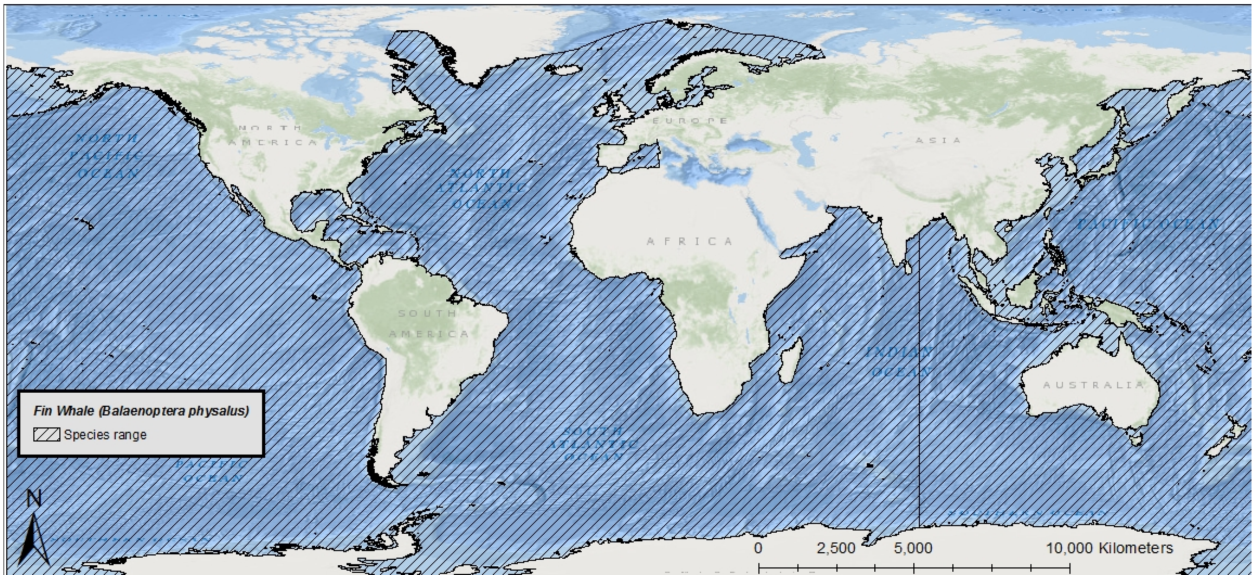

Figure 4. Map identifying the range of the endangered fin whale

Life History

Fin whales can live, on average, 80 to 90 years. They have a gestation period of less than one year, and calves nurse for six to seven months. Data from historical whaling records in Hecate Strait and Queen Charlotte Sound indicate that most births in the region occurred between mid-November and mid-March, with a peak in January (DFO 2017b). Sexual maturity is reached between six and ten years of age with an average calving interval of two to three years. They mostly inhabit deep, offshore waters of all major oceans. They winter at low latitudes, where they calve and nurse, and summer at high latitudes, where they feed, although some fin whales appear to be residential to certain areas. Acoustic recording data in British Columbia indicate that fin whales are present year-round (Koot 2015). Due to the detection of calling males from November through January, researchers assume that breeding occurs in Canadian Pacific waters in Hecate Strait and Queen Charlotte Sound during that time of year (DFO 2017b). Fin whales eat pelagic crustaceans (mainly euphausiids or krill) and schooling fish such as capelin, herring, and sand lice. There is a presumed feeding area along the Juan de Fuca Ridge off northern Washington, based on rates of fin whale calls in the area from fall through February (Muto et al. 2019).

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the fin whale.

The pre-exploitation estimate for the fin whale population in the North Pacific Ocean was 42,000 to 45,000 (Ohsumi and Wada 1974). In the North Atlantic Ocean, at least 55,000 fin whales were killed between 1910 and 1989. Approximately 704,000 fin whales were killed in the Southern Hemisphere from 1904 to 1975. Of the three to seven stocks in the North Atlantic Ocean (approximately 50,000 individuals), one occurs in United States waters, where the best estimate of abundance is 1,618 individuals (N_{min}=1,234); however, this may be an underrepresentation as the entire range of stock was not surveyed (Palka 2012). There are three stocks in United States Pacific Ocean waters: Northeast Pacific [minimum 1,368 individuals], Hawaii (approximately 58 individuals [N_{min}=27]) and California/Oregon/Washington (approximately 9,029 [N_{min}=8,127] individuals) (Nadeem et al. 2016). The International Whaling Commission also recognizes the China Sea stock of fin whales, found in the Northwest Pacific Ocean, which currently lacks an abundance estimate (Reilly et al. 2013). Abundance data for the Southern Hemisphere stock are limited; however, there were assumed to be somewhat more than 15,000 in 1983 (Thomas et al. 2016).

Current estimates indicate approximately 10,000 fin whales in United States Pacific Ocean waters, with an annual growth rate of 4.8 percent in the Northeast Pacific stock and a stable population abundance in the California/Oregon/Washington stock (Nadeem et al. 2016). Overall, population growth rates and total abundance estimates for the Hawaii stock, China Sea stock, western North Atlantic stock, and Southern Hemisphere fin whales are not available at this time.

Archer et al. (2013) recently examined the genetic structure and diversity of fin whales globally. Full sequencing of the mitochondrial DNA genome for 154 fin whales sampled in the North Atlantic Ocean, North Pacific Ocean, and Southern Hemisphere, resulted in 136 haplotypes, none of which were shared among ocean basins suggesting differentiation at least at this geographic scale. However, North Atlantic Ocean fin whales appear to be more closely related to the Southern Hemisphere population, as compared to fin whales in the North Pacific Ocean, which may indicate a revision of the subspecies delineations is warranted. Generally speaking, haplotype diversity was found to be high both within oceans basins, and across. Such high genetic diversity and lack of differentiation within ocean basins may indicate that despite some populations having small abundance estimates, the species may persist long-term and be somewhat protected from substantial environmental variance and catastrophes.

Vocalization and Hearing

Fin whales produce a variety of low frequency sounds in the 10 to 200 hertz range (Watkins 1981; Watkins et al. 1987; Edds 1988; Thompson et al. 1992). Typical vocalizations are long, patterned pulses of short duration (0.5 to two seconds) in the 18 to 35 hertz range, but only males are known to produce these (Patterson and Hamilton 1964; Clark et al. 2002). The most typically recorded call is a 20-hertz pulse lasting about one second, and reaching source levels of 189 ±4 dB re: 1 μPa at 1 meter (Watkins 1981; Watkins et al. 1987; Edds 1988; Richardson et al. 1995c; Charif et al. 2002; Clark et al. 2002; Sirovic et al. 2007). These pulses frequently occur in long sequenced patterns, are down swept (e.g., 23 to 18 hertz), and can be repeated over the course of many hours (Watkins et al. 1987).

In temperate waters, intense bouts of these patterned sounds are very common from fall through spring, but also occur to a lesser extent during the summer in high latitude feeding areas (Clark and Charif 1998). Richardson et al. (1995c) reported this call occurring in short series during spring, summer, and fall, and in repeated stereotyped patterns in winter. The seasonality and stereotype nature of these vocal sequences suggest that they are male reproductive displays (Watkins 1981; Watkins et al. 1987); a notion further supported by data linking these vocalizations to male fin whales only (Croll et al. 2002).

In Southern California, the 20 hertz pulses are the dominant fin whale call type associated both with call-counter-call between multiple animals and with singing (U.S. Navy 2010; U.S. Navy 2012). An additional fin whale sound, the 40 hertz call described by Watkins (1981), was also frequently recorded, although these calls are not as common as the 20 hertz fin whale pulses. Seasonality of the 40 hertz calls differed from the 20 hertz calls, since 40 hertz calls were more prominent in the spring, as observed at other sites across the northeast Pacific Ocean (Sirovic et al. 2012). Source levels of Eastern Pacific Ocean fin whale 20 hertz calls has been reported as 189 ± 5.8 dB re: 1 µPa at 1 meter (Weirathmueller et al. 2013). Some researchers have also recorded moans of 14 to 118 hertz, with a dominant frequency of 20 hertz, tonal vocalizations of 34 to 150 hertz, and songs of 17 to 25 hertz (Watkins 1981; Edds 1988; Cummings and Thompson 1994).

In general, source levels for fin whale vocalizations are 140 to 200 dB re: 1 µPa at 1 meter (as compiled by Erbe 2002b; see also Clark and Gagnon 2004). The source depth of calling fin whales has been reported to be about 50 meters (164 feet) (Watkins et al. 1987). Although acoustic recordings of fin whales from many diverse regions show close adherence to the typical 20-hertz bandwidth and sequencing when performing these vocalizations, there have been slight differences in the pulse patterns, indicative of some geographic variation (Watkins et al. 1987; Thompson et al. 1992).

Although their function is still in doubt, low frequency fin whale vocalizations travel over long distances and may aid in long distance communication (Payne and Webb. 1971; Edds-Walton 1997). During the breeding season, fin whales produce pulses in a regular repeating pattern, which have been proposed to be mating displays similar to those of humpback whales (Croll et al. 2002). These vocal bouts last for a day or longer (Tyack 1999). Also, it has been suggested that some fin whale sounds may function for long range echolocation of large-scale geographic targets such as seamounts, which might be used for orientation and navigation (Tyack 1999).

Direct studies of fin whale hearing have not been conducted, but it is assumed that fin whales can hear the same frequencies that they produce (low) and are likely most sensitive to this frequency range (Richardson et al. 1995c; Ketten 1997). This suggests fin whales, like other baleen whales, are more likely to have their best hearing capacities at low frequencies, including frequencies lower than those of normal human hearing, rather than mid- to high-frequencies (Ketten 1997).

In a study using computer tomography scans of a calf fin whale skull, Cranford and Krysl (2015) found sensitivity to a broad range of frequencies between 10 hertz and 12 kilohertz and a maximum sensitivity to sounds in the one to two kilohertz range. In terms of functional hearing capability, fin whales belong to the low-frequency group, which have a hearing range of seven hertz to 35 kilohertz (NOAA 2018).

Status

The fin whale is endangered as a result of past commercial whaling. Prior to commercial whaling, hundreds of thousands of fin whales existed. Fin whales may be killed under "aboriginal subsistence whaling" in Greenland, under Japan's scientific whaling program, and Iceland's formal objection to the International Whaling Commission's ban on commercial whaling. Additional threats include ship strikes, reduced prey availability due to overfishing or climate change, and noise. The species' overall large population size may provide some resilience to current threats, but trends are largely unknown.

Critical Habitat

No critical habitat has been designated for the fin whale.

Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover fin whale populations. These threats will be discussed in further detail in the *Environmental Baseline* section (Section 9) of this opinion. See the 2010 Final Recovery Plan for the fin whale (NMFS 2010b) for complete downlisting/delisting criteria for both of the following recovery goals:

1. Achieve sufficient and viable population in all ocean basins.
2. Ensure significant threats are addressed.

8.3 Humpback Whale—Mexico DPS

The humpback whale is a widely distributed baleen whale found in all major oceans. Humpback whales are distinguishable from other whales by long pectoral fins and are typically dark grey with some areas of white. The humpback whale was originally listed as endangered on December 2, 1970 (35 FR 18319). Since then, NMFS has designated 14 DPSs with four identified as endangered (Cape Verde Islands/Northwest Africa, Western North Pacific, Central America, and Arabian Sea) and one as threatened (Mexico).

Information available from the recovery plan (NMFS 1991), the recent stock assessment report (Carretta 2019b), the status review (Bettridge et al. 2015), and the final listing were used to summarize the life history, population dynamics and status of the species as follows.

Life History

Humpback whales can live, on average, 50 years. They have a gestation period of 11 to 12 months, and calves nurse for one year. Sexual maturity is reached between five to 11 years of age. Every one to five years, females give birth to a single calf, with an average calving interval of two to three years. Humpback whales mostly inhabit coastal and continental shelf waters. They winter at lower latitudes, where they calve and nurse, and summer at high latitudes, where they feed. In British Columbia, the highest numbers of humpback whales are found between May and October, however, individuals are observed throughout the year (Ford 2009). Humpback whales exhibit a wide range of foraging behaviors and feed on a range of prey types, including: small schooling fishes, euphausiids, and other large zooplankton (Bettridge et al. 2015).

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the Mexico DPS of humpback whales.

The global, pre-exploitation estimate for humpback whales is 1,000,000 (Roman and Palumbi 2003). Prior to 1905, whaling records indicate that the humpback whale population in the North Pacific was 15,000 whales. By 1966, whaling had reduced the North Pacific population to about 1,200. NMFS considers the California/Oregon/Washington stock of humpback whales to include two separate feeding groups containing individuals from the Central America DPS and the Mexico DPS (as well as humpback whales from the non-ESA-listed Hawaii DPS); the abundance estimate for the California/Oregon/Washington stock is 2,784 (CV=0.048) (Carretta 2019b). In the 2015 status review for humpback whales, the abundance of the Central America DPS was 431 (CV=0.3) and 783 (CV=0.17) individuals (Bettridge et al. 2015); however, this estimate is based on data from 2004 through 2006, and is not considered a reliable estimate of current abundance (Carretta 2019a). A population growth rate is currently unavailable for the Mexico DPS of humpback whales. The current abundance of the Mexico DPS is unavailable, but it is thought to be more than 2,000 individuals (Bettridge et al. 2015).

The Canadian Department of Fisheries and Oceans describes the humpback whales in their jurisdictional waters as the Canadian North Pacific population, which ranges from along the west coast of Vancouver, between the borders from Washington to Alaska. The best estimate of this population is 2,145 individuals (Canada 2013).

For humpback whales, DPSs that have a total population size of 2,000 to 2,500 individuals or greater provide for maintenance of genetic diversity resulting in long-term persistence and protection from substantial environmental variance and catastrophes. DPSs that have a total population of 500 individuals or less may be at a greater risk of extinction due to genetic risks resulting from inbreeding. Population at low densities (less than one hundred) are more likely to suffer from the 'Allee' effect, where inbreeding and the heightened difficulty of finding mates reduces the population growth rate in proportion with reducing density. The Central America DPS has just below 500 individuals and so may be subject to genetic risks due to inbreeding and moderate environmental variance. The Mexico DPS is estimated to have more than 2,000 individuals and thus, should have enough genetic diversity for long-term persistence and protection from substantial environmental variance and catastrophes (Bettridge et al. 2015).

The Mexico DPS is composed of humpback whales that breed along the Pacific coast of mainland Mexico, and the Revillagigedos Islands, and transit through the Baja California Peninsula coast. This DPS feeds across a broad geographic range from California to the Aleutian Islands, with concentrations in California-Oregon, northern Washington-southern British Columbia, northern and western GOA, and Bering Sea feeding grounds (81 FR 62259).

Vocalization and Hearing

Humpback whale vocalization is much better understood than is hearing. Different sounds are produced that correspond to different functions: feeding, breeding, and other social calls (Dunlop et al. 2008). Males sing complex sounds while in low-latitude breeding areas in a frequency range of 20 hertz to four kilohertz with estimated source levels from 144 to 174 dB (Winn et al. 1970; Richardson et al. 1995d; Au et al. 2000; Frazer and Mercado Iii 2000; Au et al. 2006b). Males also produce sounds associated with aggression, which are generally characterized by frequencies between 50 hertz to 10 kilohertz with most energy below three kilohertz (Tyack 1983; Silber 1986). Such sounds can be heard up to nine kilometers (4.9 nautical miles) away (Tyack 1983). Other social sounds from 50 hertz to 10 kilohertz (most energy below three kilohertz) are also produced in breeding areas (Tyack 1983; Richardson et al. 1995d). While in northern feeding areas, both sexes vocalize in grunts (25 hertz to 1.9 kilohertz), pulses (25 to 89 hertz) and songs (ranging from 30 hertz to eight kilohertz but dominant frequencies of 120 hertz to four kilohertz), which can be very loud (175 to 192 dB re: 1 μPa at 1 meter) (Payne 1985; Thompson et al. 1986; Richardson et al. 1995d; Au et al. 2000; Erbe 2002a). However, humpback whales tend to be less vocal in northern feeding areas than in southern breeding areas (Richardson et al. 1995d). NMFS classified humpback whales in the low-frequency cetacean (i.e., baleen whale) functional hearing group. As a group, it is estimated that baleen whales can hear frequencies between 0.007 and 30 hertz (NOAA 2013a). Houser et al. (2001) produced a mathematical model of humpback whale hearing sensitivity based on the anatomy of the humpback whale ear. Based on the model, they concluded that humpback whales would be sensitive to sound in frequencies ranging from 0.7 to 10 kilohertz, with a maximum sensitivity between two to six kilohertz.

Humpback whales are known to produce three classes of vocalizations: (1) "songs" in the late fall, winter, and spring by solitary males; (2) social sounds made by calves (Zoidis et al. 2008) or within groups on the wintering (calving) grounds; and (3) social sounds made on the feeding grounds (Thomson and Richardson 1995a). The best-known types of sounds produced by humpback whales are songs, which are thought to be reproductive displays used on breeding grounds and sung only by adult males (Schevill et al. 1964; Helweg et al. 1992; Gabriele and Frankel. 2002; Clark and Clapham 2004; Smith et al. 2008). Singing is most common on breeding grounds during the winter and spring months, but is occasionally heard in other regions and seasons (McSweeney et al. 1989; Gabriele and Frankel. 2002; Clark and Clapham 2004). (Au et al. 2006a) noted that humpback whales off Hawaii tended to sing louder at night compared to the day. There is a geographical variation in humpback whale song, with different populations singing a basic form of a song that is unique to their own group. However, the song evolves over the course of a breeding season but remains nearly unchanged from the end of one season to the start of the next (Payne et al. 1983). The song is an elaborate series of patterned vocalizations that are hierarchical in nature, with a series of songs ('song sessions') sometimes lasting for hours (Payne and Mcvay 1971). Components of the song range from below 20 hertz up to four kilohertz, with source levels measured between 151 and 189 dB re: 1 μPa-m and high frequency harmonics extending beyond 24 kilohertz (Winn et al. 1970; Au et al. 2006a).Social calls range from 20 hertz to 10 kilohertz, with dominant frequencies below three kilohertz (D'Vincent et al. 1985; Silber 1986; Simao and Moreira 2005; Dunlop et al. 2008). Female vocalizations appear to be simple; Simao and Moreira (2005) noted little complexity.

"Feeding" calls, unlike song and social sounds are a highly stereotyped series of narrow-band trumpeting calls. These calls are 20 hertz to two kilohertz, less than one second in duration, and have source levels of 162 to 192 dB re: 1 μPa-m (D'Vincent et al. 1985; Thompson et al. 1986). The fundamental frequency of feeding calls is approximately 500 hertz (D'Vincent et al. 1985; Thompson et al. 1986). The acoustics and dive profiles associated with humpback whale feeding behavior in the northwest Atlantic Ocean has been documented with DTAGs (Stimpert et al. 2007). Underwater lunge behavior was associated with nocturnal feeding at depth and with multiple boats of broadband click trains that were acoustically different from toothed whale echolocation: (Stimpert et al. 2007) termed these sounds "mega-clicks" which showed relatively low received levels at the DTAGs (143 to 154 dB re: 1 μPa), with the majority of acoustic energy below two kilohertz.

In terms of functional hearing capability, humpback whales belong to low frequency cetaceans which have a hearing range of seven hertz to 22 kilohertz (Southall et al. 2007a). Humpback whale audiograms using a mathematical model based on the internal structure of the ear estimate sensitivity is from 700 hertz to 10 kilohertz, with maximum relative sensitivity between two kilohertz and six kilohertz (Ketten and Mountain 2014). Research by Au et al. (2001) and Au et al. (2006a) off Hawaii indicated the presence of high frequency harmonics in vocalizations up to and beyond 24 kilohertz. While recognizing this was the upper limit of the recording equipment, it does not demonstrate that humpback whales can actually hear those harmonics, which may simply be correlated harmonics of the frequency fundamental in the humpback whale song. The ability of humpback whales to hear frequencies around three kilohertz may have been demonstrated in a playback study. Maybaum (1990) reported that humpback whales showed a mild response to a handheld sonar marine mammal detection and location device with frequency of 3.3 kilohertz at 219 dB re: 1 μPa-m or frequency sweep of 3.1 to 3.6 kilohertz. In addition, the system had some low frequency components (below 1 kilohertz) which may have been an artifact of the acoustic equipment. This possible artifact may have affected the response of the whales to both the control and sonar playback conditions.

Status

Humpback whales were originally listed as endangered because of past commercial whaling, and the five DPSs that remain listed (Cape Verde Islands/Northwest Africa, Western North Pacific, Central America, Arabian Sea, and Mexico) have likely not yet recovered from this. According to historical whaling records from five whaling stations in British Columbia, 5,638 humpback whales were killed between 1908 and 1967 (Gregr et al. 2000). We have no way of knowing the degree to which the Mexico DPS of humpback whale was affected by historical whaling. However, it is likely that individuals from the Mexico DPS was taken, based on where the whalers were hunting off British Columbia (i.e., the purported feeding grounds for Mexico DPS humpback whales). Prior to commercial whaling, hundreds of thousands of humpback whales existed. Global abundance declined to the low thousands by 1968, the last year of substantial catches (IUCN 2012). Humpback whales may be killed under "aboriginal subsistence whaling" and "scientific permit whaling" provisions of the International Whaling Commission. Additional threats include ship strikes, fisheries interactions (including entanglement), energy development, harassment from whaling watching noise, harmful algal blooms, disease, parasites, and climate change. The Mexico DPS has a comparatively larger population than the endangered Central America DPS, but still faces a risk of becoming endangered within the foreseeable future throughout all or a significant portion of its range.

Critical Habitat

On October 9, 2019, NMFS proposed critical habitat for three DPSs of humpback whale on the U.S. West Coast: Central America, Mexico, and Western North Pacific DPSs. On April 21, 2021, the final rule (86 FR 21082) designating critical habitat for Central America, Mexico, and Western North Pacific DPS humpback whales was published. Specific areas designated as critical habitat for the Mexico DPS of humpback whales contain approximately 116,098 square nautical miles of marine habitat in the North Pacific Ocean, including areas within portions of the eastern Bering Sea, Gulf of Alaska, and California Current Ecosystem. The designated critical habitat for Mexico DPS humpback whales is outside the action area and therefore is not considered in this opinion.

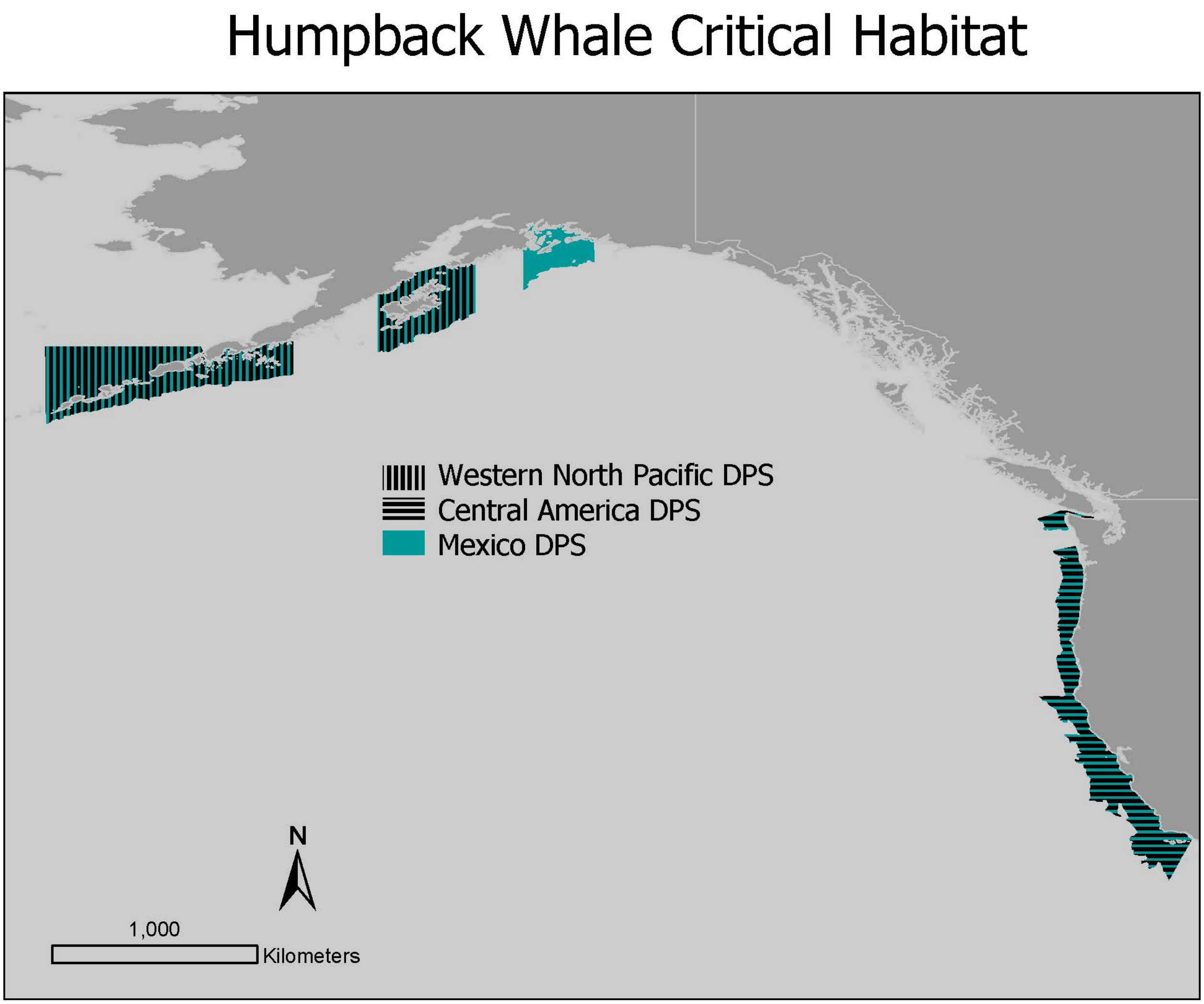

Figure 5. Designated critical habitat for the humpback whales.

Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover humpback whale populations. These threats will be discussed in further detail in the *Environmental Baseline* section (Section 9) of this opinion. See the 1991 Final Recovery Plan for the humpback whale (NMFS 1991) for the complete downlisting/delisting criteria for each of the four following recovery goals:

1. Maintain and enhance habitats used by humpback whales currently or historically.
2. Identify and reduce direct human-related injury and mortality.
3. Measure and monitor key population parameters.
4. Improve administration and coordination of recovery program for humpback whales.

8.4 North Pacific Right Whale

North Pacific right whales are found in temperate and sub-polar waters of the North Pacific Ocean (Figure 6).

The North Pacific right whale is a baleen whale found only in the North Pacific Ocean and is distinguishable by a stocky body, lack of dorsal fin, generally black coloration, and callosities on the head region (Figure 6). The species was originally listed with the North Atlantic right whale (i.e., "Northern" right whale) as endangered on December 2, 1970 (35 FR 18319). The North Pacific right whale was listed separately as endangered on March 6, 2008 (73 FR 12024). Information available from the recovery plan (NMFS 2013a) recent stock assessment reports (Carretta et al. 2016b; Muto et al. 2016; Waring et al. 2016), and status review (NMFS 2012a) were used to summarize the life history, population dynamics and status of the species as follows.

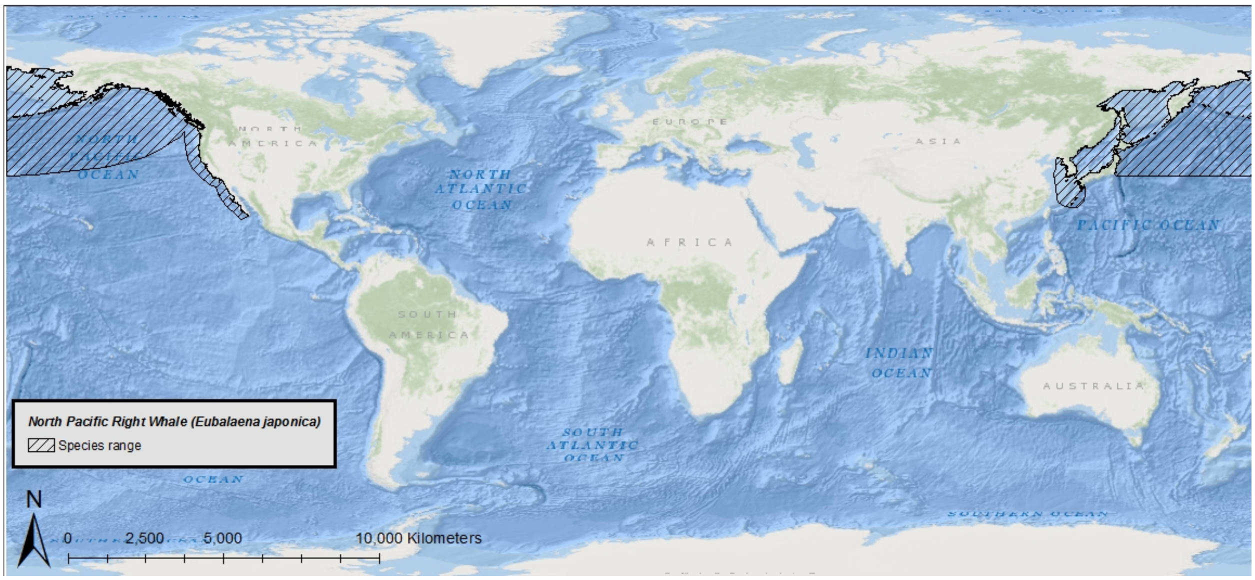

Figure 6. Map identifying the range of the endangered North Pacific right whale.

Life History

North Pacific right whales can live, on average, 50 or more years. They have a gestation period of approximately one year, and calves nurse for approximately one year. Sexual maturity is reached between nine and 10 years of age. The reproduction rate of North Pacific right whales remains unknown. However, it is likely low due to a male-biased sex ratio that may make it difficult for females to find viable mates. North Pacific right whales mostly inhabit coastal and continental shelf waters. Little is known about their migration patterns, but they have been observed in lower latitudes during winter (Japan, California, and Mexico) where they likely calve and nurse. In the summer, they feed on large concentrations of copepods in Alaskan waters. North Pacific right whales are unique compared to other baleen whales in that they are skim feeders meaning they continuously filtering through their baleen while moving through a patch of zooplankton.

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the North Pacific right whale.

The North Pacific right whale remains one of the most endangered whale species in the world. Their abundance likely numbers fewer than 1,000 individuals. Several lines of evidence indicate a total population size of less than 100. Based on photo-identification from 1998 to 2013 (Wade et al. 2011) estimated 31 individuals, with a minimum population estimate of 25.7 individuals. Genetic data have identified 23 individuals based on samples collected between 1997 and 2011 (Leduc et al. 2012). There is currently no information on the population trend of North Pacific right whales.

As a result of past commercial whaling, the remnant population of North Pacific right whales has been left vulnerable to genetic drift and inbreeding due to low genetic variability. This low diversity potentially affects individuals by depressing fitness, lowering resistance to disease and parasites, and diminishing the whales' ability to adapt to environmental changes. At the population level, low genetic diversity can lead to slower growth rates, lower resilience, and poorer long-term fitness (Lacy 1997). Marine mammals with an effective population size of a few dozen individuals likely can resist most of the deleterious consequences of inbreeding (Lande 1991). It has also been suggested that if the number of reproductive animals is fewer than fifty, the potential for impacts associated with inbreeding increases substantially. Rosenbaum et al. (2000) found that historic genetic diversity of North Pacific right whales was relatively high compared to North Atlantic right whales (*E. glacialis*), but samples from extant individuals showed very low genetic diversity, with only two matrilineal haplotypes among the five samples in their dataset.

The North Pacific right whale inhabits the Pacific Ocean, particularly between 20 and 60 degrees latitude (Figure 6). Prior to exploitation by commercial whalers, concentrations of right whales in the North Pacific where found in the Gulf of Alaska, Aleutian Islands, south central Bering Sea, Sea of Okhotsk, and Sea of Japan. There has been little recent sighting data of right whales occurring in the central North Pacific and Bering Sea. However, since 1996, North Pacific right whales have been consistently observed in Bristol Bay and the southeastern Bering Sea during summer months.

Vocalization and Hearing

Given their extremely small population size and remote location, little is known about North Pacific right whale vocalizations (Marques et al. 2011). However, data from other right whales is informative. Right whales vocalize to communicate over long distances and for social interaction, including communication apparently informing others of prey path presence (Biedron et al. 2005; Tyson and Nowacek 2005). Vocalization patterns amongst all right whale species are generally similar, with six major call types: scream, gunshot, blow, up call, warble, and down call (McDonald and Moore 2002; Parks and Tyack 2005). A large majority of vocalizations occur in the 300 to 600 Hz range with up and down sweeping modulations (Vanderlaan et al. 2003). Vocalizations below 200 Hz and above 900 Hz were rare And calls tend to be clustered, with periods of silence between clusters (Vanderlaan et al. 2003). Gunshot bouts last 1.5 hours on average and up to seven hours (Parks et al. 2012a). Gunshots appear to be largely or exclusively male vocalization (Parks et al. 2005b). Blows are associated with ventilation and are generally inaudible underwater (Parks and Clark 2007). Up calls are 100 to 400 Hz (Gillespie and Leaper 2001).

For North Atlantic right whales, smaller groups vocalize more than larger groups and vocalization is more frequent at night (Matthews et al. 2001). Moans are usually produced within 10 meters (33 feet) of the surface (Matthews et al. 2001). Up calls were detected almost year-round in Massachusetts Bay, except July and August, and peaked in April (Mussoline et al. 2012). Individuals remaining in the Gulf of Maine through winter continue to call, showing a strong diel pattern of up call and gunshot vocalizations from November through January possibly associated with mating (Bort et al. 2011; Morano et al. 2012; Mussoline et al. 2012). Estimated source levels of gunshots in non-surface active groups are 201 dB re 1 μPa peak-to-peak (Hotchkin et al. 2011). While in surface active groups, females produce scream calls and males produce up calls and gunshot calls as threats to other males; calves (at least female calves) produce warble sounds similar to their mothers' screams (Parks et al. 2003; Parks and Tyack 2005). Source levels for these calls in surface active groups range from 137 to 162 dB re 1 μPa at 1 meter (rms), except for gunshots, which are 174 to 192 dB re 1 μPa at 1 meter (rms) (Parks and Tyack 2005). Up calls may also be used to reunite mothers with calves. North Atlantic right whales shift calling frequencies, particularly of up calls, as well as increase call amplitude over both long and short-term periods due to exposure to vessel noise (Parks et al. 2005a; Parks et al. 2006; Parks and Clark 2007; Parks et al. 2007a; Parks et al. 2010; Parks et al. 2011; Parks et al. 2012b), particularly the peak frequency (Parks 2009b). North Atlantic right whales respond to anthropogenic sound designed to alert whales to vessel presence by surfacing (Nowacek et al. 2003; Nowacek et al. 2004).

There is no direct data on the hearing range of North Pacific right whales. However, based on anatomical modeling, the hearing range for North Pacific right whales is predicted to be from 10 Hz to 22 kilohertz (Parks et al. 2007b).

Status

The North Pacific right whale is endangered as a result of past commercial whaling. Prior to commercial whaling, abundance has been estimated to have been more than 11,000 individuals. Current threats to the survival of this species include hunting, ship strikes, climate change, and fisheries interactions (including entanglement). The resilience of North Pacific right whales to future perturbations is low due to its small population size and continued threats. Recovery is not anticipated in the foreseeable future (several decades to a century or more) due to small population size and lack of available current information.

In June of 2021 and June of 2018, single encounters of North Pacific Right whale have occurred off the coast of Haida Gwai (Kloster 2021). Further, in October 2013, two North Pacific right whale sightings were made off the coast of British Columbia, with a group of humpback whales moving south into the offshore area of the U.S. Navy's Northwest Training and Testing action area (U.S. Department of the Navy 2015). There have also been four sightings, each of a single North Pacific right whale, in California waters within approximately the last 30 years (in 1988, 1990, 1992, and 2017) (Carretta et al. 1994; Brownell et al. 2001; Price 2017). In addition, other various sightings of North Pacific right whales in the general vicinity of the action area have occurred on an irregular basis. Two North Pacific right whales were sighted in 1983 on Swifsure Bank at the entrance to the Strait of Juan de Fuca (Osborne et al. 1988). There were no sightings of North Pacific right whales during six vessel surveys conducted in summer and fall off California, Oregon, and Washington from 1991 through 2008 (Barlow 2010).

Critical Habitat

In 2008, NMFS designated critical habitat for the North Pacific right whale, which includes an area in the Southeast Bering Sea and an area south of Kodiak Island in the Gulf of Alaska (Figure 7). These areas are influenced by large eddies, submarine canyons, or frontal zones which enhance nutrient exchange and act to concentrate prey. These areas are adjacent to major ocean currents and are characterized by relatively low circulation and water movement. Both critical habitat areas support feeding by North Pacific right whales because they contain the designated physical and biological features (previously referred to as primary constituent elements), which include: nutrients, physical oceanographic processes, certain species of zooplankton, and a long photoperiod due to the high latitude (73 FR 19000). Consistent North Pacific right whale sightings are a proxy for locating these elements. The designated critical habitat for North Pacific right whale is outside the action area and therefore is not considered in this opinion.

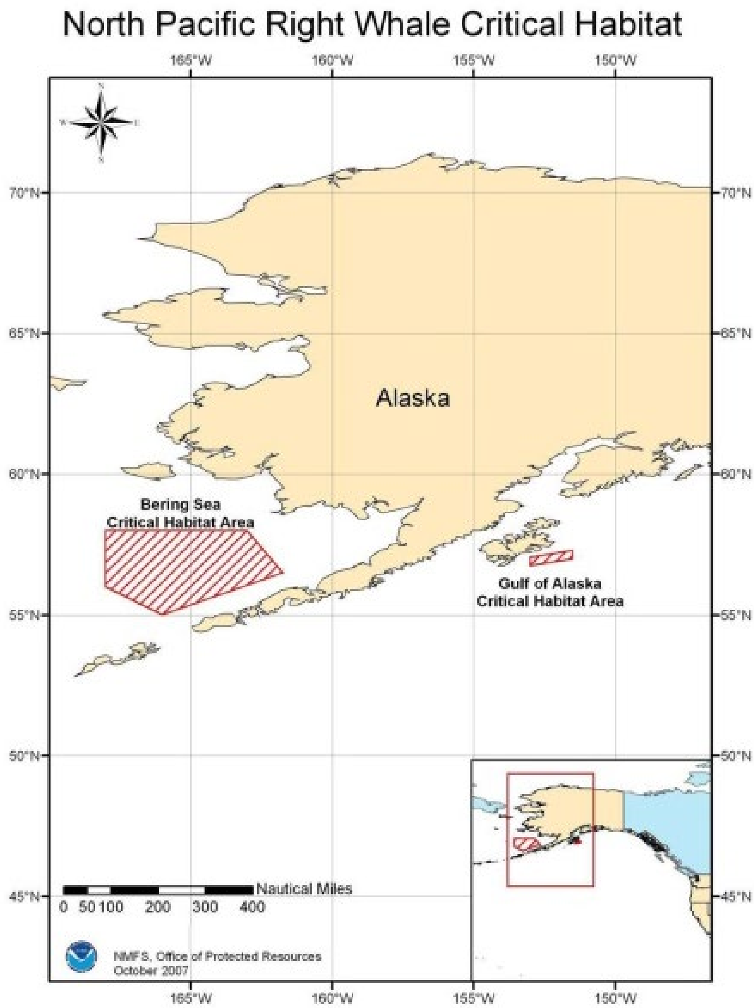

Figure 7. Map identifying designated critical habitat for the North Pacific right whale in the Southeast Bering Sea and south of Kodiak Island in the Gulf of Alaska.

Recovery Goals

See the 2013 Final Recovery Plan for the North Pacific right whale (NMFS 2013a) for complete down listing/delisting criteria for both of the following recovery goals:

1. Achieve sufficient and viable populations in all ocean basins.
2. Ensure significant threats are addressed.

8.5 Sei Whale

The sei whale is a widely distributed baleen whale found in all major oceans (Figure 8).

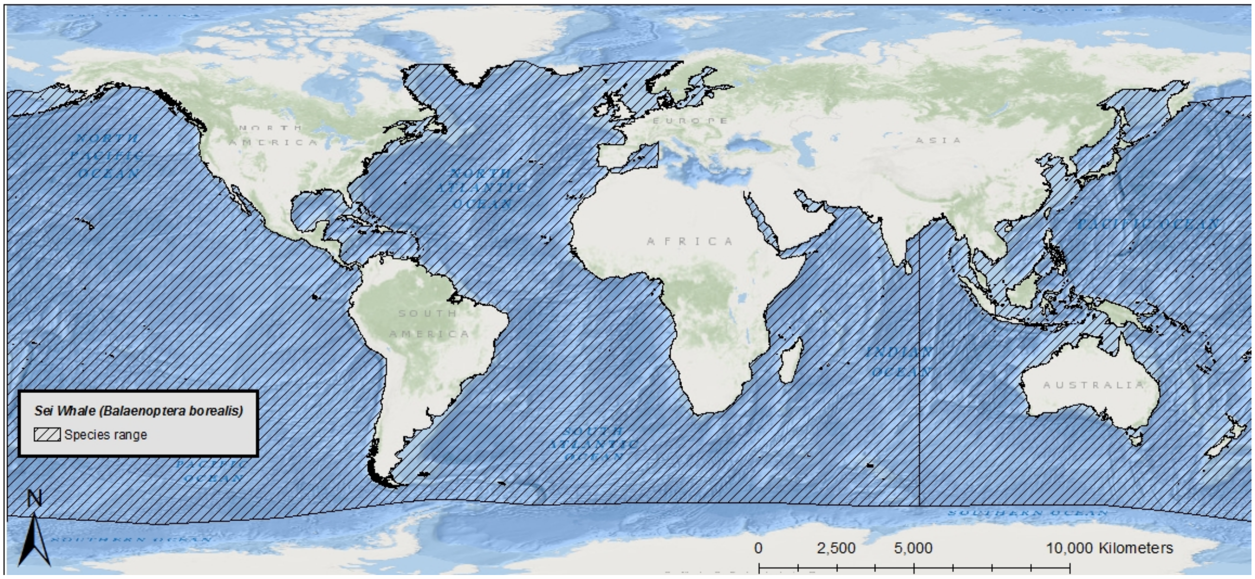

Figure 8. Map identifying the range of the endangered sei whale.

Sei whales are distinguishable from other whales by a long, sleek body that is dark bluish-gray to black in color and pale underneath, and a single ridge located on their rostrum. The sei whale was originally listed as endangered on December 2, 1970.

Information available from the recovery plan (NMFS 2011d), recent stock assessment report (Carretta 2019b), and status review (NMFS 2012b) were used to summarize the life history, population dynamics, and status of the species as follows.

Life History

Sei whales can live, on average, between 50 and 70 years. They have a gestation period of ten to 12 months, and calves nurse for six to nine months. Sexual maturity is reached between six and 12 years of age with an average calving interval of two to three years. Sei whales mostly inhabit continental shelf and slope waters far from the coastline. They winter at low latitudes, where they calve and nurse, and summer at high latitudes, where they feed on a range of prey types, including: plankton (copepods and krill) small schooling fishes, and cephalopods.

Population Dynamics

Two subspecies of sei whale are recognized, *B. b. borealis* in the Northern Hemisphere and *B. b. schlegellii* in the Southern Hemisphere. Models indicate that total abundance declined from 42,000 to 8,600 individuals between 1963 and 1974 in the North Pacific Ocean. More recently, the North Pacific Ocean population was estimated to be 29,632 (95 percent confidence intervals 18,576 to 47,267) between 2010 and 2012 (IWC 2016; Thomas et al. 2016). The best abundance estimate for sei whales for the waters of the U.S. West Coast is 519 (CV=0.40) (Carretta 2019b).

Population growth rates for sei whales are not available at this time as there are little to no systematic survey efforts to study sei whales.

Based on genetic analyses, there appears to be some differentiation between sei whale populations in different ocean basins. An early study of allozyme variation at 45 loci found some genetic differences between Southern Ocean and the North Pacific sei whales (Wada and Numachi 1991). However, more recent analyses of mtDNA control region variation show no significant differentiation between Southern Ocean and the North Pacific sei whales, though both appear to be genetically distinct from sei whales in the North Atlantic (Baker and Clapham 2004; Huijser et al. 2018). Within ocean basin, there appears to be intermediate to high genetic diversity and little genetic differentiation despite there being different managed stocks (Danielsdottir et al. 1991; Kanda et al. 2006; Kanda et al. 2011; Kanda et al. 2013; Kanda et al. 2015; Huijser et al. 2018).

Sei whales are distributed worldwide, occurring in the North Atlantic Ocean, North Pacific Ocean, and Southern Hemisphere. Very little is known about the distribution of sei whales in the northeast Pacific. Generally, the species occupies pelagic habitats, and is very rarely seen inshore; over 3,700 sei whales were killed by whalers offshore of the west coast of Vancouver Island. In the recent past, two sei whales have been sighted in Canadian Pacific waters, one in 2004 off southeastern Haida Gwaii, and the other in 2008 near Learmonth Bank in Dixon Entrance (Nichol 2011).

Vocalization and Hearing

Data on sei whale vocal behavior is limited, but includes records off the Antarctic Peninsula of broadband sounds in the 100 to 600 hertz range with 1.5 second duration and tonal and upsweep calls in the 200 to 600 hertz range of one to three second durations (McDonald et al. 2005). Vocalizations from the North Atlantic Ocean consisted of paired sequences (0.5 to 0.8 seconds, separated by 0.4 to 1.0 seconds) of 10 to 20 short (4 milliseconds) frequency modulated sweeps between 1.5 to 3.5 kilohertz (Thomson and Richardson 1995b). Source levels of 189 ±5.8 dB re: 1 μPa at 1 meter have been established for sei whales in the northeastern Pacific Ocean (Weirathmueller 2013).

Direct studies of sei whale hearing have not been conducted, but it is assumed that they can hear the same frequencies that they produce (low) and are likely most sensitive to this frequency range (Richardson et al. 1995c; Ketten 1997). This suggests sei whales, like other baleen whales, are more likely to have their best hearing capacities at low frequencies, including frequencies lower than those of normal human hearing, rather than mid- to high-frequencies (Ketten 1997). In terms of functional hearing capability, sei whales belong to the low-frequency group, which have a hearing range of seven hertz to 35 kilohertz (NOAA 2018).

Status

The sei whale is endangered as a result of past commercial whaling, reduced to about 20 percent of their pre-whaling abundance in the North Pacific Ocean (Carretta 2019b). According to historical whaling records from five whaling stations in British Columbia, 4,002 sei whales were killed between 1908 and 1967 (Gregr et al. 2000). Current threats include ship strikes, fisheries interactions (including entanglement), climate change (habitat loss and reduced prey availability), and anthropogenic sound. Given the species' overall abundance, they may be somewhat resilient to current threats. However, trends are largely unknown, especially for individual stocks, many of which have relatively low abundance estimates.

Critical Habitat

No critical habitat has been designated for the sei whale.

Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover sei whale populations. These threats will be discussed in further detail in the *Environmental Baseline* section (Section 9) of this opinion. See the 2011 Final Recovery Plan for the sei whale (NMFS 2011d) for complete downlisting/delisting criteria for both of the following recovery goals:

1. Achieve sufficient and viable populations in all ocean basins.
2. Ensure significant threats are addressed.

8.6 Sperm Whale

The sperm whale is a widely distributed species found in all major oceans (Figure 9).

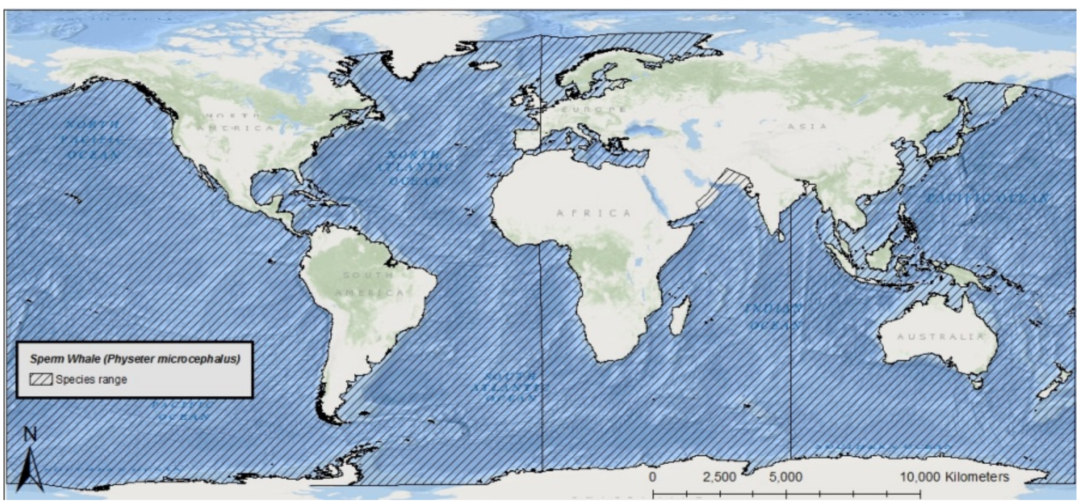

Figure 9. Map identifying the range of the endangered sperm whale.

Sperm whales are the largest toothed whale, distinguishable from other whales by its extremely large heard, which takes up to 25 to 35 percent of its total body length, and a single blowhole asymmetrically situated on the left side of the head near the tip. The sperm whale was originally listed as endangered on December 2, 1970.

Information available from the recovery plan (NMFS 2010a), recent stock assessment reports (Carretta 2019b; Carretta 2019a), and status review (NMFS 2015f) were used to summarize the life history, population dynamics, and status of the species as follows.

Life History

The average lifespan of sperm whales is estimated to be at least 50 years (Whitehead 2009). They have a gestation period of one to one and a half years, and calves nurse for approximately two years. Sexual maturity for sperm whales in the North Pacific is reached between seven and 13 years of age for females with an average calving interval for four to six years. Male sperm whales reach full sexual maturity between ages 18 and 21, after which they undergo a second growth spurt, reaching full physical maturity at around age 40 (Mizroch and Rice 2013). Data from historical whaling station records from 1908 to 1967 indicate that sperm whales mated in April through June, and calved in July to August in the offshore waters of British Columbia (Gregr et al. 2000). Sperm whales mostly occur far offshore, inhabiting areas with a water depth of 600 meters (1,968 feet) or more, and are uncommon in waters less than 300 meters (984 feet) deep. However, if there are shelf breaks or submarine canyons close to land, sperm whales can occur there. They winter at low latitudes, where they calve and nurse, and summer at high latitudes, where they feed primarily on squid; other prey includes octopus and demersal fish (including teleosts and elasmobranchs). An analysis of commercial whaling records from the Coal Harbor whaling station in northern Vancouver from 1963 to 1967 looked at sperm whale stomach contents. The samples came late spring through summer (April through September). North Pacific giant squid (*Moroteuhis robusta*) was the most abundant prey item for both males and females, but the secondary prey item differed between sexes. After giant squid, males consumed rockfish (*Sebastes spp*.), while females ate ragfish (*Icosteus spp*.) and other fish (Flinn et al. 2002).

Population Dynamics

The sperm whale is the most abundant of the large whale species, with a global population of between 300,000 and 450,000 individuals (Whitehead 2009). The higher estimates may be approaching population sizes prior to commercial whaling. In the northeast Pacific Ocean, the abundance of sperm whales was estimated to be between 26,300 and 32,100 in 1997 (NMFS 2015b). Population estimates are also available for the California/Oregon/Washington stock, estimated to consist of 1,997 individuals (N_{min}=1,270) (Carretta 2019b). There is insufficient data to evaluate trends in abundance and growth rates of sperm whales at this time.

Ocean-wide genetic studies indicate sperm whales have low genetic diversity, suggesting a recent bottleneck, but strong differentiation between matrilineally related groups (Lyrholm and Gyllensten 1998). Consistent with this, two studies of sperm whales in the Pacific Ocean indicate low genetic diversity (Mesnick et al. 2011; Rendell et al. 2012). As none of the stocks for which data are available have high levels of genetic diversity, the species may be at some risk to inbreeding and 'Allee' effects, although the extent is currently unknown.

Sperm whales have a global distribution and can be found in relatively deep waters in all ocean basins. While both males and females can be found in latitudes less than 40 degrees, only adult males venture into the higher latitudes near the poles. Sperm whale distribute widely throughout the North Pacific Ocean, with movements over 5,000 kilometers, likely driven by changes in prey abundance. Males appear to range more broadly than females (Mizroch and Rice 2013).

Vocalization and Hearing

Sound production and reception by sperm whales are better understood than in most cetaceans. Recordings of sperm whale vocalizations reveal that they produce a variety of sounds, such as clicks, gunshots, chirps, creaks, short trumpets, pips, squeals, and clangs (Goold 1999). Sperm whales typically produce short duration repetitive broadband clicks with frequencies below 100 hertz to greater than 30 kilohertz (Watkins 1977) and dominant frequencies between one to six kilohertz and 10 to 16 kilohertz. Another class of sound, "squeals," are produced with frequencies of 100 hertz to 20 kilohertz (e.g., Weir et al. 2007). The source levels of clicks can reach 236 dB re: 1 µPa at 1 meter, although lower source level energy has been suggested at around 171 dB re: 1 µPa at 1 meter (Weilgart and Whitehead 1993; Goold and Jones 1995; Weilgart and Whitehead 1997; Mohl et al. 2003). Most of the energy in sperm whale clicks is concentrated at around two to four kilohertz and 10 to 16 kilohertz (Weilgart and Whitehead 1993; Goold and Jones 1995). The clicks of neonate sperm whales are very different from typical clicks of adults in that they are of low directionality, long duration, and low frequency (between 300 hertz and 1.7 kilohertz) with estimated source levels between 140 to 162 dB re: 1 µPa at 1 meter (Madsen et al. 2003). The highly asymmetric head anatomy of sperm whales is likely an adaptation to produce the unique clicks recorded from these animals (Norris and Harvey 1972).

Long, repeated clicks are associated with feeding and echolocation (Whitehead and Weilgart 1991; Weilgart and Whitehead 1993; Goold and Jones 1995; Weilgart and Whitehead 1997; Miller et al. 2004). Creaks (rapid sets of clicks) are heard most frequently when sperm whales are foraging and engaged in the deepest portion of their dives, with inter-click intervals and source levels being altered during these behaviors (Miller et al. 2004; Laplanche et al. 2005). Clicks are also used during social behavior and intragroup interactions (Weilgart and Whitehead 1993). When sperm whales are socializing, they tend to repeat series of group-distinctive clicks (codas), which follow a precise rhythm and may last for hours (Watkins and Schevill 1977). Codas are shared between individuals in a social unit and are considered to be primarily for intragroup communication (Weilgart and Whitehead 1997; Rendell and Whitehead 2004). Research in the South Pacific Ocean suggests that in breeding areas the majority of codas are produced by mature females (Marcoux et al. 2006). Coda repertoires have also been found to vary geographically and are categorized as dialects (Weilgart and Whitehead 1997; Pavan et al. 2000). For example, significant differences in coda repertoire have been observed between sperm whales in the Caribbean Sea and those in the Pacific Ocean (Weilgart and Whitehead 1997). Three coda types used by male sperm whales have recently been described from data collected over multiple years: these codas are associated with dive cycles, socializing, and alarm (Frantzis and Alexiadou 2008).

Our understanding of sperm whale hearing stems largely from the sounds they produce. The only direct measurement of hearing was from a young stranded individual from which auditory evoked potentials were recorded (Carder and Ridgway 1990). From this whale, responses support a hearing range of 2.5 to 60 kilohertz and highest sensitivity to frequencies between five to 20 kilohertz. Other hearing information consists of indirect data. For example, the anatomy of the sperm whale's inner and middle ear indicates an ability to best hear high-frequency to ultrasonic hearing (Ketten 1992a). The sperm whale may also possess better low-frequency hearing than other odontocetes, although not as low as many baleen whales (Ketten 1992a). Reactions to anthropogenic sounds can provide indirect evidence of hearing capability, and several studies have made note of changes seen in sperm whale behavior in conjunction with these sounds. For example, sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders and submarine sonar (Watkins and Schevill 1975; Watkins et al. 1985a). In the Caribbean Sea, Watkins et al. (1985a) observed that sperm whales exposed to 3.25 to 8.4 kilohertz pulses (presumed to be from submarine sonar) interrupted their activities and left the area. Similar reactions were observed from artificial sound generated by banging on a boat hull (Watkins et al. 1985a). André et al. (1997) reported that foraging whales exposed to a 10 kilohertz pulsed signal did not ultimately exhibit any general avoidance reactions: when resting at the surface in a compact group, sperm whales initially reacted strongly, and then ignored the signal completely. Thode et al. (2007) observed that the acoustic signal from the cavitation of a fishing vessel's propeller (110 dB re: 1 μPa^2-s between 250 hertz and one kilohertz) interrupted sperm whale acoustic activity and resulted in the animals converging on the vessel. Sperm whales have also been observed to stop vocalizing for brief periods when codas are being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones 1995). Because they spend large amounts of time at depth and use low frequency sound, sperm whales are likely to be susceptible to low frequency sound in the ocean (Croll et al. 1999). Nonetheless, sperm whales are considered to be part of the mid-frequency marine mammal hearing group, with a hearing range between 150 hertz and 160 kilohertz (NOAA 2018).

Status

The sperm whale is endangered as a result of past commercial whaling. According to historical whaling records from five whaling stations in British Columbia, 6,158 sperm whales were killed between 1908 and 1967 (Gregr et al. 2000). Although the aggregate abundance worldwide is probably at least several hundred thousand individuals, the extent of depletion and degree of recovery of populations are uncertain. Commercial whaling is no longer allowed, however, illegal hunting may occur at biologically unsustainable levels. Continued threats to sperm whale populations include ship strikes, entanglement in fishing gear, competition for resources due to overfishing, population, loss of prey and habitat due to climate change, and noise. The species' large population size shows that it is somewhat resilient to current threats.

Critical Habitat

No critical habitat has been designated for the sperm whale.

Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover sperm whale populations. These threats will be discussed in further detail in the *Environmental Baseline* section (Section 9) of this opinion. See the 2010 Final Recovery Plan for the sperm whale (NMFS 2010a) for complete downlisting/delisting criteria for both of the following recovery goals:

1. Achieve sufficient and viable populations in all ocean basins.
2. Ensure significant threats are addressed.

8.7 Gray Whale —Western North Pacific DPS

The gray whale is a baleen whale and the only species in the family Eschrichtiidae. There are two isolated geographic distributions of gray whales in the North Pacific Ocean: the Eastern North Pacific stock, found along the west coast of North America, and the Western North Pacific or "Korean" stock, found along the coast of eastern Asia (Figure 10).

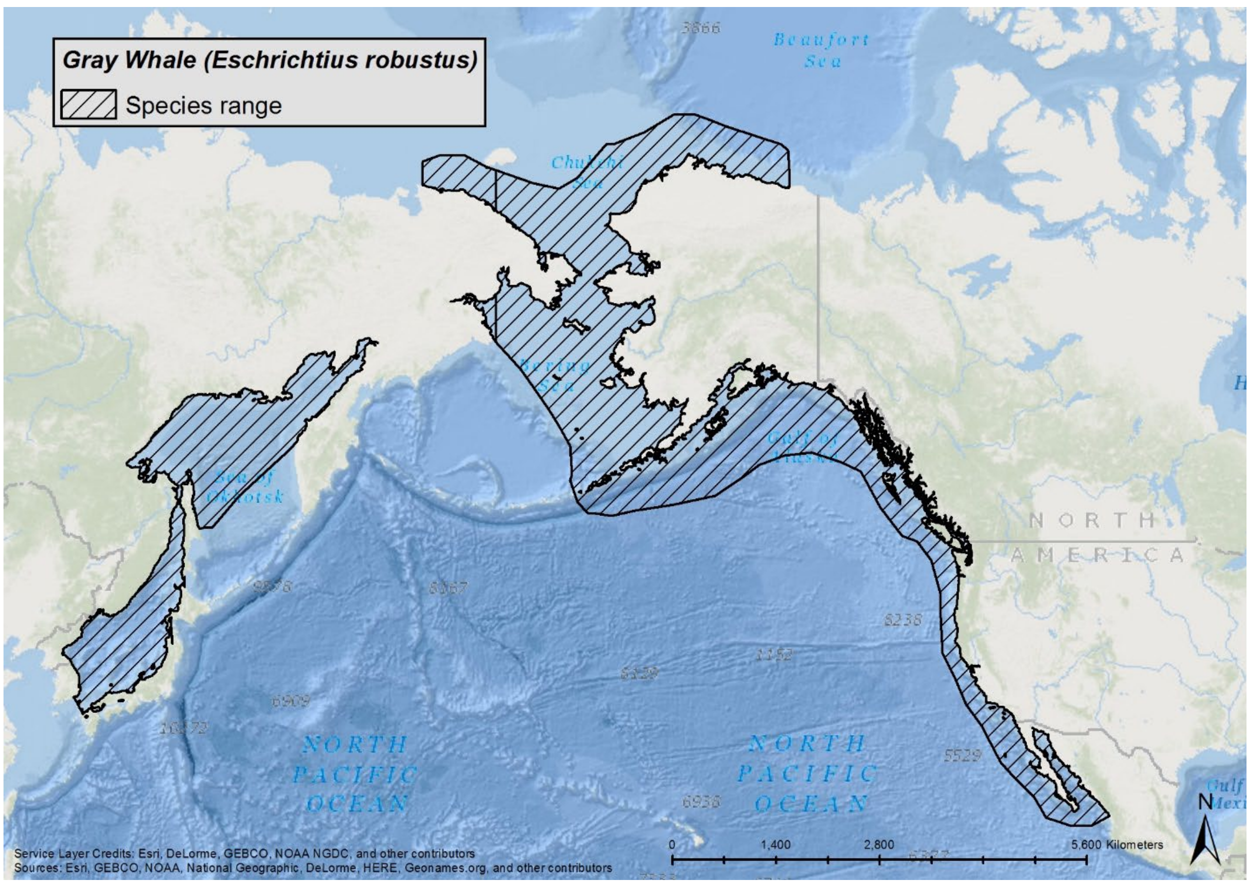

Figure 10. Map identifying the range of the gray whale.

Gray whales are distinguishable from other whales by a mottled gray body, small eyes located near the corners of their mouth, no dorsal fin, broad, paddle-shaped pectoral fins and a dorsal hump with a series of eight to 14 small bumps known as "knuckles." The gray whale was originally listed as endangered on December 2, 1970. The Eastern North Pacific stock was officially delisted on June 16, 1994 when it reached pre-exploitation numbers. The Western North Pacific population of gray whales remained listed as endangered.

Information available from the recent stock assessment reports (Carretta et al. 2016b; Muto et al. 2016; Waring et al. 2016) were used to summarize the life history, population dynamics and status of the species as follows.

Life History

The average life span of gray whales is unknown but it is thought to be as long as 80 years. They have a gestation period of twelve to thirteen months, and calves nurse for seven to eight months. Sexual maturity is reached between six and 12 years of age with an average calving interval of two to four years (Weller et al. 2009). Gray whales mostly inhabit shallow coastal waters in the North Pacific Ocean. Some Western North Pacific gray whales winter on the west coast of North America while others migrate south to winter in waters off Japan and China, and summer in the Okhotsk Sea off northeast Sakhalin Island, Russia, and off southeastern Kamchatka in the Bering Sea (Burdin et al. 2013). Gray whales travel alone or in small, unstable groups and are known as bottom feeders that eat "benthic" amphipods.

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the gray whale.

The current best estimate of the Western North Pacific population of gray whales is 140 (N_{min}=135) individuals (Carretta et al. 2018). Photo-identification data collected between 1994 and 2011 on the Western North Pacific population of gray whale summer feeding ground off Sakhalin Island were used to calculate an abundance estimate of 140 whales for the non-calf population size in 2012 (Cooke et al. 2013). The minimum population estimate for the Western North Pacific stock is 135 individual gray whales on the summer feeding ground off Sakhalin Island. The current best growth rate estimate for the Western North Pacific population of gray whale stock is 3.3 percent annually.

There are often observed movements between individuals from the Eastern North Pacific stock and Western North Pacific stock; however, genetic comparisons show significant mitochondrial and nuclear genetic differences between whales sampled from each stock indicating genetically distinct populations (Leduc et al. 2002). A study conducted between 1995 and 1999 using biopsy samples found that Western North Pacific population of gray whales have retained a relatively high number of mitochondrial DNA haplotypes for such a small population. Although the number of haplotypes currently found in the Western North Pacific stock is higher than might be expected, this pattern may not persist into the future. Populations reduced to small sizes, such as the Western North Pacific stock, can suffer from a loss of genetic diversity, which in turn may compromise their ability to respond to changing environmental conditions (Willi et al. 2006) and negatively influence long-term viability (Spielman et al. 2004; Frankham 2005). (Brüniche-

Olsen et al. 2018) found a high degree of gene flow into the Western North Pacific stock and they determined that the Western North Pacific stock is still genetically diverse at functionally important loci.

Gray whales in the Western North Pacific population are thought to feed in the summer and fall in the Okhotsk Sea, primarily off Sakhalin Island, Russia and the Kamchatka peninsula in the Bering Sea, and winter in the South China Sea. However, tagging, photo-identification, and genetic studies have shown that some whales identified as members of the Western North Pacific stock have been observed in the Eastern North Pacific Ocean, which may indicate that not all gray whales share the same migratory patterns.

Vocalization and Hearing

No data are available regarding Western North Pacific population of gray whale hearing and little regarding communication. The U.S. Navy has recorded short-duration (approximately one second) frequency sweeps at 55 hertz in the East China Sea, the likely source of which was determined to be Western North Pacific gray whales (Gagnon 2016). These sweeps are often emitted in pairs or triplets with an intersweep interval of approximately three or four seconds. These vocalizations contain multiple harmonics; the first harmonic is the weakest while the second and third harmonics are usually the strongest. Otherwise, we assume that Eastern North Pacific population of gray whale communication is representative of the Western North Pacific population of gray whale and present information stemming from this population. Individuals produce broadband sounds within the 100 hertz to 12 kilohertz range (Thompson et al. 1979; Dahlheim et al. 1984; Jones and Swartz 2002). The most common sounds encountered are on feeding and breeding grounds, where "knocks" of roughly 142 decibels re: 1 μPa at 1 meter (source level) have been recorded (Cummings et al. 1968; Thomson and Richardson 1995a; Jones and Swartz 2002). However, other sounds have also been recorded in Russian foraging areas, including rattles, clicks, chirps, squeaks, snorts, thumps, knocks, bellows, and sharp blasts at frequencies of 400 hertz to five kilohertz (Petrochenko et al. 1991). Estimated source levels for these sounds ranged from 167 to 188 decibels re: 1 μPa at 1 meter (Petrochenko et al. 1991). Low frequency (less than 1.5 kilohertz) "bangs" and "moans" are most often recorded during migration and during ice-entrapment (Carroll et al. 1989; Crane and Lashkari. 1996). Sounds vary by social context and may be associated with startle responses (Rohrkasse-Charles et al. 2011). Calves exhibit the greatest variation in frequency range used, while adults are narrowest; groups with calves were never silent while in calving grounds (Rohrkasse-Charles et al. 2011). Based upon a single captive calf, moans were more frequent when the calf was less than a year old, but after a year, croaks were the predominant call type (Wisdom et al. 1999).

Auditory structure suggests hearing is attuned to low frequencies (Ketten 1992b; Ketten 1992a). Responses of free-ranging and captive individuals to playbacks in the 160 hertz to two kilohertz range demonstrate the ability of individuals to hear within this range (Cummings and Thompson 1971a; Dahlheim and Ljungblad 1990; Buck and Tyack 2000; Wisdom et al. 2001; Moore and

Clark 2002). Responses to low-frequency sounds stemming from oil and gas activities also support low-frequency hearing (Malme et al. 1986b; Moore and Clark 2002).

Status

The Western North Pacific population of gray whale is endangered as a result of past commercial whaling and may still be hunted under "aboriginal subsistence whaling" provisions of the International Whaling Commission. Current threats include vessel strikes, fisheries interactions (including entanglement), habitat degradation, harassment from whale watching, illegal whaling or resumed legal whaling, and noise.

The Western North Pacific population of gray whales has increased over the last ten years at an estimated rate of 3.3 percent. The Western North Pacific population was thought to be geographically isolated from the Eastern North Pacific population, but recent documentation of some gray whales moving between geographic areas in the Pacific Ocean indicate otherwise. Also, in recent years, gray whales have been sighted in the Eastern Atlantic Ocean and Mediterranean Sea, but it is unknown to which population those animals belong.

Since January 1, 2019, elevated gray whale strandings have occurred along the west coast of North America, from Mexico through Alaska, and it has been declared an Unusual Mortality Event (UME)[6]. Several dead whales were emaciated with moderate to heavy whale lice (cyamid) loads. Full or partial necropsy examinations conducted on a subset of whales found evidence of vessel strike in three whales and entanglement in one whale. Findings are preliminary and investigations are ongoing, with more research needed to understand the cause of the strandings and if any of the dead gray whales are from the western population.

Critical Habitat

No critical habitat has been designated for the Western North Pacific population of gray whale. NMFS cannot designate critical habitat in foreign waters.

Recovery Goals

NMFS has not prepared a recovery plan for the Western North Pacific population of gray whale. In general, ESA-listed species, which occur entirely outside United States jurisdiction, are not likely to benefit from recovery plans (55 FR 24296; June 15, 1990).

8.8 Steller Sea Lion – Western DPS

The Steller sea lion ranges from Japan, through the Okhotsk and Bering Seas, to central California. It consists of two morphologically, ecologically, and behaviorally separate DPSs: the Eastern, which includes sea lions in Southeast Alaska, British Columbia, Washington, Oregon,

[6] https://www.fisheries.noaa.gov/national/marine-life-distress/2019-2021-gray-whale-unusual-mortality-event-along-west-coast-and (Accessed 1/08/21)

and California; and the Western, which includes sea lions in all other regions of Alaska, as well as Russia and Japan (See Figure 11).

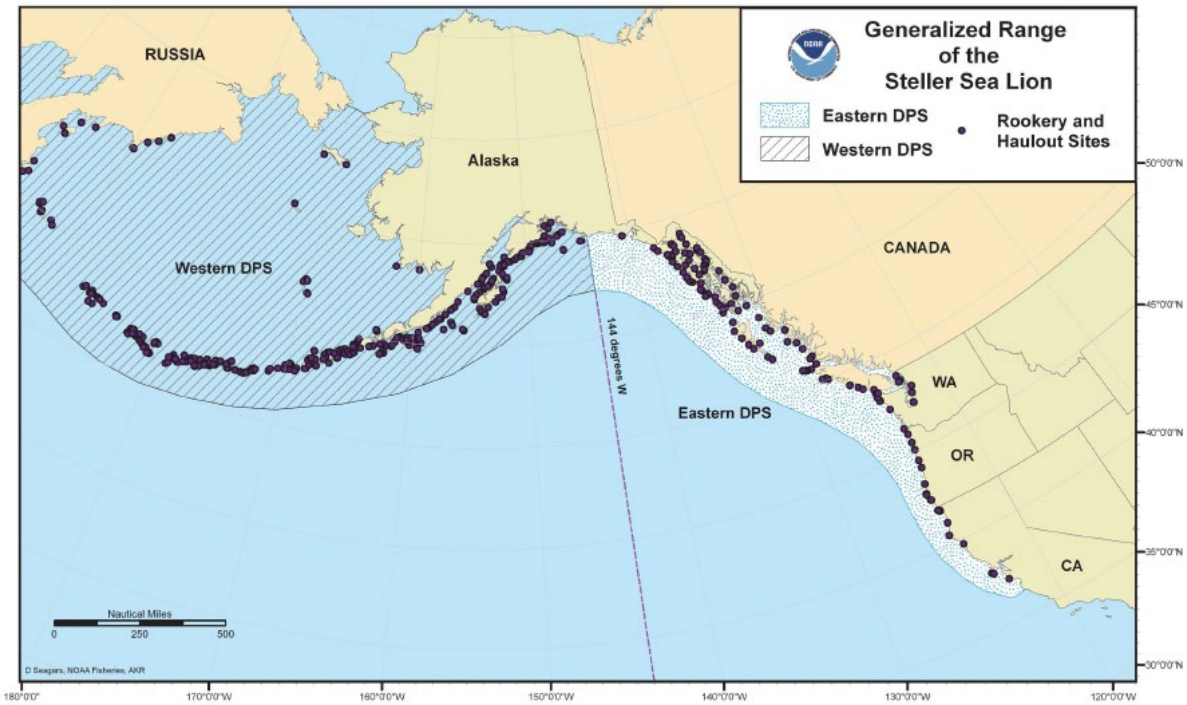

Figure 11. Map identifying the range of the endangered Western DPS of Steller sea lion.

Steller sea lion adults are light blonde to reddish brown and slightly darker on the chest and abdomen. At the time of their initial listing, Steller sea lions were considered a single population listed as threatened. On May 5, 1997, following a status review, NMFS established two DPSs of Steller sea lions, and issued a final determination to list the Western DPS as endangered under the ESA. The Eastern DPS of Steller sea lion was delisted on November 4, 2013, and the Western DPS of Steller sea lion retained its endangered status (78 FR 66139).

We used information available in the final listing, the revised Recovery Plan (NMFS 2008b), and the most recent stock assessment report (Muto et al. 2018) to summarize the status of the Western DPS of Steller sea lions, as follows.

Life History

Within the Western DPS of Steller sea lions, pupping and breeding occurs at numerous major rookeries from late May to early July. Male Steller sea lions become sexually mature at three to seven years of age. They are polygynous, competing for territories and females by age ten or eleven. Female Steller sea lions become sexually mature at three to six years of age and reproduce into their early 20's. Most females breed annually, giving birth to a single pup. Pups are usually weaned in one to two years. Females and their pups disperse from rookeries by August to October. Juveniles and adults disperse widely, especially males. Their large aquatic ranges are used for foraging, resting, and traveling. Steller sea lions forage on a wide variety of demersal, semi-demersal, and pelagic prey, including fish and cephalopods.

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the Western DPS of the Steller sea lion.

As of 2017, the best estimate of abundance of the Western DPS of Steller sea lion in Alaska was 11,952 pups and 42,315 for non-pups (total N_{min}= 54,267) (Muto et al. 2018). This represents a large decline since counts in the 1950s (N=140,000) and 1970s (N=110,000).

Using data collected from 1978 through 2017, there is strong evidence that pup and non-pup counts of western stock Steller sea lions in Alaska were at their lowest levels in 2002 and 2003, respectively, and have increased by 1.78 percent and 2.14 percent, respectively, between 2002 and 2017 (Sweeney et al. 2016). Western DPS Steller sea lion site counts decreased 40 percent from 1991 through 2000, an average annual decline of 5.4 percent; however, counts increased three percent between 2004 through 2008, the first recorded population increase since the 1970s (NMFS 2008b). Overall, there are strong regional differences across the range in Alaska, with positive trends in the Gulf of Alaska and eastern Bering Sea east of Samalga Pass (approximately 170 degrees West) and generally negative trends to the west in the Aleutian Islands (Muto et al. 2018). Non-pup trends from 2002 to 2017 in Alaska have a longitudinal gradient with highest rates of increase generally in the east (eastern GOA) and steadily decreasing rates to the west (Muto et al. 2018).

Based on the results of genetic studies, the Steller sea lion population was reclassified into two DPSs: Western and Eastern. The data which came out of these studies indicated that the two populations had been separate since the last ice age (Bickham et al. 1998). Further examination of the Steller sea lions from the Gulf of Alaska (i.e., the Western DPS) revealed a high level of haplotype diversity, indicating that genetic diversity had been retained despite the decline in abundance (Bickham et al. 1998).

Steller sea lions are distributed mainly around the coast to the outer continental shelf along the North Pacific Ocean rim from northern Hokkaido, Japan through the Kuril Islands and Okhotsk Sea, Aleutian Islands and central Bering Sea, southern coast of Alaska and south to California (Figure 11). The Western DPS includes Steller sea lions that reside in the central and western GOA, and Aleutian Islands, as well as those that inhabit the coastal waters and breed in Asia (e.g., Japan and Russia).

Vocalization and Hearing

Steller sea lions hear within the range of 0.5 to 32 kilohertz (Kastelein et al. 2005). Males and females apparently have different hearing sensitivities, with males hearing best at 1 to 16 kilohertz (best sensitivity at the low end of the range) and females hearing from 16 to 25 kilohertz (best hearing at the upper end of the range) (Kastelein et al. 2005).

Status

The species was ESA-listed as threatened in 1990 because of significant declines in population sizes (55 FR 49204). Sea lions have been hunted by humans for centuries for their fur, meat, and oil. While hunting was previously the primary cause of population decline among ESA-listed Steller sea lions, it no longer represents a major threat and limited subsistence hunting of Steller sea lions is permitted. The Steller Sea Lion Recovery Plan (NMFS 2008b) ranked subsistence harvest as a low threat to the recovery of the Western DPS. The most recent subsistence harvest data were collected by the ADF&G through 2008 and by the Ecosystem Conservation Office of the Aleut Community of St. Paul through 2009. The mean annual subsistence take for Alaskan communities that harvest Western U.S. DPS Steller sea lions is a combined annual mean of 203 (Muto et al. 2019).

At the time of listing, the major threat to the species was thought to be reduction in prey availability. To protect and recover the species, NMFS established the following measures: prohibition of shooting at or near Steller sea lions; prohibition of vessel approach to within three nautical miles (5.6 kilometers) of listed rookeries, within one-half statutory miles (0.8 kilometers) on land, and within sight of listed rookeries; and restriction of incidental fisheries take to 675 Steller sea lions annually in Alaskan waters. In 1997, the Western DPS of Steller sea lions was reclassified as endangered because it had continued to decline since its initial ESA-listing in 1990. Despite additional protections the Western DPS of Steller sea lions is still in declining in portions of the range. The reasons for the continued decline are unknown but may be associated with nutritional stress as a result of environmental change and competition with commercial fisheries.

Critical Habitat

In 1993, NMFS designated critical habitat for the Steller sea lion (58 FR 45269). The designated critical habitat includes specific rookeries, haulouts, and associated areas, as well as three foraging areas that are considered to be essential for health, continued survival, and recovery of the species.

As described in Section 7.3.1, the PBFs for the Western DPS Steller sea lion designated critical habitat include three special aquatic foraging areas in Alaska. Two of them are in the Aleutians, Bogoslof Island and Seaguam Pass, and Shelikof Strait is in the Gulf of Alaska. These important foraging areas are located near Steller sea lion abundance centers and concentrations of prey, which also attract commercial fisheries.

Recovery Goals

See the 2008 revised Recovery Plan for the Steller sea lion (NMFS 2008b) for complete downlisting/delisting criteria for each of the following recovery goals.

1. Baseline population monitoring.
2. Insure adequate habitat and range for recovery.
3. Protect from over-utilization for commercial, recreational, scientific, or educational purposes.
4. Protect from diseases, contaminants, and predation.

5. Protect from other natural or anthropogenic actions and administer the recovery program.

8.9 Leatherback Sea Turtle

The leatherback sea turtle is unique among sea turtles for its large size, wide distribution (due to thermoregulatory systems and behavior), and lack of a hard, bony carapace. It ranges from tropical to subpolar latitudes, worldwide (Figure 12).

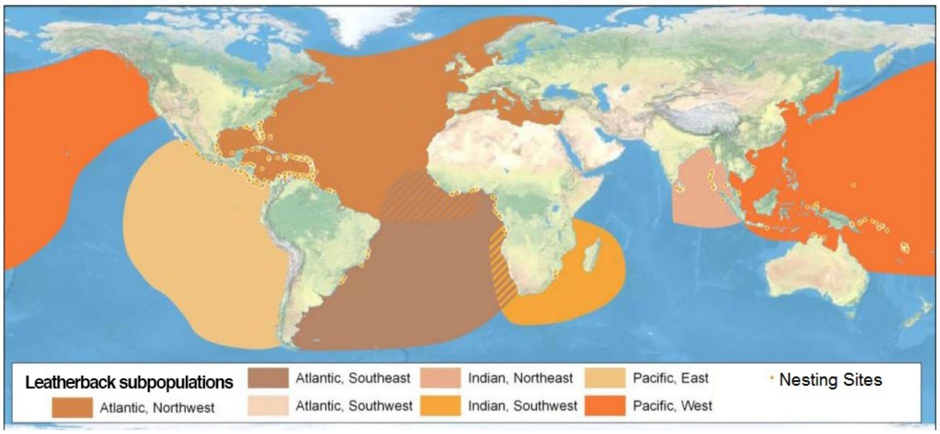

Figure 12. Map identifying the range of the endangered leatherback turtle. Adapted from (Wallace et al. 2013).

Leatherback turtles are the largest living turtle, reaching lengths of two meters (6.5 feet) long, and weighing up to 907.2 kilograms (2,000 pounds). Leatherback turtles have a distinct black leathery skin covering their carapace with pinkish white skin on their belly. The species was first listed under the Endangered Species Conservation Act (35 FR 8491) and listed as endangered under the ESA since 1973.

We used information available in the five year review (NMFS and USFWS 2013c) and the critical habitat designation (77 FR 61573) to summarize the life history, population dynamics and status of the species, as follows.

8.9.1 Life History

Age at maturity has been difficult to ascertain, with estimates ranging from five to 29 years (Spotila et al. 1996; Avens et al. 2009). Females lay up to seven clutches per season, with more than sixty-five eggs per clutch and eggs weighing greater than 80 grams (0.17 pounds) (Reina et al. 2002; Wallace et al. 2007). The number of leatherback turtle hatchlings that make it out of the nest on to the beach (i.e., emergent success) is approximately 50 percent worldwide (Eckert et al. 2012). Females nest every one to seven years. Natal homing, at least within an ocean basin, results in reproductive isolation between five broad geographic regions: eastern and western Pacific, eastern and western Atlantic, and Indian Ocean. Leatherback turtles migrate long, transoceanic distances between their tropical nesting beaches and the highly productive temperate waters where they forage, primarily on jellyfish and tunicates. These gelatinous prey are relatively nutrient-poor, such that leatherback turtles must consume large quantities to support their body weight. Leatherback turtles weigh about 33 percent more on their foraging grounds than at nesting, indicating that they probably catabolize fat reserves to fuel migration and subsequent reproduction (James et al. 2005; Wallace et al. 2006). Sea turtles must meet an energy threshold before returning to nesting beaches. Therefore, their remigration intervals (the time between nesting) are dependent upon foraging success and duration (Hays 2000; Price et al. 2004).

8.9.2 Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the leatherback turtle.

Leatherback turtles are globally distributed, with nesting beaches in the Atlantic, Indian, and Pacific Oceans. Detailed population structure is unknown, but is likely dependent upon nesting beach location. Based on estimates calculated from nest count data, there are between 34,000 and 94,000 adult leatherback turtles in the North Atlantic Ocean (TEWG 2007). In contrast, leatherback turtle populations in the Pacific Ocean are much lower. Overall, Pacific populations have declined from an estimated 81,000 individuals to less than 3,000 total adults and subadults (Spotila et al. 2000). Population abundance in the Indian Ocean is difficult to assess due to lack of data and inconsistent reporting. Available data from southern Mozambique show that approximately ten females nest per year from 1994 through 2004, and about 296 nests per year counted in South Africa (NMFS and USFWS 2013c).

Population growth rates for leatherback turtles vary by ocean basin. Counts of leatherback turtles at nesting beaches in the western Pacific Ocean indicate that the subpopulation has been declining at a rate of almost six percent per year since 1984 (Tapilatu et al. 2013). Leatherback turtle subpopulations in the Atlantic Ocean, however, are showing signs of improvement. Nesting females in South Africa are increasing at an annual rate of four to 5.6 percent, and from nine to 13 percent in Florida and the U.S. Virgin Islands (TEWG 2007), believed to be a result of conservation efforts.

Analyses of mitochondrial DNA from leatherback turtles indicates a low level of genetic diversity, pointing to possible difficulties in the future if current population declines continue (Dutton et al. 1999). Further analysis of samples taken from individuals from rookeries in the Atlantic and Indian Oceans suggest that each of the rookeries represent demographically independent populations (NMFS and USFWS 2013c).

Leatherback turtles are distributed in oceans throughout the world (Figure 12). Leatherback turtles occur throughout marine waters, from nearshore habitats to oceanic environments (Shoop and Kenney 1992). Movements are largely dependent upon reproductive and feeding cycles and the oceanographic features that concentrate prey, such as frontal systems, eddy features, current boundaries, and coastal retention areas (Benson et al. 2011c).

8.9.3 Vocalization and Hearing

Sea turtles hear best within low frequency ranges, typically hearing frequencies from 30 hertz to two kilohertz, with a range of maximum sensitivity between 100 and 800 hertz (Ridgway et al. 1969; Lenhardt 1994; Bartol et al. 1999; Lenhardt 2002; Moein Bartol and Ketten 2006). Piniak (2012) measured hearing of leatherback turtle hatchlings in water an in air, and observed reactions to low frequency sounds, with responses to stimuli occurring between 50 hertz and 1.6 kilohertz in air between 50 hertz and 1.2 kilohertz in water (lowest sensitivity recorded was 93 dB re: 1 μPa at 300 hertz).

These hearing sensitivities are similar to those reported for two terrestrial species: pond and wood turtles. Pond turtles respond best to sounds between 200 and 700 hertz, with slow declines below 100 hertz and rapid declines above 700 hertz, and almost no sensitivity above three kilohertz (Wever and Vernon 1956). Wood turtles are sensitive up to about 500 hertz, followed by a rapid decline above 1 kilohertz and almost no responses beyond three to four kilohertz (Patterson 1966).

8.9.4 Status

The leatherback turtle is an endangered species whose once large nesting populations have experienced steep declines in recent decades. The primary threats to leatherback turtles include fisheries bycatch, harvest of nesting females, and egg harvesting. Harvest of leatherback sea turtles and their eggs has been a significant factor causing the decline of the species. Despite conservation efforts, this harvest continues on nesting beaches, legally and illegally, in nations throughout parts of their range (Benson et al. 2007; Benson et al. 2011b).

Because of these threats, once large rookeries are now functionally extinct, and there have been range-wide reductions in population abundance. Other threats include loss of nesting habitat due to development, tourism, and sand extraction. Lights on or adjacent to nesting beaches alter nesting adult behavior and are often fatal to emerging hatchlings as they are drawn to light sources and away from the sea. Plastic ingestion is common in leatherback turtles and can block gastrointestinal tracts leading to death. Climate change may alter sex ratios (as temperature determines hatchling sex), range (through expansion of foraging habitat), and habitat (through the loss of nesting beaches, because of sea-level rise). The species' resilience to additional perturbation is low.

8.9.5 Critical Habitat

On March 23, 1979, leatherback turtle critical habitat was designated adjacent to Sandy Point, St. Croix, Virgin Islands from the 183 meters (600 feet) isobath to mean high tide level between 17 degrees North and 65 degrees West (Figure 13). The designated critical habitat in the Atlantic Ocean is outside the action area and therefore is not considered in this opinion.

On January 20, 2012, NMFS issued a final rule to designate additional critical habitat for the leatherback turtle (50 C.F.R. §226). This designation includes approximately 43,798 square kilometers (12,769 square nautical miles) stretching along the California coast from Point Arena to Point Arguello east of the 3,000 meters (9,842 feet) depth contour; and 64,760 square kilometers (18,881 square nautical miles) stretching from Cape Flattery, Washington to Cape Blanco, Oregon east of the 2,000 meter (6,562 feet) depth contour (Table 35). The designated areas comprise approximately 108,558 square kilometers (31,650 square nautical miles) of marine habitat and include waters from the ocean surface down to a maximum depth of 80 meters (262 feet). They were designated specifically because of the occurrence of prey species, primarily *scyphomedusae* of the order *Semaeostomeae* (i.e., jellyfish), of sufficient condition, distribution, diversity, abundance and density necessary to support individual as well as population growth, reproduction, and development of leatherback turtles. The designated critical habitat in the Pacific Ocean is outside the action area and therefore is not considered in this opinion.

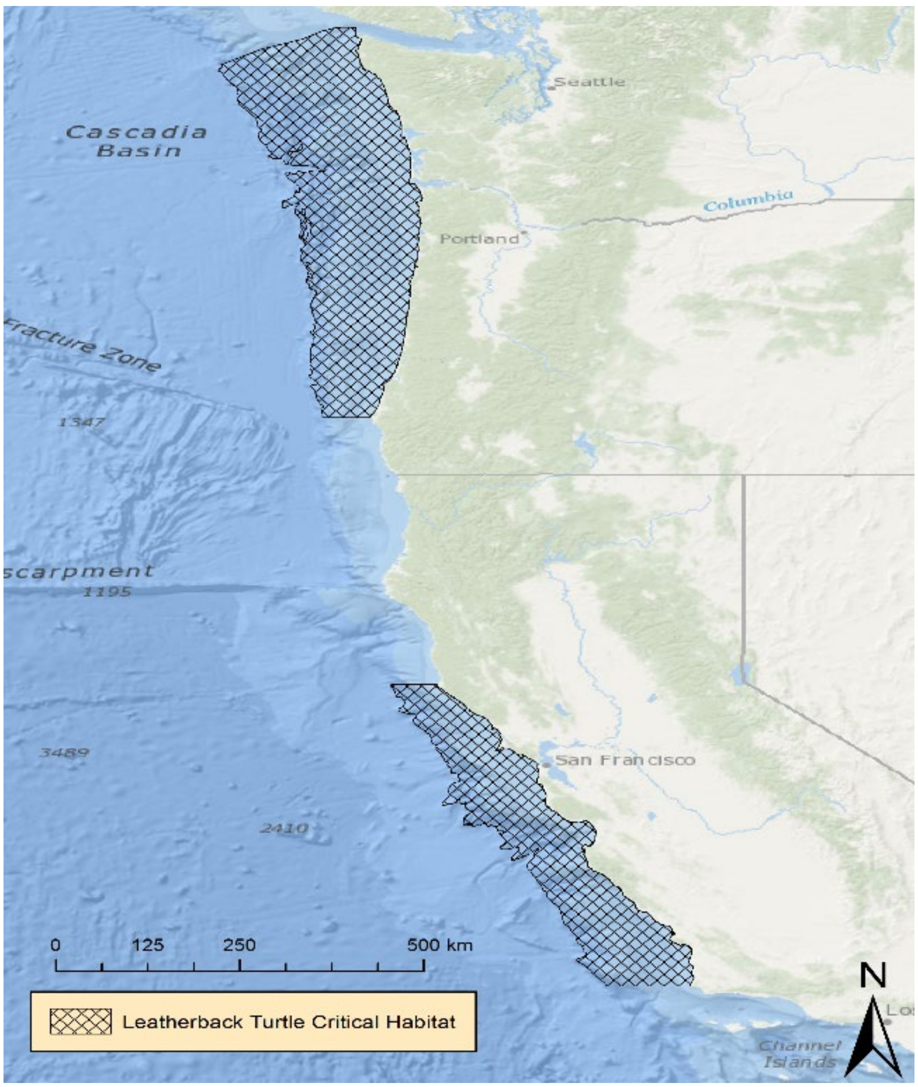

Figure 13. Map depicting leatherback turtle designated critical habitat along the United States Pacific Coast.

8.9.6 Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover leatherback turtle populations. Rangewide threats to leatherback sea turtles include bycatch in fishing gear, harvesting of turtles and eggs, loss and degradation of habitat, vessel strike, and pollution. These threats will be discussed in the context of their impact within the action area within the *Environmental Baseline* section (Section 9) of this opinion. See the 1998 and 1991 Recovery Plans for the U.S. Pacific and U.S Caribbean, Gulf of Mexico and Atlantic leatherback turtles (NMFS 1992; NMFS 1998) for complete down listing/delisting criteria for each of their respective recovery goals. The following items were the top five recovery actions identified to support in the Leatherback Five Year Action Plan:

3. Reduce fisheries interactions
4. Improve nesting beach protection and increase reproductive output
5. International cooperation
6. Monitoring and research
7. Public engagement

8.10 Chinook Salmon – Lower Columbia River ESU

Chinook salmon, also referred to as king salmon in California, are the largest of the Pacific salmon. Spawning adults are olive to dark maroon in color, without conspicuous streaking or blotches on the sides. Spawning males are darker than females, and have a hooked jaw and slightly humped back. They can be distinguished from other spawning salmon by the color pattern, particularly the spotting on the back and tail, and by the dark, solid black gums of the lower jaw (Moyle 2002). The Lower Columbia River ESU of Chinook salmon includes naturally spawned Chinook salmon originating from the Columbia River and its tributaries downstream of a transitional point east of the Hood and White Salmon Rivers, and any such fish originating from the Willamette River and its tributaries below Willamette Falls (Figure 14). On March 24, 1999, NMFS listed the Lower Columbia River ESU of Chinook salmon as a “threatened” species (64 FR 14308). The listing was revisited and confirmed as “threatened” in 2005 (70 FR 37160).

Life History

Lower Columbia River Chinook salmon display three run types including early fall-runs, late fall-runs, and spring-runs. Presently, the fall-run is the predominant life history type. Spring-run Chinook salmon were numerous historically. Fall-run Chinook salmon enter fresh water typically in August through October. Early fall-run spawn within a few weeks in large river mainstems. The late fall-run enters in immature conditions, has a delayed entry to spawning grounds, and resides in the river for a longer time between river entry and spawning. Spring-run Chinook salmon enter fresh water in March through June to spawn in upstream tributaries in August and September.

Offspring of fall-run spawning may migrate as fry to the ocean soon after yolk absorption (*i.e.*, ocean-type), at 30–45 mm in length (Healey 1991). In the Lower Columbia River system, however, the majority of fall-run Chinook salmon fry migrate either at 60-150 days post-hatching in the late summer or autumn of their first year. Offspring of fall-run spawning may also include a third group of yearling juveniles that remain in fresh water for their entire first year before emigrating. The spring-run Chinook salmon migrates to the sea as yearlings (stream-

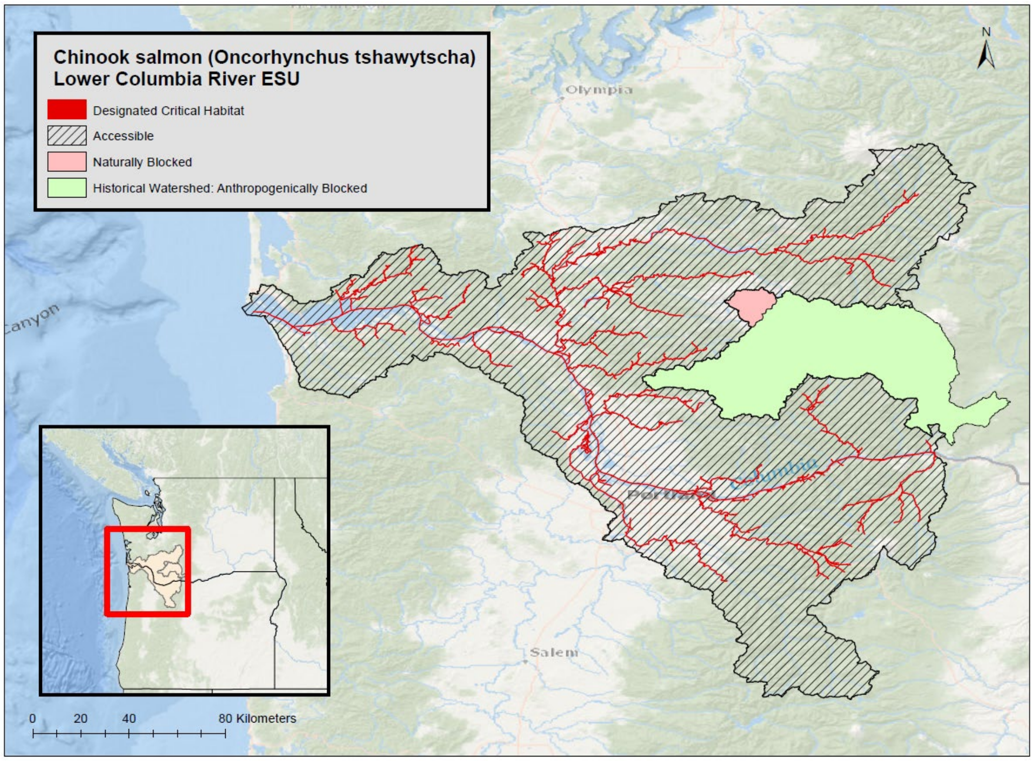

Figure 14. Geographic range and designated critical habitat of Lower Columbia River ESU Chinook salmon.

type) typically in spring. However, the natural timing of Lower Columbia River spring-run Chinook salmon emigration is obscured by hatchery releases (Myers et al. 2006). Once at sea, the ocean-type Columbia River Chinook salmon tend to migrate along the coast, while stream-type Lower Columbia River Chinook salmon appear to move far off the coast into the central North Pacific Ocean (Healey 1991; Myers et al. 2006). Adults return to tributaries in the Lower Columbia River predominately as three- and four-year-olds for fall-run fish and four- and five-year-olds for spring-run fish.

Juvenile Chinook salmon forage in shallow areas with protective cover, such as tidally influenced sandy beaches and vegetated zones (Healey et al. 1991). Cladocerans, copepods, amphipods, and larvae of diptera, as well as small arachnids and ants are common prey items (Kjelson et al. 1981; MacFarlane and Norton 2002; Sommer et al. 2001a). Upon reaching the ocean, juvenile Chinook salmon feed voraciously on larval and juvenile fishes, plankton, and terrestrial insects (Healey et al. 1991; MacFarlane and Norton 2002). Chinook salmon grow rapidly in the ocean environment, with growth rates dependent on water temperatures and food availability.

Population Dynamics

Populations of Lower Columbia River Chinook salmon have declined substantially from historical levels. Many of the ESU's populations are believed to have very low abundance of natural-origin spawners (100 fish or fewer), which increases genetic and demographic risks. Other populations have higher total abundance, but several of these also have high proportions of hatchery-origin spawners (NMFS 2016b). Current abundance estimates for the Lower Columbia River ESU of Chinook salmon are presented in Table 7 below.

Table 7. Abundance Estimates for the Lower Columbia River ESU of Chinook salmon (NMFS 2020a).

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

The genetic diversity of all populations (except the late fall-run Chinook salmon) has been eroded by large hatchery influences and periodically by low effective population sizes. The near loss of the spring-run life history type remains an important concern for maintaining diversity within the ESU (NMFS 2016b).

The ESU spans three distinct ecological regions: Coastal, Cascade, and Gorge. Distinct life-histories (run and spawn timing) within ecological regions in this ESU were identified as major population groups (MPGs). In total, 32 historical demographically independent populations (DIPs) were identified in this ESU, nine spring-run, 21 fall-run, and two late-fall run, organized in six MPGs (based on run timing and ecological region). The basin wide spatial structure has remained generally intact. However, the loss of about 35% of historic habitat has affected distribution within several Columbia River subbasins (NMFS 2016b).

Status

Populations of Lower Columbia River Chinook salmon have declined substantially from historical levels. Out of the 32 populations that make up this ESU, only the two late-fall runs (the North Fork Lewis and Sandy) are considered viable. Most populations (26 out of 32) have a very low probability of persistence over the next 100 years and some are extirpated or nearly so. Five of the six strata fall significantly short of the recovery plan criteria for viability. Low abundance, poor productivity, losses of spatial structure, and reduced diversity all contribute to the very low persistence probability for most Lower Columbia River Chinook salmon populations. Hatchery contribution to naturally-spawning fish remains high for a number of populations, and it is likely that many returning unmarked adults are the progeny of hatchery origin parents, especially where large hatchery programs operate. Continued land development and habitat degradation in combination with the potential effects of climate change will present a continuing strong negative influence into the foreseeable future (NMFS 2016b).

Critical Habitat

NMFS designated critical habitat for Lower Columbia River Chinook salmon on September 2, 2005 (70 FR 52630). It includes all Columbia River estuarine areas and river reaches proceeding upstream to the confluence with the Hood Rivers as well as specific stream reaches in a number of tributary subbasins. Designated critical habitat for the Lower Columbia River Chinook salmon does not overlap spatially with the action area and, therefore, will not be analyzed further in this opinion.

Recovery Goals

Recovery plan targets for this species are tailored for each life history type, and within each type, specific population targets are identified (NMFS 2013b). For spring Chinook salmon, all populations are affected by aspects of habitat loss and degradation. Four of the nine populations require significant reductions in every threat category. Protection and improvement of tributary and estuarine habitat are specifically noted.

For fall Chinook salmon, recovery requires restoration of the Coast and Cascade strata to high probability of persistence, to be achieved primarily by ensuring habitat protection and restoration. Very large improvements are needed for most fall Chinook salmon populations to improve their probability of persistence.

For late fall Chinook salmon, recovery requires maintenance of the North Fork Lewis and Sandy populations which are comparatively healthy, together with improving the probability of persistence of the Sandy population from its current status of "high" to "very high." Improving the status of the Sandy population depends largely on harvest and hatchery changes. Habitat improvements to the Columbia River estuary and tributary spawning areas are also necessary. Of the 32 DIPs in this ESU, only the two late-fall run populations (Lewis River and Sandy River) could be considered viable or nearly so (NMFS 2016b).

8.11 Chinook Salmon – Puget Sound ESU

The Puget Sound ESU includes naturally spawned Chinook salmon originating from rivers flowing into Puget Sound from the Elwha River (inclusive) eastward, including rivers in Hood Canal, South Sound, North Sound and the Georgia Strait (Figure 15). Twenty-six artificial propagation programs are included as part of the Puget Sound ESU. The physical attributes of Chinook salmon are discussed in Section 8.10. On March 24, 1999, NMFS listed the Puget

Sound ESU of Chinook salmon as a "threatened" species (64 FR 14308). The listing was revisited and confirmed as "threatened" in 2005 (70 FR 37160).

Life History

Puget Sound Chinook salmon populations are both early-returning (August) and late-returning (mid-September and October) spawners (Healey 1991). Juvenile Chinook salmon within the Puget Sound generally exhibit an "ocean-type" life history. However, substantial variation occurs with regard to juvenile residence time in freshwater versus estuarine environments. Hayman (Hayman et al. 1996) described three juvenile life histories for Chinook salmon with varying freshwater and estuarine residency times in the Skagit River system in northern Puget Sound. In this system, 20 percent to 60 percent of sub-yearling migrants rear for several months in freshwater habitats while the remaining fry migrate to rear in the Skagit River estuary and delta (Beamer et al. 2005). Juveniles in tributaries to Lake Washington exhibit both a stream rearing and a lake rearing strategy. Lake rearing fry are found in highest densities in nearshore shallow (<1 meters) habitat adjacent to the opening of tributaries or at the mouth of tributaries where they empty into the lake (Tabor et al. 2006). Puget Sound Chinook salmon also have several estuarine rearing juvenile life history types that are highly dependent on estuarine areas for rearing (Beamer et al. 2005). In the estuaries, fry use tidal marshes and connected tidal channels including dikes and ditches developed to protect and drain agricultural land. During their first ocean year, immature Chinook salmon use nearshore areas of Puget Sound during all seasons and can be found long distances from their natal river systems (Brennan et al. 2004).

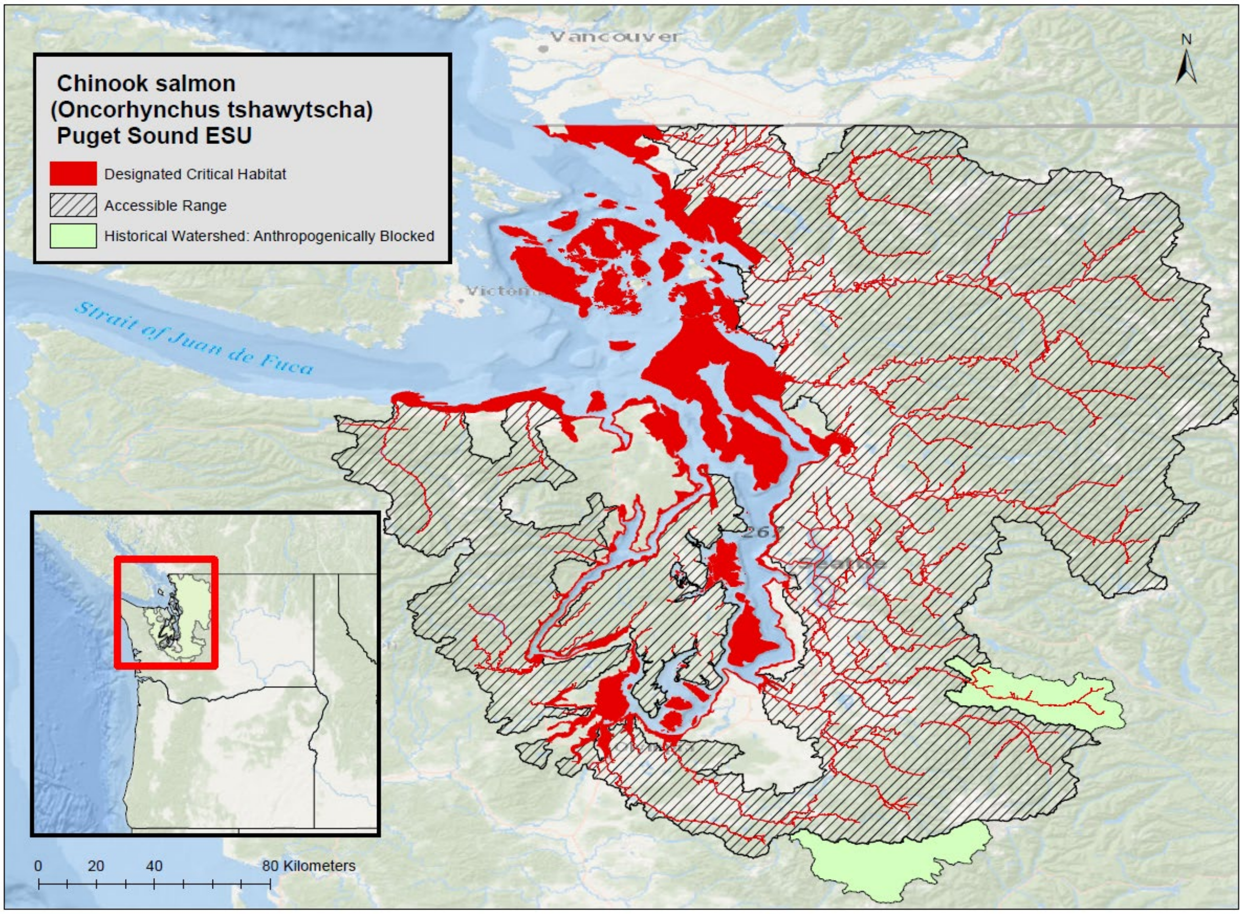

Figure 15. Geographic range and designated critical habitat of Puget Sound ESU Chinook salmon.

Juvenile Chinook salmon forage in shallow areas with protective cover, such as tidally influenced sandy beaches and vegetated zones (Healey et al. 1991). Cladocerans, copepods, amphipods, and larvae of diptera, as well as small arachnids and ants are common prey items (Sommer et al. 2001; MacFarlane and Norton 2002). Upon reaching the ocean, juvenile Chinook salmon feed voraciously on larval and juvenile fishes, plankton, and terrestrial insects (Healey et al. 1991; MacFarlane and Norton 2002). Chinook salmon grow rapidly in the ocean environment, with growth rates dependent on water temperatures and food availability.

Population Dynamics

Estimates of the historic abundance range from 1,700 to 51,000 potential Puget Sound Chinook salmon spawners per population. During the period from 1996 to 2001, the geometric mean of natural spawners in populations of Puget Sound Chinook salmon ranged from 222 to just over 9,489 fish. Thus, the historical estimates of spawner capacity are several orders of magnitude higher than spawner abundances currently observed throughout the ESU (Good et al. 2005). Current abundance estimates for the Puget Sound ESU of Chinook salmon are found in Table 8 and Table 9 below.

Table 8. Average abundance estimates for Puget Sound Chinook salmon natural- and hatchery-origin spawners 2012-2016 (NMFS 2020a).

Population Name	Natural-origin Spawners[a]	Hatchery-origin Spawners[a]	% Hatchery Origin	Minimum Viability Abundance	Expected Number of Outmigrants[c]
Georgia Strait MPG					
NF Nooksack River[d]	181	945	83.95%	16,000	90,009
SF Nooksack River[d]	18	15	45.04%	9,100	2,597
Strait of Juan de Fuca MPG					
Elwha River	130	2,156	94.30%	15,100	182,895
Dungeness River	189	213	52.91%	4,700	32,163
Hood Canal MPG					
Skokomish River	224	1,158	83.82%	12,800	110,505
Mid-Hood Canal	165	117	41.55%	11,000	22,589
Whidbey Basin MPG					
Skykomish River	2,001	1,466	42.29%	17,000	277,348
Snoqualmie River	881	219	19.93%	17,000	87,978
NF Stillaguamish River	385	291	43.04%	17,000	54,137
SF Stillaguamish River	42	29	40.57%	15,000	5,676
Upper Skagit River	9,505	120	1.25%	17,000	770,047
Lower Skagit River	2,207	13	0.60%	16,000	177,643
Upper Sauk River	1,106	5	0.46%	3,000	88,899
Lower Sauk River	559	3	0.59%	5,600	44,984
Suiattle River	590	5	0.77%	600	47,582
Cascade River	205	7	3.12%	1,200	16,937
Central / South Sound MPG					
Sammamish River	125	885	87.64%	10,500	80,823
Cedar River	883	440	33.26%	11,500	105,864
Duwamish/Green River	1,120	4,171	78.83%	17,000	423,326
Puyallup River	565	1,240	68.72%	17,000	144,384
White River	569	1,438	71.64%	14,200	160,622
Nisqually River	747	606	44.81%	13,000	108,281
ESU Average	**22,398**	**15,543**	**40.97%**		**3,035,288**

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

[b] Ford (2011a)

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

[d] 2012-2016 five year geometric mean (2017 data not available).

Table 9. Expected 2019 Puget Sound Chinook salmon hatchery releases (NMFS 2020a).

Subbasin	Artificial propagation program	Brood year	Run Timing	Clipped Adipose Fin	Intact Adipose Fin
Deschutes	Tumwater Falls	2018	Fall	3,800,000	-
Dungeness-Elwha	Dungeness	2018	Spring	-	50,000

Subbasin	Artificial propagation program	Brood year	Run Timing	Clipped Adipose Fin	Intact Adipose Fin
	Elwha	2017	Fall	-	200,000
		2018	Fall	250,000	2,250,000
	Gray Wolf River	2018	Spring	-	50,000
	Hurd Creek	2018	Spring	-	50,000
	Upper Dungeness Pond	2018	Spring	-	50,000
Duwamish	Icy Creek	2017	Fall	300,000	-
	Palmer	2018	Fall	-	1,000,000
	Soos Creek	2018	Fall	3,000,000	200,000
Hood Canal	Hood Canal Schools	2018	Fall	-	500
	Hoodsport	2017	Fall	120,000	-
		2018	Fall	3,000,000	-
Kitsap	Bernie Gobin	2017	Spring	40,000	-
		2018	Fall	-	200,000
			Summer	2,300,000	100,000
	Garrison	2018	Fall	850,000	-
	George Adams	2018	Fall	3,375,000	425,000
	Gorst Creek	2018	Fall	730,000	-
	Grovers Creek	2018	Fall	1,250,000	-
	Hupp Springs	2018	Spring	-	400,000
	Lummi Sea Ponds	2018	Fall	500,000	-
	Minter Creek	2018	Fall	1,250,000	-
Lake Washington	Salmon in the Schools	2018	Fall	-	540
	Issaquah	2018	Fall	2,000,000	-
Nisqually	Clear Creek	2018	Fall	3,300,000	200,000
	Kalama Creek	2018	Fall	600,000	-
	Nisqually MS	2018	Fall	-	90
Nooksack	Kendall Creek	2018	Spring	800,000	-
	Skookum Creek	2018	Spring	-	1,000,000
Puyallup	Clarks Creek	2018	Fall	400,000	-
	Voights Creek	2018	Fall	1,600,000	-
	White River	2017	Spring	-	55,000
		2018	Spring	-	340,000
San Juan Islands	Glenwood Springs	2018	Fall	725,000	-
Skokomish	McKernan	2018	Fall	-	100,000
Skykomish	Wallace River	2017	Summer	500,000	-
		2018	Summer	800,000	200,000
Stillaguamish	Brenner	2018	Fall	-	200,000
	Whitehorse Pond	2018	Summer	220,000	-
Georgia Strait	Samish	2018	Fall	3,800,000	200,000
Upper Skagit	Marblemount	2018	Spring	387,500	200,000
			Summer	200,000	-
Total Annual Release Number				**36,297,500**	**7,271,130**

Available data on total abundance since 1980 indicate that although abundance trends have fluctuated between positive and negative for individual populations, there are widespread negative trends in natural-origin Chinook salmon spawner abundance across the ESU (Ford

2011a). Productivity remains low in most populations, and hatchery-origin spawners are present in high fractions in most populations outside of the Skagit watershed. Available data now shows that most populations have declined in abundance over the past seven to 10 years. Further, escapement levels for all populations remain well below the Technical Recovery Team planning ranges for recovery, and most populations are consistently below the spawner-recruit levels identified by the Technical Recovery Team as consistent with recovery (Ford 2011a).

Current estimates of diversity show a decline over the past 25 years, indicating a decline of salmon in some areas and increases in others. Salmon returns to the Whidbey Region increased in abundance while returns to other regions declined. In aggregate, the diversity of the ESU as a whole has been declining over the last 25 years.

The Puget Sound technical recovery team identified 22 extant populations, grouped into five major geographic regions, based on consideration of historical distribution, geographic isolation, dispersal rates, genetic data, life history information, population dynamics, and environmental and ecological diversity.

Status

All Puget Sound Chinook salmon populations are well below escapement abundance levels identified as required for recovery to low extinction risk in the recovery plan. In addition, most populations are consistently below the productivity goals identified in the recovery plan as necessary for recovery. Although trends vary for individual populations across the ESU, most populations have declined in total natural origin recruit abundance since the last status review; and natural origin recruit escapement trends since 1995 are mostly stable. Several of the risk factors identified in the previous status review (Good et al. 2005) are still present, including high fractions of hatchery fish in many populations and widespread loss and degradation of habitat. Although this ESU's total abundance is greatly reduced from historic levels, recent abundance levels do not indicate that the ESU is at immediate risk of extinction. This ESU remains relatively well distributed over 22 populations in five geographic areas across the Puget Sound. Although current trends are concerning, the available information indicates that this ESU remains at moderate risk of extinction (NMFS 2011a).

Critical Habitat

Critical habitat was designated for the Puget Sound ESU of Chinook salmon on September 2, 2005 (70 FR 52630) and includes 1,683 miles of stream channels, 41 mi^2 of lakes, and 2,182 mi of nearshore marine habitat (Figure 15). Designated critical habitat for the Puget Sound ESU of Chinook salmon does not overlap spatially with the action area and, therefore, will not be analyzed further in this opinion.

Recovery Goals

The recovery plan consists of two documents: the Puget Sound salmon recovery plan (Shared Strategy for Puget Sound 2007) and a supplement by NMFS (2006c). The recovery plan adopts

ESU and population level viability criteria recommended by the Puget Sound Technical Recovery Team (PSTRT; Ruckelshaus et al. 2002). The PSTRT's biological recovery criteria will be met when all of the following conditions are achieved:

- The viability status of all populations in the ESU is improved from current conditions, and when considered in the aggregate, persistence of the ESU is assured;
- Two to four Chinook salmon populations in each of the five biogeographical regions of the ESU achieve viability, depending on the historical biological characteristics and acceptable risk levels for populations within each region;
- At least one population from each major genetic and life history group historically present within each of the five biogeographical regions is viable;
- Tributaries to Puget Sound not identified as primary freshwater habitat for any of the 22 identified populations are functioning in a manner that is sufficient to support an ESU-wide recovery scenario; Production of Chinook salmon from tributaries to Puget Sound not identified as primary freshwater habitat for any of the 22 identified populations occurs in a manner consistent with ESU recovery; and
- Populations that do not meet the viability criteria for all VSP parameters are sustained to provide ecological functions and preserve options for ESU recovery.

8.12 Chinook Salmon – Snake River Fall-Run ESU

The listed ESU currently includes all natural-origin fall-run Chinook salmon originating from the mainstem Snake River below Hells Canyon Dam (the lowest of three impassable dams that form the Hells Canyon Complex) and from the Tucannon River, Grande Ronde River, Imnaha River, Salmon River, and Clearwater River subbasins. The listed ESU also includes fall-run Chinook salmon from four artificial propagation programs (NMFS 2011b; NMFS 2015d; Figure 16). The physical attributes of Chinook salmon are discussed in Section 8.10. NMFS first listed Snake River fall Chinook salmon as a threatened species under the ESA on April 22, 1992 (57 FR 14658). NMFS reaffirmed the listing status in June 28, 2005 (70 FR 37160), and reaffirmed the status again in its 2014 (79 FR 20802).

Life History

Snake River fall-run Chinook salmon return to the Columbia River in August and September, pass the Bonneville Dam from mid-August to the end of September, and enter the Snake River between early September and mid-October (DART 2013). Once they reach the Snake River, fall Chinook salmon generally travel to one of five major spawning areas and spawn from late October through early December (Connor et al. 2014).

Upon emergence from the gravel, most young fall Chinook salmon move to shoreline riverine habitat (NMFS 2015d). Some fall Chinook salmon smolts sustain active migration after passing Lower Granite Dam and enter the ocean as subyearlings, whereas some delay seaward migration and enter the ocean as yearlings (Connor et al. 2005; McMichael et al. 2008; NMFS 2015d).

Snake River fall Chinook salmon can be present in the estuary as juveniles in winter, as fry from March to May, and as fingerlings throughout the summer and fall (Fresh et al. 2005; Roegner et al. 2012; Teel et al. 2014).

Once in the Northern California Current, dispersal patterns differ for yearlings and subyearlings. Subyearlings migrate more slowly, are found closer to shore in shallower water, and do not disperse as far north as yearlings (Trudel et al. 2009; Tucker et al. 2011; Sharma and Quinn 2012; Fisher et al. 2014b). Snake River basin fall Chinook salmon spend one to four years in the Pacific Ocean, depending on gender and age at the time of ocean entry (Connor et al. 2005).

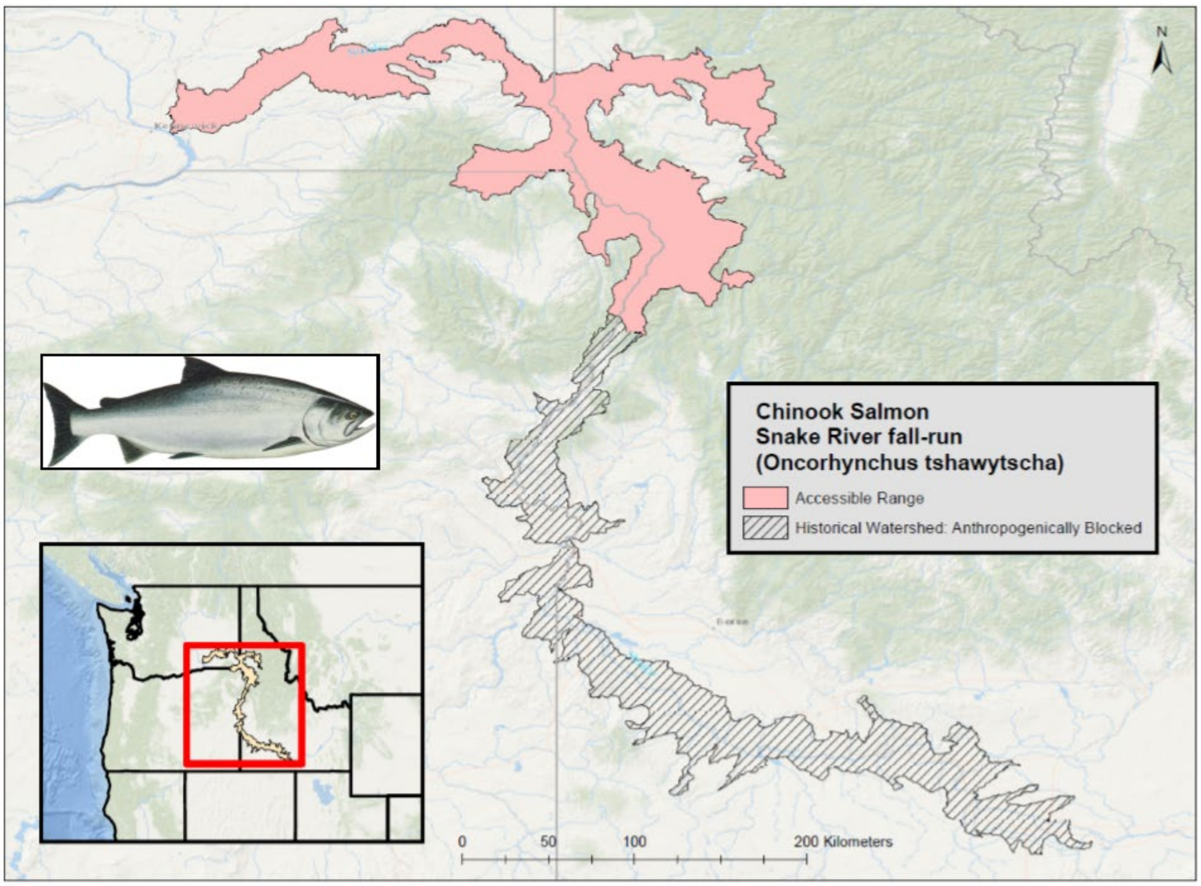

Figure 16. Geographic range of Snake River fall-run ESU Chinook salmon.

Juvenile Chinook salmon forage in shallow areas with protective cover, such as tidally influenced sandy beaches and vegetated zones (Healey et al. 1991). Cladocerans, copepods, amphipods, and larvae of diptera, as well as small arachnids and ants are common prey items (Kjelson et al. 1982; MacFarlane and Norton 2002). Upon reaching the ocean, juvenile Chinook salmon feed voraciously on larval and juvenile fishes, plankton, and terrestrial insects (Healey et al. 1991). Chinook salmon grow rapidly in the ocean environment, with growth rates dependent on water temperatures and food availability.

Population Dynamics

The naturally spawning fall Chinook salmon in the lower Snake River have included both returns originating from naturally spawning parents and from returning hatchery releases. The geometric mean natural-origin adult abundance from 2005 to 2014 of annual spawner escapement estimates was 6,418, with a standard error of 0.19 (NMFS 2015d). Current abundance estimates for the Snake River fall-run ESU of Chinook salmon are presented in Table 10 below.

Table 10. Average Abundance Estimates for the Snake River Fall-Run ESU of Chinook salmon from 2015 to 2019 (NMFS 2020a).

Production	Life Stage	Abundance
Natural	Adult	10,337
Natural	Juvenile	692,819
Listed Hatchery Adipose Clip	Adult	12,508
Listed Hatchery Adipose Clip	Juvenile	2,483,713
Listed Hatchery Intact Adipose	Adult	13,551
Listed Hatchery Intact Adipose	Juvenile	2,862,418

Past estimates of productivity for this population (1990-2009 brood years) was 1.53 with a standard error of 0.18. This estimate of productivity, however, may be problematic for two reasons: (1) the increasingly small number of years that actually contribute to the productivity estimate means that there is increasing statistical uncertainty surrounding that estimate, and (2) the years contributing to the estimate are now far in the past and may not accurately reflect the true productivity of the current population NMFS (2015d).

Genetic samples from the aggregate population in recent years indicate that composite genetic diversity is being maintained and that the Snake River Fall Chinook salmon hatchery stock is similar to the natural component of the population, an indication that the actions taken to reduce the potential introgression of out-of-basin hatchery strays has been effective. Overall, the current genetic diversity of the population represents a change from historical conditions and, applying the Interior Columbia Technical Recovery Team (ICTRT) McClure et al. (2005) guidelines, the rating for this metric is moderate risk (NMFS 2015d).

The ICTRT identified three populations of this species, although only the lower mainstem population exists at present, and it spawns in the lower main stem of the Clearwater, Imnaha, Grande Ronde, Salmon, and Tucannon rivers. The extant population of Snake River fall-run Chinook salmon is the only remaining population from an historical ESU that also included large mainstem populations upstream of the current location of the Hells Canyon Dam complex (ICTRT 2003; McClure et al. 2005). The population is at moderate risk for diversity and spatial structure (Ford 2011a).

Status

As late as the late 1800s, approximately 408,500 to 536,180 fall Chinook salmon are believed to have returned annually to the Snake River. The run began to decline in the late 1800s and then continued to decline through the early and mid-1900s as a result of overfishing and other human activities, including the construction of major dams. This ESU has one extant population. The extant population is at moderate risk for both diversity and spatial structure and abundance and productivity (NMFS 2016d). The overall viability rating for this population is 'viable.' Overall, the status of Snake River fall Chinook salmon has clearly improved compared to the time of listing and compared to prior status reviews. The single extant population in the ESU is currently meeting the criteria for a rating of 'viable' developed by the ICTRT, but the ESU as a whole is not meeting the recovery goals described in the recovery plan for the species, which require the single population to be "highly viable with high certainty" and/or will require reintroduction of a viable population above the Hells Canyon Dam complex (NMFS 2016d).

Critical Habitat

NMFS designated critical habitat for Snake River fall-run Chinook salmon on December 28, 1993 (58 FR 68543). Designated critical habitat for the Snake River fall-run Chinook salmon does not overlap spatially with the action area and, therefore, will not be analyzed further in this opinion.

Recovery Goals

Recovery goals, objectives and criteria for the Snake River fall-run Chinook salmon are fully outlined in the 2015 Recovery Plan (NMFS 2015d). ESA recovery goals should support conservation of natural fish and the ecosystems upon which they depend. Thus, the ESA recovery goal for Snake River fall Chinook salmon is that: the ecosystems upon which Snake River fall Chinook salmon depend are conserved such that the ESU is self-sustaining in the wild and no longer needs ESA protection.

8.13 Chinook Salmon – Snake River Spring/Summer-Run ESU

The Snake River spring/summer Chinook salmon ESU includes all naturally spawned populations of spring/summer Chinook salmon in the mainstem Snake River and the Tucannon River, Grand Ronde River, Imnaha River, and Salmon River subbasins (Figure 17). The ESU is broken into five major population groups (MPG). Together, the MPGs contain 28 extant independent naturally spawning populations, three functionally extirpated populations, and one extirpated population. The Upper Salmon River MPG contains eight extant populations and one extirpated population. The Middle Fork Salmon River MPG contains nine extant populations. The South Fork Salmon River MPG contains four extant populations. The Grande Ronde/Imnaha Rivers MPG contains six extant populations, with two functionally extirpated populations. The Lower Snake River MPG contains one extant population and one functionally extirpated population. The South Fork and Middle Fork Salmon Rivers currently support most of the natural spring/summer Chinook salmon production in the Snake River drainage (NMFS 2016d).

The physical attributes of Chinook salmon are discussed in Section 8.10. Snake River spring/summer-run Chinook salmon, an ESU, was listed as a threatened species under the ESA on April 22, 1992 (57 FR 14658). NMFS reaffirmed the listing on June 28, 2005 (70 FR 37160) and made minor technical corrections to the listing on April 14, 2014 (79 FR 20802).

Life History

Adult spring-run Chinook salmon destined for the Snake River return to the Columbia River from the ocean in early spring and pass Bonneville Dam beginning in early March and ending May 31st. Snake River summer-run Chinook salmon return to the Columbia River from June through July. Adults from both runs hold in deep pools in the mainstem Columbia and Snake Rivers and the lower ends of the spawning tributaries until late summer, when they migrate into the higher elevation spawning reaches. Generally, Snake River spring-run Chinook salmon spawn in mid- through late August. Snake River summer-run Chinook salmon spawn approximately one month later than spring-run fish and tend to spawn lower in the tributary drainages, although their spawning areas often overlap with those of spring-run spawners.

The eggs that Snake River spring and summer Chinook salmon deposit in late summer and early fall incubate over the following winter, and hatch in late winter and early spring. Juveniles rear through the summer, overwinter, and typically migrate to sea in the spring of their second year of life, although some juveniles may spend an additional year in fresh water. Depending on the tributary and the specific habitat conditions, juveniles may migrate extensively from natal reaches into alternative summer-rearing or overwintering areas. Most yearling fish are thought to spend relatively little time in the estuary compared to sub-yearling ocean-type fish however there is considerable variation in residence times in different habitats and in the timing of estuarine and ocean entry among individual fish (McElhany et al. 2000; Holsman et al. 2012).

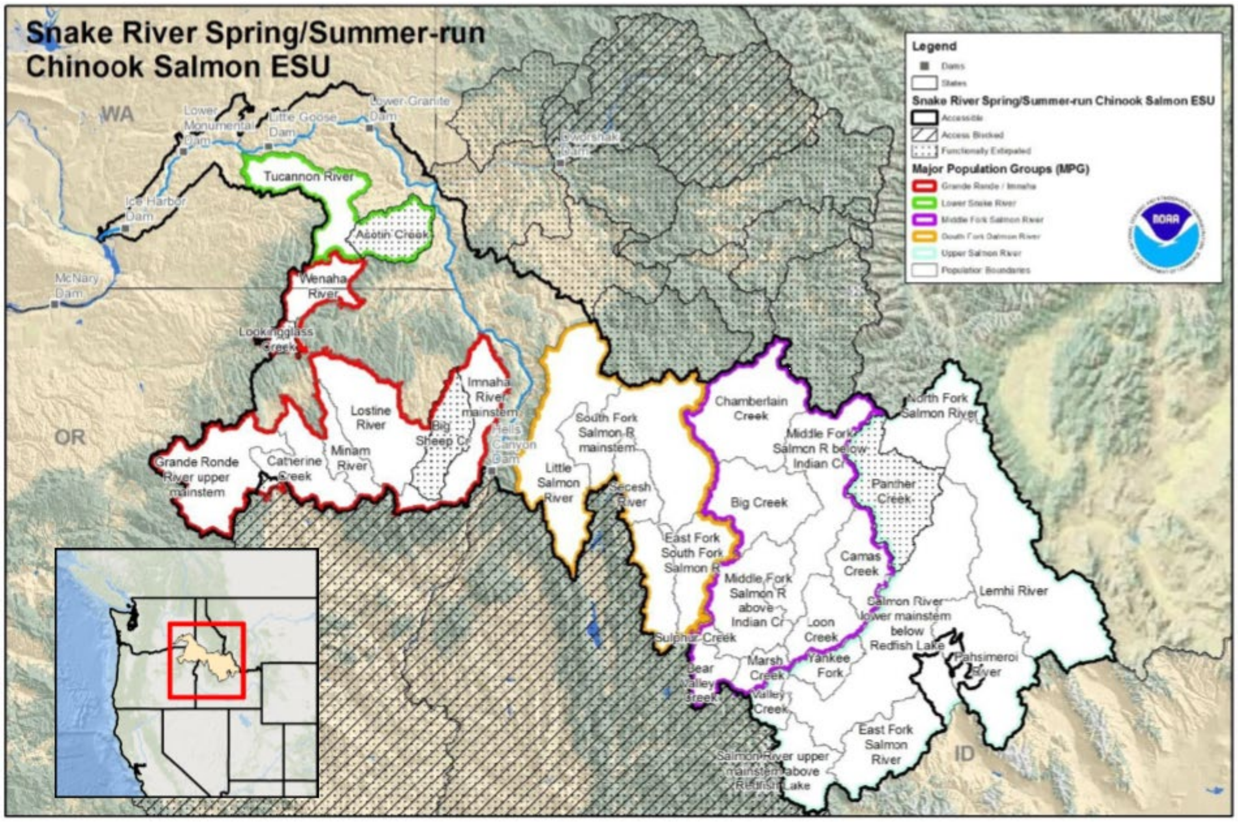

Figure 17. Geographic range and major population groups of Snake River spring/summer-run ESU Chinook salmon.

Juvenile Chinook salmon forage in shallow areas with protective cover, such as tidally influenced sandy beaches and vegetated zones (Healey et al. 1991). Cladocerans, copepods, amphipods, and larvae of diptera, as well as small arachnids and ants are common prey items (Kjelson et al. 1982; MacFarlane and Norton 2002). Upon reaching the ocean, juvenile Chinook salmon feed voraciously on larval and juvenile fishes, plankton, and terrestrial insects (Healey et al. 1991; MacFarlane and Norton 2002). Chinook salmon grow rapidly in the ocean environment, with growth rates dependent on water temperatures and food availability.

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes: abundance, population growth rate, and genetic diversity as it relates major population groups (MPGs) within the Snake River spring/summer-run ESU of Chinook salmon. Current abundance estimates of the Snake River spring/summer-run ESU of Chinook salmon are presented in Table 11 below.

Table 11. Average Abundance Estimates for the Snake River Spring/Summer-Run ESU of Chinook salmon for 2014-2018 (NMFS 2020a).

Production	Life Stage	Abundance
Natural	Adult	12,798
Natural	Juvenile	1,296,641
Listed Hatchery Adipose Clip	Adult	2,387
Listed Hatchery Adipose Clip	Juvenile	4,760,250
Listed Hatchery Intact Adipose	Adult	421
Listed Hatchery Intact Adipose	Juvenile	868,679

Lower Snake River MPG: Abundance and productivity remain the major concern for the Tucannon River population. Natural spawning abundance (10-year geometric mean) has increased but remains well below the minimum abundance threshold for the single extant population in this MPG. Poor natural productivity continues to be a major concern. The integrated spatial structure/diversity risk rating for the Lower Snake River MPG is moderate (NMFS 2016d).

Grande Ronde/Imnaha MPG: The Wenaha River, Lostine/Wallowa River and Minam River populations showed substantial increases in natural abundance relative to the previous ICTRT review, although each remains below their respective minimum abundance thresholds. The Catherine Creek and Upper Grande Ronde populations each remain in a critically depressed state. Geometric mean productivity estimates remain relatively low for all populations in the MPG. The Upper Grande Ronde population is rated at high risk for spatial structure and diversity while the remaining populations are rated at moderate (NMFS 2016d).

South Fork Salmon River MPG: Natural spawning abundance (10-year geometric mean) estimates increased for the three populations with available data series. Productivity estimates for these populations are generally higher than estimates for populations in other MPGs within the ESU. Viability ratings based on the combined estimates of abundance and productivity remain at high risk, although the survival/capacity gaps relative to moderate and low risk viability curves are smaller than for other ESU populations. Spatial structure/diversity risks are currently rated moderate for the South Fork Mainstem population (relatively high proportion of hatchery spawners) and low for the Secesh River and East Fork South Fork populations (NMFS 2016d).

Middle Fork Salmon River MPG: Natural-origin abundance and productivity remains extremely low for populations within this MPG. As in the previous ICTRT assessment, abundance and productivity estimates for Bear Valley Creek and Chamberlain Creek (limited data series) are the closest to meeting viability minimums among populations in the MPG. Spatial structure/diversity risk ratings for Middle Fork Salmon River MPG populations are generally moderate. This primarily is driven by moderate ratings for genetic structure assigned by the ICTRT because of uncertainty arising from the lack of direct genetic samples from within the component populations (NMFS 2016d).

Upper Salmon River MPG: Abundance and productivity estimates for most populations within this MPG remain at very low levels relative to viability objectives. The Upper Salmon Mainstem has the highest relative abundance and productivity combination of populations within the MPG. Spatial structure/diversity risk ratings vary considerably across the Upper Salmon River MPG. Four of the eight populations are rated at low or moderate risk for overall spatial structure and diversity and could achieve viable status with improvements in average abundance/productivity. The high spatial structure/diversity risk rating for the Lemhi population is driven by a substantial loss of access to tributary spawning/rearing habitats and the associated reduction in life-history diversity. High risk ratings for Pahsimeroi River, East Fork Salmon River, and Yankee Fork Salmon River are driven by a combination of habitat loss and diversity concerns related to low natural abundance combined with chronically high proportions of hatchery spawners in natural areas (NMFS 2016d).

Status

The historical run of Chinook salmon in the Snake River likely exceeded one million fish annually in the late 1800s, by the 1950s the run had declined to nearly 100,000 adults per year. The adult counts fluctuated throughout the 1980s but then declined further, reaching a low of 2,200 fish in 1995. Currently, the majority of extant spring/summer Chinook salmon populations in the Snake River spring/summer Chinook salmon ESU remain at high overall risk of extinction, with a low probability of persistence within 100 years. Factors cited in the 1991 status review as contributing to the species' decline since the late 1800s include overfishing, irrigation diversions, logging, mining, grazing, obstacles to migration, hydropower development, and questionable management practices and decisions (Matthews and Waples 1991). In addition, new threats such as those posed by toxic contamination, increased predation by non-native species, and effects due to climate change are emerging (NMFS 2016d). Hinrichsen and Paulsen (2020) estimated carrying capacity and 24-year extinction probabilities for 26 populations in the Snake River spring/summer Chinook salmon ESU using alternative quasi-extinction thresholds. They found that carrying capacities estimates were low in several of the populations and that extinction probability increases sharply with decreasing carrying capacity.

Critical Habitat

Critical habitat for Snake River spring/summer Chinook salmon was designated on December 28, 1993 (58 FR 68543) and revised slightly on October 25, 1999 (64 FR 57399). Designated critical habitat for the Snake River spring/summer Chinook salmon does not overlap spatially with the action area and, therefore, will not be analyzed further in this opinion.

Recovery Goals

Recovery goals, scenarios and criteria for the Snake River spring and summer-run Chinook salmon are fully outlined in the 2016 proposed recovery plan (NMFS 2016d). The status levels targeted for populations within an ESU are referred to collectively as the “recovery scenario” for the ESU. NMFS has incorporated the viability criteria into viable recovery scenarios for each Snake River spring/summer Chinook salmon and steelhead MPG. The criteria should be met for an MPG to be considered Viable, or low (five percent or less) risk of extinction, and thus contribute to the larger objective of ESU viability.

8.14 Chinook Salmon – Upper Columbia River Spring-Run ESU

The physical attributes of Chinook salmon are discussed in Section 8.10. Upper Columbia River spring-run Chinook salmon, an ESU, was listed as an endangered species under the ESA on March 24, 1999 (64 FR 14308). NMFS reaffirmed the listing on June 28, 2005 (70 FR 37160).

Life History

Upper Columbia River Spring-Run ESU Chinook salmon includes naturally spawned spring-run Chinook salmon originating from Columbia River tributaries upstream of the Rock Island Dam and downstream of Chief Joseph Dam (excluding the Okanogan River subbasin) (Figure 18). Adult Spring Chinook salmon in the Upper Columbia Basin begin returning from the ocean in the early spring, with the run into the Columbia River peaking in mid-May. Spring Chinook salmon enter the Upper Columbia tributaries from April through July. After migration, they hold in freshwater tributaries until spawning occurs in the late summer, peaking in mid to late August. Juvenile spring Chinook salmon spend a year in freshwater before migrating to salt water in the spring of their second year of life. Most Upper Columbia spring Chinook salmon return as adults after two or three years in the ocean. Some precocious males, or jacks, return after one winter at sea. A few other males mature sexually in freshwater without migrating to the sea. However, four and five year old fish that have spent two and three years at sea, respectively, dominate the run. Fecundity ranges from 4,200 to 5,900 eggs, depending on the age and size of the female.

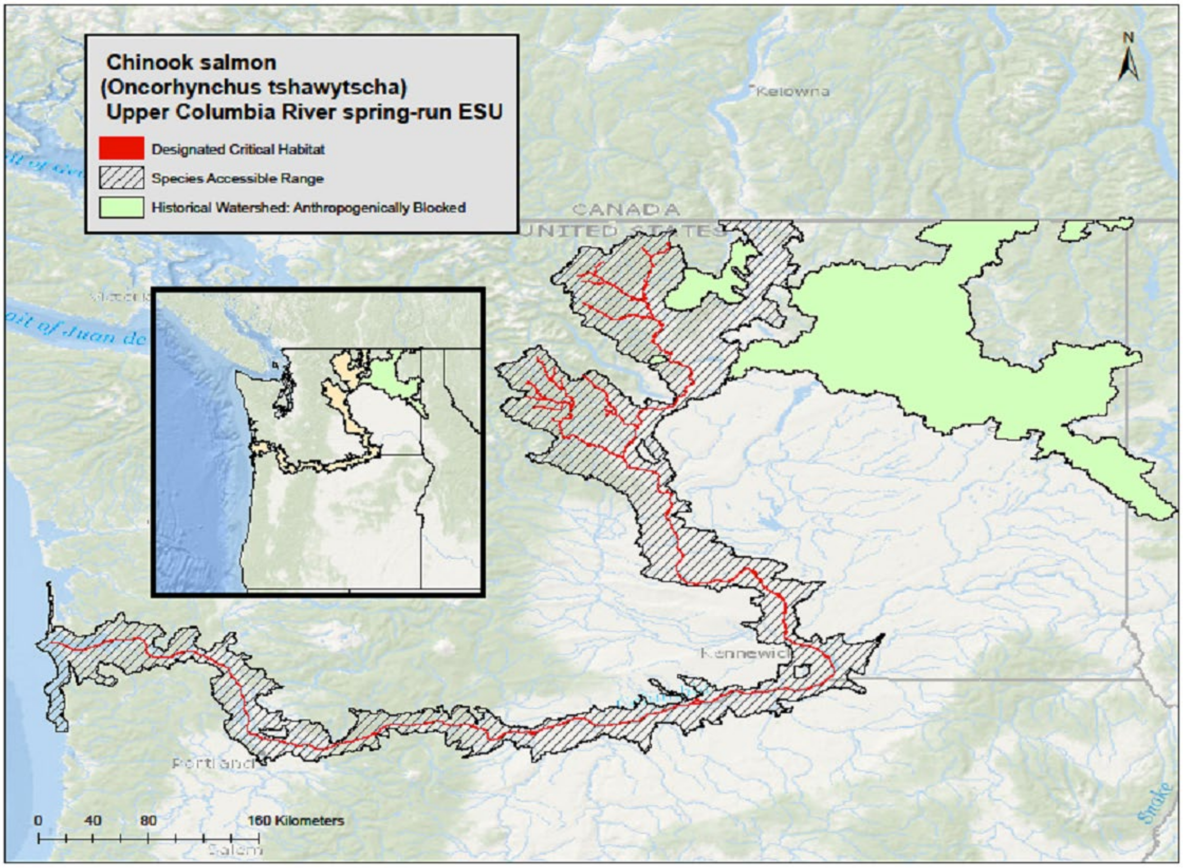

Figure 18. Geographic range and designated critical habitat of Chinook salmon, upper Columbia River ESU.

Juvenile Chinook salmon forage in shallow areas with protective cover, such as tidally influenced sandy beaches and vegetated zones (Healey et al. 1991). Cladocerans, copepods, amphipods, and larvae of diptera, as well as small arachnids and ants are common prey items (Kjelson et al. 1982; MacFarlane and Norton 2002). Upon reaching the ocean, juvenile Chinook salmon feed voraciously on larval and juvenile fishes, plankton, and terrestrial insects (Healey et al. 1991; MacFarlane and Norton 2002). Chinook salmon grow rapidly in the ocean environment, with growth rates dependent on water temperatures and food availability.

Population Dynamics

For all populations, average abundance over the recent 10-year period is below the average abundance thresholds that the ICTRT identifies as a minimum for low risk (2008b; ICTRT 2008a; 2008c). The geometric mean spawning escapements from 1997 to 2001 were 273 for the Wenatchee population, 65 for the Entiat population, and 282 for the Methow population. These numbers represent only eight percent to 15 percent of the minimum abundance thresholds. The 10-year geometric mean abundance of adult natural-origin spawners has increased for each population relative to the levels reported in the 2011 status review, but natural origin escapements remain below the corresponding ICTRT thresholds. Current abundance estimates of the upper Columbia River spring-run ESU of Chinook salmon are presented in Table 12 below.

Table 12. Five Year Average (2015 to 2020) Abundance Estimates for the Upper Columbia River Spring-Run ESU of Chinook salmon (NMFS 2020a).

Production	Life Stage	Abundance
Natural	Adult	2,872
Natural	Juvenile	468,820
Listed Hatchery Adipose Clip	Adult	6,226
Listed Hatchery Adipose Clip	Juvenile	621,759
Listed Hatchery Intact Adipose	Adult	3,364
Listed Hatchery Intact Adipose	Juvenile	368,642

Overall abundance and productivity remains rated at high risk for each of the three extant populations in this MPG/ESU (NWFSC 2015b). The Short term lambda estimate for the Wenatchee River is 0.60; the Entiat River is 0.94; and the Methow River is 0.46.

The ICTRT characterizes the diversity risk to all Upper Columbia River Spring-run Chinook salmon populations as “high”. The high risk is a result of reduced genetic diversity from homogenization of populations that occurred under the Grand Coulee Fish Maintenance Project in 1939-1943.

Spring Chinook salmon currently spawn and rear in the upper main Wenatchee River upstream from the mouth of the Chiwawa River, overlapping with summer Chinook salmon in that area (Peven et al. 1994). The primary spawning areas of spring Chinook salmon in the Wenatchee subbasin include Nason Creek and the Chiwawa, Little Wenatchee, and White rivers. The current spawning distribution for spring Chinook salmon in the Entiat subbasin has been described as the Entiat River (river mile 16.2 to 28.9) and the Mad River (river mile 32 1.5-5.0) (NMFS 2007b). Spring Chinook salmon of the Methow population currently spawn in the mainstem Methow River and the Twisp, Chewuch, and Lost drainages (NMFS 2007b). A few also spawn in Gold, Wolf, and Early Winters creeks.

Status

This ESU comprises four independent populations. Three are at high risk and one is functionally extirpated. Current estimates of natural origin spawner abundance increased relative to the levels observed in the prior review for all three extant populations, and productivities were higher for the Wenatchee and Entiat populations and unchanged for the Methow population. However, abundance and productivity remained well below the viable thresholds called for in the Upper Columbia Recovery Plan for all three populations. Although the status of the ESU is improved relative to measures available at the time of listing, all three populations remain at high risk (NWFSC 2015b).

Critical Habitat

NMFS designated critical habitat for Upper Columbia River Spring-run Chinook salmon on September 2, 2005 (70 FR 52630). Critical habitat includes freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and estuarine areas. Designated critical habitat for the Upper Columbia River Chinook salmon does not overlap spatially with the action area and, therefore, will not be analyzed further in this opinion.

Recovery Goals

Recovery goals, objectives and detailed criteria for the Upper Columbia River spring-run Chinook salmon are fully outlined in the 2007 Recovery Plan (NMFS 2007c). The general recovery objectives are:

- Increase the abundance of naturally produced spring Chinook salmon spawners within each population in the Upper Columbia ESU to levels considered viable.
- Increase the productivity (spawner ratios and smolts/redds[7]) of naturally produced spring Chinook salmon within each population to levels that result in low risk of extinction.
- Restore the distribution of naturally produced spring Chinook salmon to previously occupied areas (where practical) and allow natural patterns of genetic and phenotypic diversity to be expressed.

8.15 Chinook Salmon – Upper Willamette River ESU

This ESU, includes naturally spawned spring-run Chinook salmon originating from the Clackamas River and from the Willamette River and its tributaries above Willamette Falls (Figure 19). Also, the Upper Willamette River spring-run ESU of Chinook salmon originate from six artificial propagation programs.

The physical attributes of Chinook salmon are discussed in Section 8.10. The upper Willamette River spring-run Chinook salmon ESU was listed as an endangered species under the ESA on March 24, 1999 (64 FR 14308). NMFS reaffirmed the listing on June 28, 2005 (70 FR 37160).

Life History

Upper Willamette River Chinook salmon exhibit an earlier time of entry into the Columbia River than other spring-run Chinook salmon ESUs (Myers et al. 1998). Adults appear in the lower Willamette River in February, but the majority of the run ascends Willamette Falls in April and May, with a peak in mid- to late May. However, present-day salmon ascend the Willamette Falls via a fish ladder. Consequently, the migration of spring Chinook salmon over Willamette Falls

[7] gravel nests excavated by spawning females.

extends into July and August (overlapping with the beginning of the introduced fall-run of Chinook salmon).

The adults hold in deep pools over summer and spawn in late fall or early winter when winter storms augments river flows. Fry may emerge from February to March and sometimes as late as June (Myers et al. 2006). Juvenile migration varies with three distinct juvenile emigration "runs": fry migration in late winter and early spring; sub-yearling (0 year +) migration in fall to early winter; and yearlings (1 year +) migrating in late winter to spring. Sub-yearlings and yearlings rear in the mainstem Willamette River where they also use floodplain wetlands in the lower Willamette River during the winter-spring floodplain inundation period. Juvenile Chinook salmon forage in shallow areas with protective cover, such as tidally influenced sandy beaches and vegetated zones (Healey et al. 1991). Cladocerans, copepods, amphipods, and larvae of diptera, as well as small arachnids and ants are common prey items (Kjelson et al. 1982; MacFarlane and Norton 2002). Upon reaching the ocean, juvenile Chinook salmon feed voraciously on larval and juvenile fishes, plankton, and terrestrial insects (Healey et al. 1991; MacFarlane and Norton 2002). Chinook salmon grow rapidly in the ocean environment, with growth rates dependent on water temperatures and food availability.

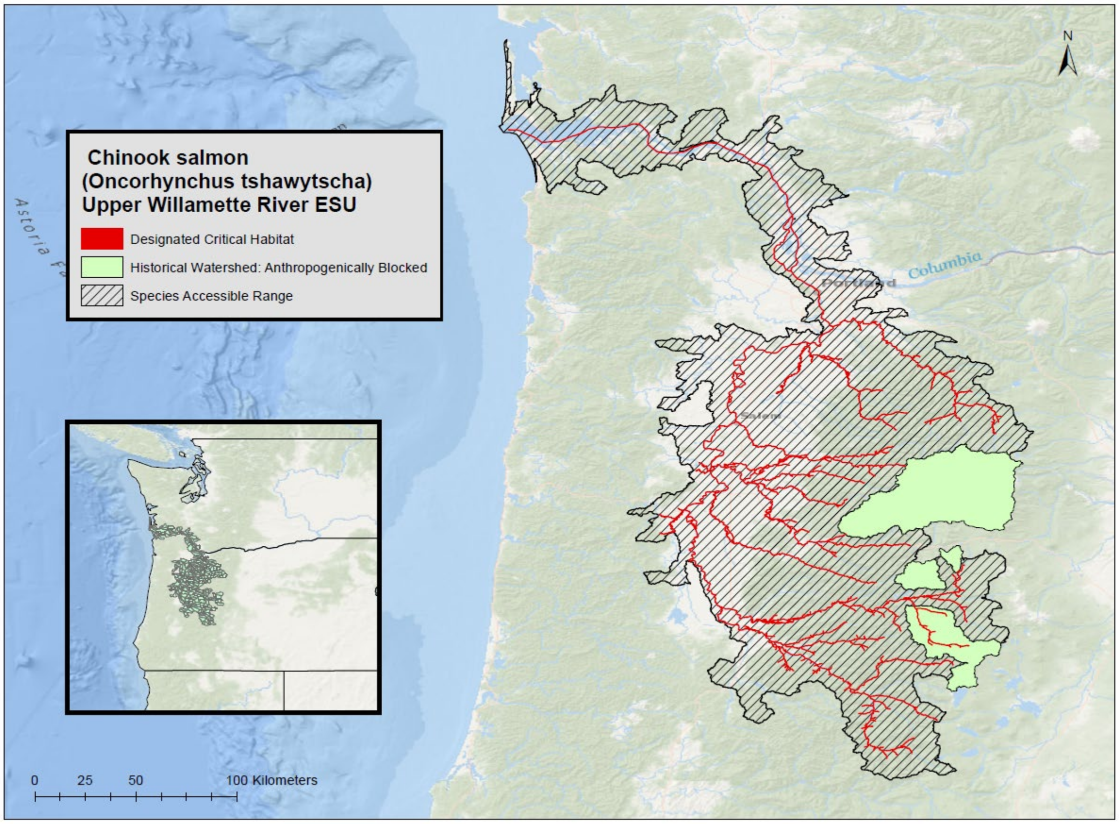

Figure 19.Geographic range and designated critical habitat of Chinook salmon, upper Willamette River ESU.

Population Dynamics

Abundance levels for five of the seven DIPs in this ESU remain well below their recovery goals. Of these, the Calapooia River may be functionally extinct and the Molalla River remains critically low (although perhaps only marginally better than the 0 VSP score estimated in the Recovery Plan; ODFW and NMFS 2011). 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 proportion of natural origin spawners improved in the North and South Santiam basins, but was still well below identified recovery goals. Improvement in the status of the Middle Fork Willamette River relates solely to the return of natural adults to Fall Creek, however the capacity of the Fall Creek basin alone is insufficient to achieve the recovery goals for this DIP. The Clackamas and McKenzie Rivers 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 (NWFSC 2015b). Current abundance estimates of the Upper Willamette River spring-run ESU of Chinook salmon are presented in Table 13 below.

Table 13. Average Abundance Estimates for the Upper Willamette River Spring-Run ESU of Chinook salmon from 2014 to 2018 for Adults and 2015 to 2020 for Juveniles (NMFS 2020a).

Production	Life Stage	Abundance
Natural	Adult	10,203
Natural	Juvenile	1,211,863
Listed Hatchery Clipped and Intact Adipose	Adult	31,476
Listed Hatchery Adipose Clip	Juvenile	4,709,045
Listed Hatchery Intact Adipose	Juvenile	157

Access of fall-run Chinook salmon to the upper Willamette River and the mixing of hatchery stocks within the ESU have threatened the genetic integrity and diversity of the species. Much of the genetic diversity that existed between populations has been homogenized (Myers et al. 2006).

Radio-tagging results from 2014 suggest that few fish strayed into west-side tributaries (no detections) and relatively fewer fish were unaccounted for between Willamette Falls and the tributaries, 12.9 percent of clipped fish and 5.3 percent of unclipped fish (NWFSC 2015b). In contrast to most of the other populations in this ESU, McKenzie River Chinook salmon have access to much of their historical spawning habitat, although access to historically high quality habitat above Cougar Dam (South Fork McKenzie River) is still limited by poor downstream juvenile passage. Similarly, natural-origin returns to the Clackamas River have remained flat, despite adults having access to much of their historical spawning habitat.

Status

The Upper Willamette River Chinook salmon ESU is considered to be extremely depressed, likely numbering less than 10,000 fish compared to a historical abundance estimate of 300,000 (NMFS 2011e). There are seven demographically independent populations of spring-run Chinook salmon in the Upper Willamette River Chinook salmon ESU: Clackamas, Molalla, North Santiam, South Santiam, Calapooia, McKenzie, and the Middle Fork Willamette (NMFS 2011e). The Clackamas and McKenzie Rivers 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. Juvenile spring Chinook salmon produced by hatchery programs are released throughout many of the subbasins and adult Chinook salmon returns to the ESU are typically 80-90 percent hatchery origin fish. Access to historical spawning and rearing areas is restricted by large dams in the four historically most productive tributaries, and in the absence of effective passage programs will continue to be confined to more lowland reaches where land development, water temperatures, and water quality may be limiting. Pre-spawning mortality levels are generally high in the lower tributary reaches where water temperatures and fish densities are generally the highest.

Critical Habitat

NMFS designated critical habitat for this species on September 2, 2005 (70 FR 52630). Critical habitat includes freshwater spawning sites, freshwater rearing sites, freshwater migration corridors and estuarine areas. Designated critical habitat for the Upper Willamette River Chinook salmon does not overlap spatially with the action area and, therefore, will not be analyzed further in this opinion.

Recovery Goals

Recovery goals, objectives and detailed criteria for the Upper Willamette River Chinook salmon are fully outlined in the 2011 Recovery Plan (NMFS 2011e). The 2011 recovery plan outlines five potential scenario options for meeting the viability criteria for recovery. Of the five scenarios, "scenario one" reportedly represented the most balanced approach given limitations in some populations. The approach in this scenario is to recover the McKenzie (core and genetic legacy population) and the Clackamas populations to an extinction risk status of very low risk (beyond minimal viability thresholds), to recover the North Santiam and Middle Fork Willamette populations (core populations) to an extinction risk status of low risk, to recover the South Santiam population to moderate risk, and improve the status of the remaining populations from very high risk to high risk.

8.16 Chum Salmon – Columbia River ESU

The Columbia River ESU of chum salmon includes naturally spawned chum salmon originating from the Columbia River and its tributaries in Washington and Oregon (Figure 20), and also chum salmon from two artificial propagation programs.

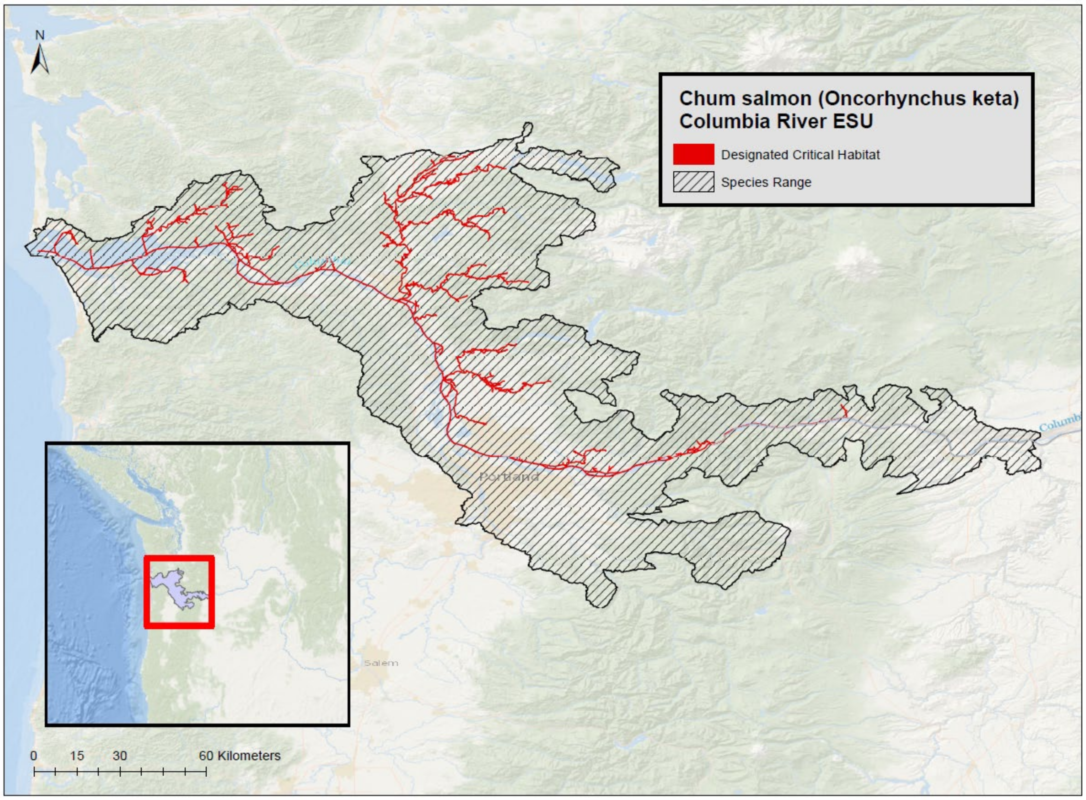

Figure 20. Geographic range and designated critical habitat of chum salmon, Columbia River ESU.

Chum salmon are an anadromous (i.e., adults migrate from marine to freshwater streams and rivers to spawn) and semelparous (i.e., they spawn once and then die) fish species. Adult chum salmon are typically between eight and fifteen pounds, but they can get as large as 45 pounds and 3.6 feet long. Males have enormous canine-like fangs and a striking calico pattern body color (front two-thirds of the flank marked by a bold, jagged, reddish line and the posterior third by a jagged black line) during spawning. Females are less flamboyantly colored and lack the extreme dentition of the males. Ocean stage chum salmon are metallic greenish-blue along the back with black speckles. Chum salmon have the widest natural geographic and spawning distribution of the Pacific salmonids. On March 25, 1999, NMFS listed the Hood Canal summer-run ESU and the Columbia River ESU of chum salmon as threatened (64 FR 14508). NMFS reaffirmed the status of these two ESUs as threatened on June 28, 2005 (70 FR 37160).

Life History

Most chum salmon mature and return to their birth stream to spawn between three and five years of age, with 60 to 90 percent of the fish maturing at four years of age. Age at maturity appears to follow a latitudinal trend (i.e., greater in the northern portion of the species' range). Chum salmon typically spawn in the lower reaches of rivers, with redds usually dug in the mainstem or in side channels of rivers from just above tidal influence to 100 kilometers from the sea. Juveniles out-migrate to seawater almost immediately after emerging from the gravel covered redds (Salo 1991b). The survival and growth in juvenile chum salmon depend less on freshwater conditions (unlike stream-type salmonids which depend heavily on freshwater habitats) than on favorable estuarine conditions. Chum salmon form schools, presumably to reduce predation (Pitcher 1986), especially if their movements are synchronized to swamp predators (Miller and Brannon 1982).

Chum salmon spend two to five years in feeding areas in the northeast Pacific Ocean, which is a greater proportion of their life history compared to other Pacific salmonids. Chum salmon distribute throughout the North Pacific Ocean and Bering Sea, although North American chum salmon (as opposed to chum salmon originating in Asia), rarely occur west of 175 E longitude (Johnson et al. 1997a). North American chum salmon migrate north along the coast in a narrow band that broadens in southeastern Alaska, although some data suggests that chum salmon may travel directly offshore into the north Pacific Ocean (Johnson et al. 1997a).

Population Dynamics

Chum salmon populations in the Columbia River historically reached hundreds of thousands to a million adults each year (NMFS 2017a). In the past 50 years, the average has been a few thousand a year. The majority of populations in the Columbia River chum salmon ESU remain at high to very high risk, with very low abundances (NWFSC 2015b). Ford (2011b) concluded that 14 out of 17 of chum salmon populations in this ESU were either extirpated or nearly extirpated. Current abundance estimates of the Columbia River ESU of chum salmon are presented in Table 14 below. To estimate abundance of 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 NMFS' Northwest Fisheries Science Center (Zabel 2015; Zabel 2017b; Zabel 2017a; Zabel 2018; Zabel 2020). For juvenile natural-origin Columbia River chum salmon is juvenile salmon, an estimated average of 6,626,218 outmigrated over the last five years.

Table 14. Abundance Estimates for the Columbia River ESU of Chum salmon (Zabel 2015; Zabel 2017b; Zabel 2017a; Zabel 2018; NMFS 2019d; Zabel 2020).

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

Only one population (Grays River) is at low risk, with spawner abundances in the thousands, and demonstrating a recent positive trend. Two other populations (Washougal River and Lower Gorge) maintain moderate numbers of spawners and appear to be relatively stable (NWFSC 2015b). The overall trend since 2000 is negative, with the recent peak in abundance (2010-2011) being considerably lower than the previous peak in 2002.

There are currently four hatchery programs in the Lower Columbia River releasing juvenile chum salmon: Grays River Hatchery, Big Creek Hatchery, Lewis River Hatchery, and Washougal Hatchery (NMFS 2017a). Total annual production from these hatcheries has not exceeded 500,000 fish. All of the hatchery programs in this ESU use integrated stocks developed to supplement natural production. Other populations in this ESU persist at very low abundances and the genetic diversity available would be very low (NWFSC 2015b). Diversity has been greatly reduced at the ESU level because of presumed extirpations and low abundance in the remaining populations (fewer than 100 spawners per year for most populations) (LCFRB 2010; NMFS 2013c).

The Columbia River chum salmon ESU includes all natural-origin chum salmon in the Columbia River and its tributaries in Washington and Oregon. The ESU consists of three populations: Grays River, Hardy Creek and Hamilton Creek in Washington State. Chum salmon from four artificial propagation programs also contribute to this ESU.

Status

The majority of the populations within the Columbia River chum salmon ESU are at high to very high risk, with very low abundances (NWFSC 2015b). These populations are at risk of extirpation due to demographic stochasticity and 'Allee' effects. One population, Grays River, is at low risk, with spawner abundances in the thousands and demonstrating a recent positive trend. The Washougal River and Lower Gorge populations maintain moderate numbers of spawners and appear to be relatively stable. The life history of chum salmon is such that ocean conditions have a strong influence on the survival of emigrating juveniles. The potential prospect of poor ocean conditions for the near future may put further pressure on the Columbia River chum salmon ESU (NWFSC 2015b). Freshwater habitat conditions may be negatively influencing spawning and early rearing success in some basins, and contributing to the overall low productivity of the ESU. Columbia River chum salmon were historically abundant and subject to substantial harvest until the 1950s (NWFSC 2015b). There is no directed harvest of this ESU and the incidental harvest rate has been below one percent for the last five years (NWFSC 2015b). Land development, especially in the low gradient reaches that chum salmon prefer, will continue to be a threat to most chum salmon populations due to projected increases in the population of the greater Vancouver-Portland area and the Lower Columbia River overall (Metro 2015). The Columbia River chum salmon ESU remains at a moderate to high risk of extinction (NWFSC 2015b).

Critical Habitat

NMFS designated critical habitat for the Columbia River chum salmon ESU in 2005 (70 FR 52630). This designation includes defined areas in the following subbasins: Middle Columbia/Hood, Lower Columbia/Sandy, Lewis, Lower Columbia/Clatskanie, Lower Cowlitz, and Lower Columbia sub-basin and river corridor (Figure 20). Columbia River chum salmon critical habitat includes freshwater spawning, freshwater rearing, and freshwater migration areas.

Designated critical habitat for the Columbia River chum salmon ESU does not overlap spatially with the action area and, therefore, will not be analyzed further in this opinion.

Recovery Goals

The ESU recovery strategy for Columbia River chum salmon focuses on improving tributary and estuarine habitat conditions, reducing or mitigating hydropower impacts, and reestablishing chum salmon populations where they may have been extirpated (NMFS 2013b). The goal of the strategy is to increase the abundance, productivity, diversity, and spatial structure of chum salmon populations such that the Coast and Cascade chum salmon strata are restored to a high probability of persistence, and the persistence probability of the two Gorge populations improves. For details on Columbia River chum salmon ESU recovery goals, including complete down-listing/delisting criteria, see the NMFS 2013 recovery plan (NMFS 2013b).

8.17 Chum Salmon – Hood Canal Summer-Run ESU

Hood Canal summer-run ESU chum include naturally spawned summer-run chum salmon originating from Hood Canal and its tributaries as well as from Olympic Peninsula rivers between Hood Canal and Dungeness Bay (Figure 21). Also, summer-run chum salmon originate from four artificial propagation programs.

A physical description of chum salmon is provided in Section 8.16. On March 25, 1999, NMFS listed the Hood Canal Summer-run ESU and the Columbia River ESU of chum salmon as threatened (64 FR 14508). NMFS reaffirmed the status of these two ESUs as threatened on June 28, 2005 (70 FR 37160).

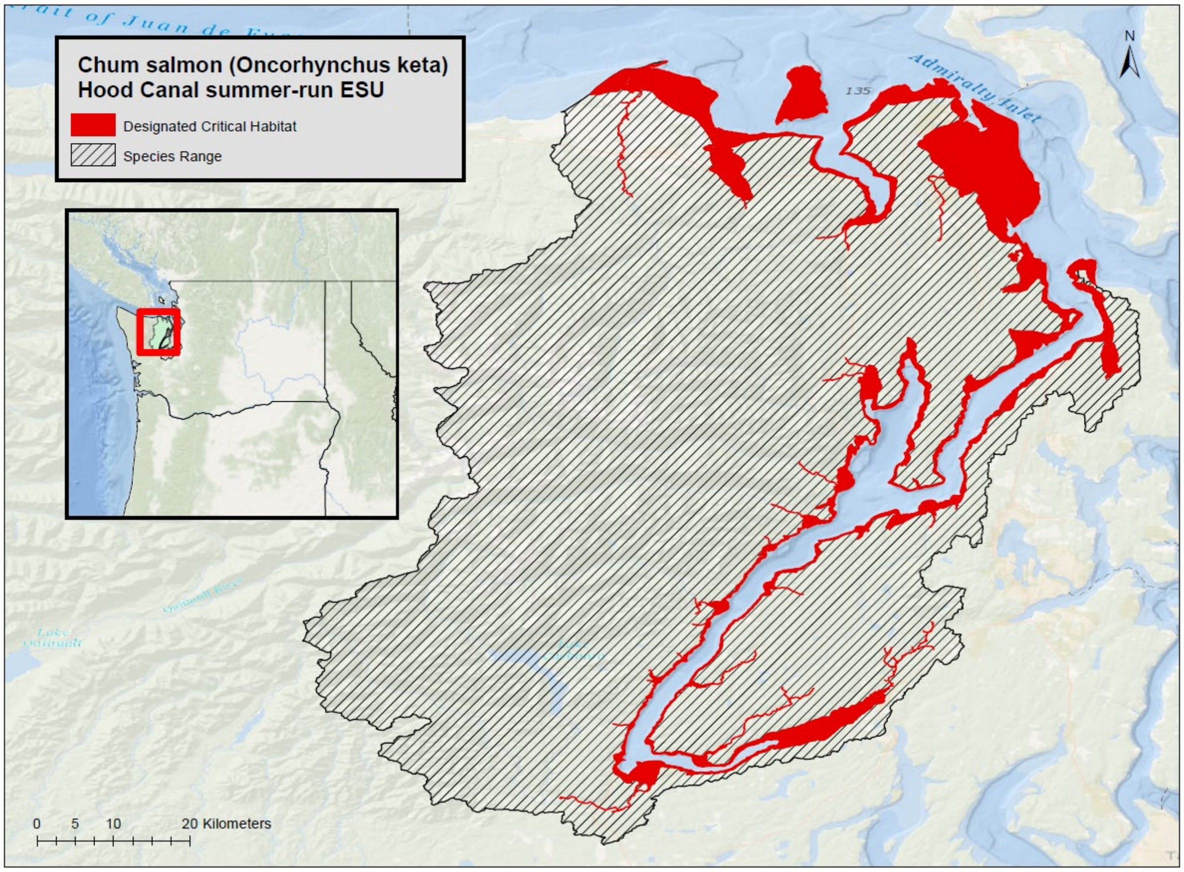

Figure 21. Geographic range and designated critical habitat of chum salmon, Hood Canal ESU.

Life History

The life history of chum is provided in Section 8.16.

Population Dynamics

Of the sixteen populations that comprise the Hood Canal Summer-run chum salmon ESU, seven are considered "functionally extinct" (Skokomish, Finch Creek, Anderson Creek, Dewatto, Tahuya, Big Beef Creek and Chimicum). NMFS examined average escapements (geometric means) for five-year intervals and estimated trends over the intervals for all natural spawners and for natural-origin only spawners. For both populations, abundance was relatively high in the 1970s, lowest for the period 1985-1999, and high again from 2005 to 2015 (NWFSC 2015b). Current abundance estimates of the Hood Canal summer-run ESU of chum salmon are presented in Table 15 and Table 16 below.

Table 15. Hood Canal summer-run juvenile chum salmon hatchery releases (NMFS 2020a).

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

Subbasin	Artificial propagation program	Brood year	Run Timing	Clipped Adipose Fin	Intact Adipose Fin
Total Annual Release Number				**-**	**150,000**

Table 16. Abundance of natural-origin and hatchery-origin HCS chum salmon spawners in escapements 2013-2017 (NMFS 2020a).

Population Name	Natural-origin Spawners[a]	Hatchery-origin Spawners[b]	% Hatchery Origin	Expected Number of Outmigrants[c]
Strait of Juan de Fuca Population				
Jimmycomelately Creek	1,288	0	0.00%	188,313
Salmon Creek	1,836	0	0.00%	268,531
Snow Creek	311	0	0.00%	45,541
Chimacum Creek	902	0	0.00%	131,971
Population Average[d]	4,337	0	0.00%	634,355
Hood Canal Population				
Big Quilcene River	6,437	0	0.00%	941,450
Little Quilcene River	122	0	0.00%	17,795
Big Beef Creek	10	0	0.00%	1,532
Dosewallips River	2,021	0	0.00%	295,524
Duckabush River	3,172	0	0.00%	463,856
Hamma River	2,944	10	0.34%	432,056
Anderson Creek	3	0	0.00%	376
Dewatto River	95	0	0.00%	13,947
Lilliwaup Creek	857	1,141	57.10%	292,159
Tahuya River	205	299	59.36%	73,777
Union River	2,789	2	0.07%	408,166
Skokomish River	2,154	0	0.00%	314,960
Population Average[d]	20,809	1,452	6.52%	3,255,599
ESU Average	**25,146**	**1,452**	**5.46%**	**3,889,955**

[a] Five-year geometric mean of post fishery natural-origin spawners (2015-2019).
[b] Five-year geometric mean of post fishery hatchery-origin spawners (2015-2019).
[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 (2015-2019).

The overall trend in spawning abundance is generally stable for the Hood Canal population (all natural spawners and natural-origin only spawners) and for the Strait of Juan de Fuca population (all natural spawners). Productivity rates, which were quite low during the five-year period from 2005-2009 (Ford 2011b), increased from 2011-2015 and were greater than replacement rates from 2014-2015 for both major population groups (NWFSC 2015b).

There were likely at least two ecological diversity groups within the Strait of Juan de Fuca population and at least four ecological diversity groups within the Hood Canal population. With the possible exception of the Dungeness River aggregation within the Strait of Juan de Fuca population, Hood Canal ESU summer chum salmon spawning groups exist today that represent each of the ecological diversity groups within the two populations (NMFS 2017a). Diversity values (Shannon diversity index) were generally lower in the 1990s for both independent populations within the ESU, indicating that most of the abundance occurred at a few spawning sites (NWFSC 2015b). Although the overall linear trend in diversity appears to be negative, the last five-year interval shows the highest average value for both populations within the Hood Canal ESU.

The Hood Canal summer-run chum salmon ESU includes all naturally spawned populations of summer-run chum salmon in Hood Canal and its tributaries as well as populations in Olympic Peninsula rivers between Hood Canal and Dungeness Bay, Washington. The nine populations are well distributed throughout the ESU range except for the eastern side of Hood Canal (Johnson et al. 1997a). Two independent major population groups have been identified for this ESU: (1) spawning aggregations from rivers and creeks draining into the Strait of Juan de Fuca, and (2) spawning aggregations within Hood Canal proper (Sands 2009).

Status

The two most recent status reviews (2011 and 2015) indicate some positive signs for the Hood Canal summer-run chum salmon ESU. Diversity has increased from the low levels seen in the 1990s due to both the reintroduction of spawning aggregates and the more uniform relative abundance between populations which is considered a good sign for viability in terms of spatial structure and diversity (Ford 2011b). Spawning distribution within most streams was also extended further upstream with increased abundance. At present, spatial structure and diversity viability parameters for each population nearly meet the viability criteria (NWFSC 2015b). Spawning abundance has remained relatively high compared to the low levels observed in the early 1990's (Ford 2011b). Natural-origin spawner abundance has shown an increasing trend since 1999, and spawning abundance targets in both populations were met in some years (NWFSC 2015b). Despite substantive gains towards meeting viability criteria in the Hood Canal and Strait of Juan de Fuca summer chum salmon populations, the ESU still does not meet all of the recovery criteria for population viability at this time (NWFSC 2015b). Overall, the Hood Canal Summer-run chum salmon ESU remains at a moderate risk of extinction.

Critical Habitat

NMFS designated critical habitat for Hood Canal summer-run chum salmon in 2005 (70 FR 52630), which includes 79 miles of stream channels and 377 miles of nearshore marine habitat (Figure 21). NMFS excluded some particular DOD sites from the Hood Canal Summer-run chum salmon critical habitat designation because the benefits of exclusion outweigh the benefits of inclusion, and exclusion of those areas will not result in the extinction of the species. Designated critical habitat for the Hood Canal summer-run chum salmon ESU does not overlap spatially with the action area and, therefore, will not be analyzed further in this opinion.

Recovery Goals

The recovery strategy for Hood Canal Summer-run chum salmon focuses on habitat protection and restoration throughout the geographic range of the ESU, including both freshwater habitat and nearshore marine areas within a one-mile radius of the watersheds' estuaries (NMFS 2007a). The recovery plan includes an ongoing harvest management program to reduce exploitation rates, a hatchery supplementation program, and the reintroduction of naturally spawning summer chum salmon aggregations to several streams where they were historically present. The Hood Canal plan gives first priority to protecting the functioning habitat and major production areas of the ESU's eight extant stocks, keeping in mind the biological and habitat needs of different life-history stages, and second priority to restoration of degraded areas, where recovery of natural processes appears to be feasible (HCCC 2005). For details on Hood Canal Summer-run chum salmon ESU recovery goals, including complete down-listing/delisting criteria, see the Hood Canal Coordinating Council 2005 recovery plan (HCCC 2005) and the NMFS 2007 supplement to this recovery plan (NMFS 2007a).

8.18 Sockeye Salmon – Ozette Lake ESU

This ESU includes naturally spawned sockeye salmon originating from the Ozette River and Ozette Lake and its tributaries (Figure 22). Also, sockeye salmon are bred in two artificial propagation programs.

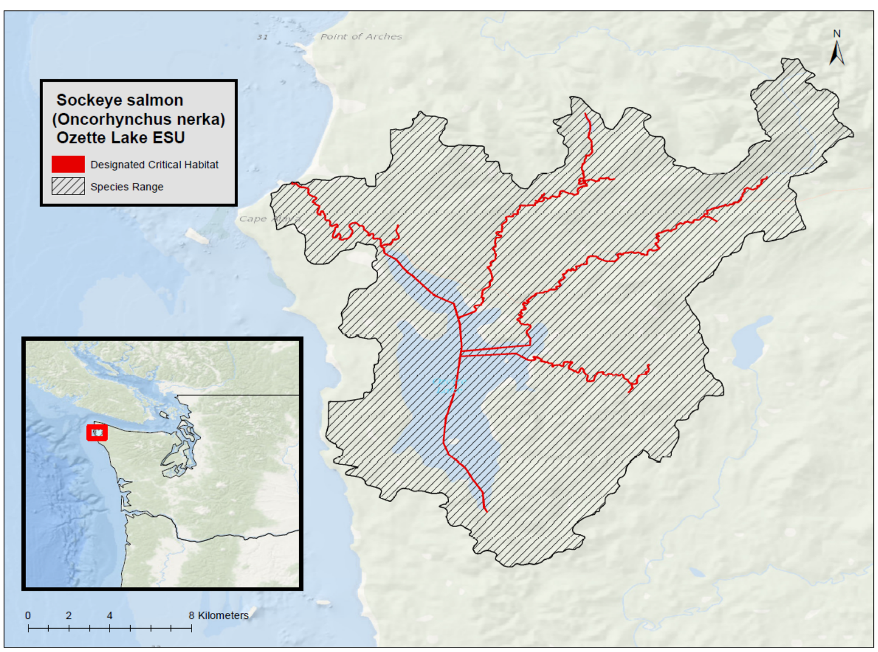

Figure 22. Range and Designated Critical Habitat of the Ozette Lake ESU of Sockeye Salmon.

The sockeye salmon is an anadromous species, although some sockeye spend their entire lives (about five years) in freshwater. Adult sockeye salmon are about three feet long and eight pounds. Sockeyes are bluish black with silver sides when they are in the ocean, and they turn bright red with a green head when they are spawning. On March 25, 1999, NMFS listed the Ozette Lake sockeye salmon ESU as threatened (64 FR 14528) and reaffirmed the ESU's status as threatened on June 28, 2005 (70 FR 37160).

Life History

Most sockeye salmon exhibit a lake-type life history (i.e., they spawn and rear in or near lakes), though some exhibit a river-type life history. Spawning generally occurs in late summer and fall, but timing can vary greatly among populations. In lakes, sockeye salmon commonly spawn along "beaches" where underground seepage provides fresh oxygenated water. Females spawn in three to five redds over a couple of days. Incubation period is a function of water temperature and generally lasts 100 to 200 days (Burgner 1991). Sockeye salmon spawn once, generally in late summer and fall, and then die (semelparity).

Sockeye salmon fry primarily rear in lakes; river-emerged and stream-emerged fry migrate into lakes to rear. In the early fry stage from spring to early summer, juveniles forage exclusively in the warmer littoral (i.e., shoreline) zone where they depend mostly on fly larvae and pupae, copepods, and water fleas. Sub-yearling sockeye salmon move from the littoral habitat to a pelagic (i.e., open water) existence where they feed on larger zooplankton; however, flies may still make up a substantial portion of their diet. From one to three years after emergence, juvenile sockeye salmon generally rear in lakes, though some river-spawned sockeye may migrate to sea in their first year. Juvenile sockeye salmon feeding behaviors change as they transition through life stages after emergence to the time of smoltification. Distribution in lakes and prey preference is a dynamic process that changes daily and yearly depending on many factors including water temperature, prey abundance, presence of predators and competitors, and size of the juvenile. Peak emigration to the ocean occurs in mid-April to early May in southern sockeye populations (lower than 52ºN latitude) and as late as early July in northern populations (62ºN latitude) (Burgner 1991). Adult sockeye salmon return to their natal lakes to spawn after spending one to four years at sea. The diet of adult salmon consists of amphipods, copepods, squid and other fish.

Population Dynamics

The historical abundance of the Ozette Lake ESU of sockeye salmon is poorly documented, but may have been as high as 50,000 individuals (Blum 1988). Escapement estimates (run size minus broodstock take) from 1996 to 2006 range from a low of 1,404 in 1997 to a high of 6,461 in 2004, with a median of approximately 3,800 sockeye per year (geometric mean: 3,353) (Rawson et al. 2009). Current abundance estimates for Ozette Lake ESU sockeye salmon are presented in Table 17 below.

Table 17. Abundance Estimates for the Ozette Lake ESU of Sockeye Salmon (NMFS 2020a).

Production	Life Stage	Abundance
Natural and Hatchery (Clipped and Intact Adipose)	Adult	5,036
Natural	Juvenile	1,037,787
Listed Hatchery Adipose Clipped	Juvenile	45,750
Listed Hatchery Intact Adipose	Juvenile	259,250

Productivity has fluctuated up and down over the last few decades, but overall appears to have remained stable (NWFSC 2015b). Given the degree of uncertainty in the abundance estimates, any interpretation of trends of small magnitude or over short time periods is speculative. (NWFSC 2015b).

For the Ozette Lake sockeye salmon ESU, the proportion of beach spawners is likely low; therefore, hatchery-originated fish are not likely to greatly affect the genetics of the naturally-spawned population. However, Ozette Lake sockeye have a relatively low genetic diversity compared to other sockeye salmon populations examined in Washington State (NWFSC 2015b). Genetic differences do occur among age cohorts. However, because different age groups do not reproduce together, the population may be more vulnerable to significant reductions in population structure due to catastrophic events or unfavorable conditions affecting a single year class.

The Ozette Lake sockeye salmon ESU is composed of one historical population with multiple spawning aggregations and two populations from the Umbrella Creek and Big River sockeye hatchery programs (NWFSC 2015b). Historically, at least four lake beaches were used for spawning; today only two beach spawning locations, Allen's and Olsen's Beaches, are used. Additionally, spawning occurs in the two tributaries of the hatchery programs (NWFSC 2015b). The Umbrella creek population is a large component of the total population (averaging over 50 percent for the last decade of data).

Status

NMFS listed the Ozette Lake sockeye salmon ESU because of habitat loss and degradation from the combined effects of logging, road building, predation, invasive plant species, and overharvest. Ozette Lake sockeye salmon have not been commercially harvested since 1982 and only minimally harvested by the Makah Tribe since 1982 (0 to 84 fish per year); there is no known marine fishing of this ESU. Overall abundance is substantially below historical levels, and whether the decrease in abundance is a result of fewer spawning aggregations, lower abundances in each aggregation, or a combination of both factors is unknown. Regardless, this ESU's viability has not improved, and the ESU would likely have a low resilience to additional perturbations. However, recovery potential for the Ozette Lake sockeye salmon ESU is good, particularly because of protections afforded it based on the lake's location within Olympic National Park (NWFSC 2015b).

Critical Habitat

NMFS designated critical habitat for Ozette Lake sockeye salmon on September 2, 2005 (70 FR 52630). Critical habitat includes juvenile summer and winter rearing areas, juvenile migration corridors, areas for growth and development to adulthood, adult migration corridors, and spawning areas. Designated critical habitat for the Ozette Lake sockeye salmon does not overlap spatially with the action area and, therefore, will not be analyzed further in this opinion.

Recovery Goals

We adopted a recovery plan for Lake Ozette ESU sockeye salmon (NMFS 2009c) in May 2009. The criteria of the recovery plan were based upon Rawson et al. (2009). Recovery criteria include:

- Multiple, spatially distinct and persistent spawning aggregations throughout the historical range of the population (i.e., along the lake beaches and in one or more tributaries).
- One or more persistent spawning aggregations from each major genetic and life history group historically present. Also, genetic distinctness between anadromous sockeye, and kokanee salmon in the lake.
- Abundance between 31,250 and 121,000 adult spawners, over a number of years.

8.19 Sockeye Salmon – Snake River ESU

This ESU includes naturally spawned anadromous and residual sockeye salmon originating from the Snake River basin (Figure 23), and also sockeye salmon from one artificial propagation program: Redfish Lake Captive Broodstock Program.

A physical description of sockeye salmon is provided in Section 8.18. On November 20, 1991 NMFS listed the Snake River sockeye salmon ESU as endangered (56 FR 58619), and reaffirmed the ESU's status as endangered on June 28, 2005 (70 FR 37160).

Life History

The life history of sockeye salmon is provided in Section 8.18.

Population Dynamics

Adult returns over the last several years have ranged from a high of 1,579 fish in 2014 (including 453 natural-origin fish) to a low of 257 adults in 2012 (including 52 natural-origin fish). Sockeye salmon returns to Alturas Lake ranged from one fish in 2002 to 14 fish in 2010. No fish returned to Alturas Lake in 2012, 2013, or 2014 (NMFS 2015b). Current abundance estimates for the Snake River ESU of sockeye salmon are presented in Table 18 below.

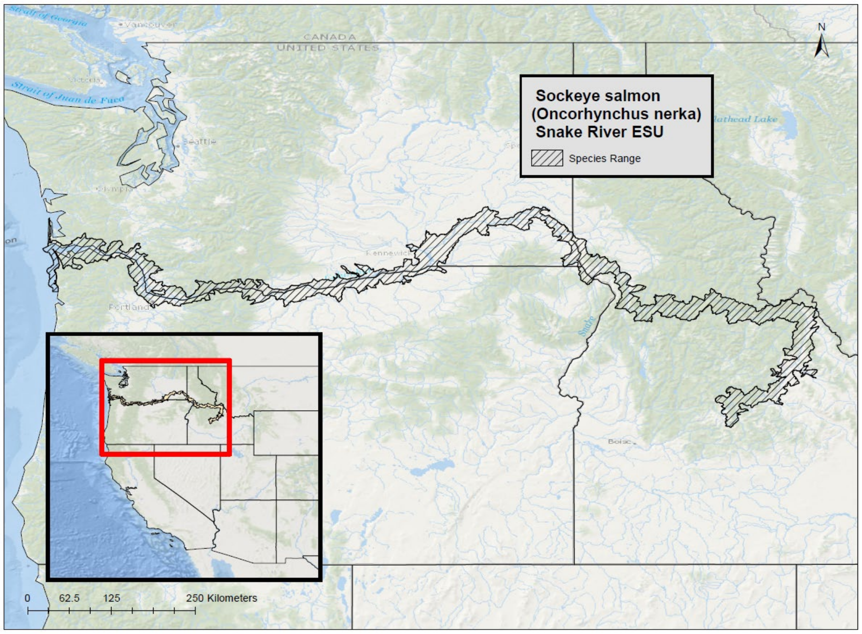

Figure 23. Geographic range of Sockeye salmon, Snake River ESU.

Table 18. Current Abundance Estimates for Snake River ESU Sockeye salmon (NMFS 2020a).

Production	Life Stage	Abundance
Natural	Adult	546
Natural	Juvenile	19,181
Listed Hatchery Adipose Clipped	Adult	4,004
Listed Hatchery Adipose Clipped	Juvenile	242,610

The large increases in returning adults in recent years reflect improved downstream and ocean survival as well as increases in juvenile production since the early 1990s. Although total sockeye salmon returns to the Sawtooth Valley in recent years have been high enough to allow for some level of natural spawning in Redfish Lake, the hatchery program remains at its initial phase with a priority on genetic conservation and building sufficient returns to support sustained outplanting and recolonization of the species' historic range (NMFS 2015b; NWFSC 2015b).

For the Snake River ESU, the Sawtooth Hatchery is focusing on genetic conservation. An overrepresentation of genes from the anadromous population in Redfish Lake exists, but inbreeding is low, which is a sign of a successful captive broodstock program (NMFS 2015b; NWFSC 2015b) .

This species includes all anadromous and residual sockeye salmon from the Snake River basin, Idaho, and artificially-propagated sockeye salmon from the Redfish Lake Captive Broodstock Program (USDC 2014; NMFS 2015b; NWFSC 2015b). The ICTRT treats Sawtooth Valley

Sockeye salmon as the single MPG within the Snake River Sockeye salmon ESU. The MPG contains one extant population (Redfish Lake) and two to four historical populations (Alturas, Petit, Stanley, and Yellowbelly Lakes) (NMFS 2015b). At the time of listing in 1991, the only confirmed extant population included in this ESU was the beach-spawning population of sockeye salmon from Redfish Lake, with about 10 fish returning per year (NMFS 2015b).

Status

The Snake River sockeye salmon ESU includes only one population comprised of all anadromous and residual sockeye salmon from the Snake River Basin, Idaho, as well as artificially propagated sockeye salmon from the Redfish Lake captive propagation program. Historical evidence indicates that the Snake River sockeye salmon once had a range of life history patterns, with spawning populations present in several of the small lakes in the Sawtooth Basin. NMFS listed the Snake River sockeye salmon ESU because of habitat loss and degradation from the combined effects of damming and hydropower development, overexploitation, fisheries management practices, and poor ocean conditions. Recent effects of climate change, such as reduced stream flows and increased water temperatures, are limiting Snake River ESU productivity (NMFS 2015b; NWFSC 2015b). Adults produced through the captive propagation program currently support the entire ESU. This ESU is still at extremely high risk across all four basic risk measures (abundance, productivity, spatial structure, and diversity) and would likely have a very low resilience to additional perturbations. Habitat improvement projects have slightly decreased the risk to the species, but habitat concerns and water temperature issues remain. Overall, although the status of the Snake River sockeye salmon ESU appears to be improving, there is no indication that the biological risk category has changed (NWFSC 2015b).

Critical Habitat

NMFS designated critical habitat for Snake River sockeye salmon on December 28, 1993 (58 FR 68543). The critical habitat encompasses the waters, waterway bottoms, and adjacent riparian zones of specified lakes and river reaches in the Columbia River that are or were accessible to salmon of this ESU (except reaches above impassable natural falls, and Dworshak and Hells Canyon Dams). Specific PBFs were not designated in the critical habitat final rule; instead, four "essential habitat" categories were described: 1) spawning and juvenile rearing areas, 2) juvenile migration corridors, 3) areas for growth and development to adulthood, and 4) adult migration corridors. Designated critical habitat for the Snake River sockeye salmon does not overlap spatially with the action area and, therefore, will not be analyzed further in this opinion.

Recovery Goals

See the 2015 recovery plan for the Snake River sockeye salmon ESU for complete down-listing/delisting criteria for recovery goals for the species (NMFS 2015b). Broadly, recovery plan goals emphasize restoring historical lake populations and improving water quality and quantity in lakes and migration corridors.

8.20 Steelhead – California Central Valley DPS

The Central Valley DPS of steelhead includes naturally spawned anadromous steelhead originating below natural and manmade impassable barriers from the Sacramento and San Joaquin Rivers and their tributaries and excludes such fish originating from San Francisco and San Pablo Bays and their tributaries (Figure 24). Further the Central Valley DPS of steelhead includes steelhead from two artificial propagation programs.

Steelhead are dark-olive in color, shading to silvery-white on the underside with a speckled body and a pink-red stripe along their sides. Those migrating to the ocean develop a slimmer profile, becoming silvery in color, and typically growing larger than rainbow trout that remain in fresh water. Steelhead grow to 55 pounds (25 kilogram) in weight and 45 inches (120 centimeters) in length, though average size is much smaller. On March 19, 1998 NMFS listed the California Central Valley DPS of steelhead as threatened (63 FR 13347) and reaffirmed the DPS's status as threatened on January 5, 2006 (71 FR 834).

Life History

The Central Valley DPS of steelhead spawn downstream of dams on every major tributary within the Sacramento and San Joaquin River systems. The female steelhead selects a site with good intergravel flow, digs a redd with her tail, usually in the coarse gravel of the tail of a pool or in a riffle, and deposits eggs while an attendant male fertilizes them. The preferred water temperature range for steelhead spawning is reported to be 30 degrees Fahrenheit to 52 degrees Fahrenheit (CDFW 2000). The eggs hatch in three to four weeks at 50 degree Fahrenheit to 59 degrees Fahrenheit, and fry emerge from the gravel four to six weeks later (Shapovalov and Taft 1954). Regardless of life history strategy, for the first year or two of life steelhead are found in cool, clear, fast flowing permanent streams and rivers where riffles predominate over pools, there is ample cover from riparian vegetation or undercut banks, and invertebrate life is diverse and abundant (Moyle 2002). The smallest fish are most often found in riffles, intermediate size fish in runs, and larger fish in pools.

Steelhead typically migrate to marine waters after spending two years in fresh water. They reside in marine waters for typically two or three years prior to returning to their natal stream to spawn as four- or five-year olds. Unlike Pacific salmon, steelhead are capable of spawning more than once before they die. However, it is rare for steelhead to spawn more than twice before dying, and most that do so are females (Moyle 2002). Currently, Central Valley steelhead are considered "ocean-maturing" (also known as winter) steelhead, although summer steelhead may have been present prior to construction of large dams (Moyle 2002). Ocean maturing steelhead enter fresh water with well-developed gonads and spawn shortly after river entry. Central Valley steelhead enter fresh water from August through April. They hold until flows are high enough in tributaries to enter for spawning (Moyle 2002). Steelhead adults typically spawn from December through April, with peaks from January through March in small streams and tributaries where cool, well oxygenated water is available year-round (Hallock et al. 1961; McEwan 2001).

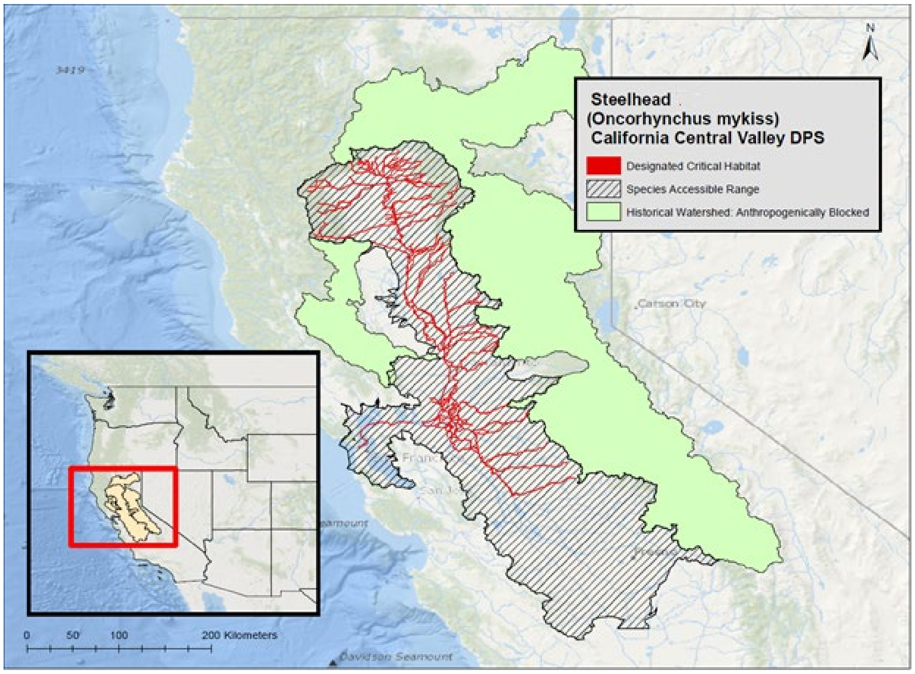

Figure 24. Geographic range and designated critical habitat of California Central Valley Steelhead.

Population Dynamics

Historic Central Valley steelhead run size may have approached one to two million adults annually (McEwan 2001). By the early 1960s, the steelhead run size had declined to about 40,000 adults (McEwan 2001). Over the past 30 years, the naturally spawned steelhead populations in the upper Sacramento River have declined substantially. Based on catch ratios at Chipps Island in the Delta and using some generous assumptions regarding survival, the average number of Central Valley steelhead females spawning naturally in the entire Central Valley during the years 1980 to 2000 was estimated at about 3,600 (Good et al. 2005). Current abundance estimates for the California Central Valley DPS of steelhead are presented in Table 19 below.

Table 19. Current Abundance Estimates for the California Central Valley DPS of Steelhead (NMFS 2020a).

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

California Central Valley steelhead lack annual monitoring data for calculating trends. However, the Red Bluff Diversion Dam counts and redd counts up to 1993 and later sporadic data show that the DPS has had a significant long-term downward trend in abundance (NMFS 2009a).

The Central Valley steelhead distribution ranges over a wide variety of environmental conditions and likely contains biologically significant amounts of spatially structured genetic diversity (Lindley et al. 2006). The loss of populations and reduction in abundances have reduced the large diversity that existed within the DPS. The genetic diversity of the majority of steelhead spawning runs within this DPS is also compromised by hatchery-origin fish.

Status

Many watersheds in the Central Valley are experiencing decreased abundance of California Central Valley steelhead. Dam removal and habitat restoration efforts in Clear Creek appear to be benefiting steelhead as recent increases in non-clipped (wild) abundance have been observed. Despite the positive trend in Clear Creek, all other concerns raised in the previous status review remain, including low adult abundances, loss and degradation of a large percentage of the historic spawning and rearing habitat, and domination of smolt production by hatchery fish. Many other planned restoration and reintroduction efforts have yet to be implemented or completed, or are focused on Chinook salmon, and have yet to yield demonstrable improvements in habitat, let alone documented increases in naturally produced steelhead. There are indications that natural production of steelhead continues to decline and is now at a very low levels. Their continued low numbers in most tributaries, domination by hatchery fish, and relatively sparse monitoring makes the continued existence of naturally reproduced steelhead a concern. California Central Valley steelhead remains likely to become endangered within the foreseeable future (i.e. it continues to be threatened).

Critical Habitat

NMFS designated critical habitat for California Central Valley steelhead on September 2, 2005 (70 FR 52488). Critical habitat includes freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and estuarine areas. The PBFs that characterize these sites include water quality and quantity, natural cover, forage, adequate passage conditions, and floodplain connectivity necessary to support spawning, incubation and larval development, juvenile growth and mobility, and adult survival. Designated critical habitat for the California Central Valley steelhead does not overlap spatially with the action area and, therefore, will not be analyzed further in this opinion.

Recovery Goals

See the 2014 recovery plan for the California Central Valley steelhead DPS for complete down-listing/delisting criteria for recovery goals for the species (NMFS 2014). The delisting criteria for this DPS are:

- One population in the Northwestern California Diversity Group at low risk of extinction

- Two populations in the Basalt and Porous Lava Flow Diversity Group at low risk of extinction
- Four populations in the Northern Sierra Diversity Group at low risk of extinction
- Two populations in the Southern Sierra Diversity Group at low risk of extinction
- Maintain multiple populations at moderate risk of extinction

8.21 Steelhead – Central California Coast DPS

The Central California Coast DPS of steelhead includes all naturally spawned populations of steelhead (and their progeny) in streams from the Russian River to Aptos Creek, Santa Cruz County, California (inclusive). It also includes the drainages of San Francisco and San Pablo Bays (Figure 25).

A physical description of steelhead is presented in Section 8.20. On August 18, 1997 NMFS listed the Central California Coast DPS of steelhead as threatened (62 FR 43937) and reaffirmed the DPS's status as threatened on January 5, 2006 (71 FR 834).

Life History

The Central California Coast DPS of steelhead is entirely composed of winter-run fish. Adults return to the Russian River and migrate upstream from December to April, and smolts emigrate between March and May (Shapovalov and Taft 1954; Hayes et al. 2004). Most spawning takes place from January through April. The female steelhead selects a site with good intergravel flow, digs a redd with her tail, usually in the coarse gravel of the tail of a pool or in a riffle, and deposits eggs while an attendant male fertilizes them. The preferred water temperature range for steelhead spawning is reported to be 30 degrees Fahrenheit to 52 degrees Fahrenheit (CDFW 2000).

The eggs hatch in three to four weeks at 50 degrees Fahrenheit to 59 degrees Fahrenheit, and fry emerge from the gravel four to six weeks later (Shapovalov and Taft 1954). Regardless of life history strategy, for the first year or two of life steelhead are found in cool, clear, fast flowing permanent streams and rivers where riffles predominate over pools, there is ample cover from riparian vegetation or undercut banks, and invertebrate life is diverse and abundant (Moyle 2002). The smallest fish are most often found in riffles, intermediate size fish in runs, and larger fish in pools.

Steelhead typically migrate to marine waters after spending two years in fresh water. They reside in marine waters for typically two or three years prior to returning to their natal stream to spawn as four- or five-year olds. Unlike Pacific salmon, steelhead are capable of spawning more than once before they die. However, it is rare for steelhead to spawn more than twice before dying, and most that do so are females (Moyle 2002).While age of smoltification typically ranges for one to four years, recent studies indicate that growth rates in Soquel Creek likely prevent juveniles from undergoing smoltification until age two (Sogard et al. 2009).

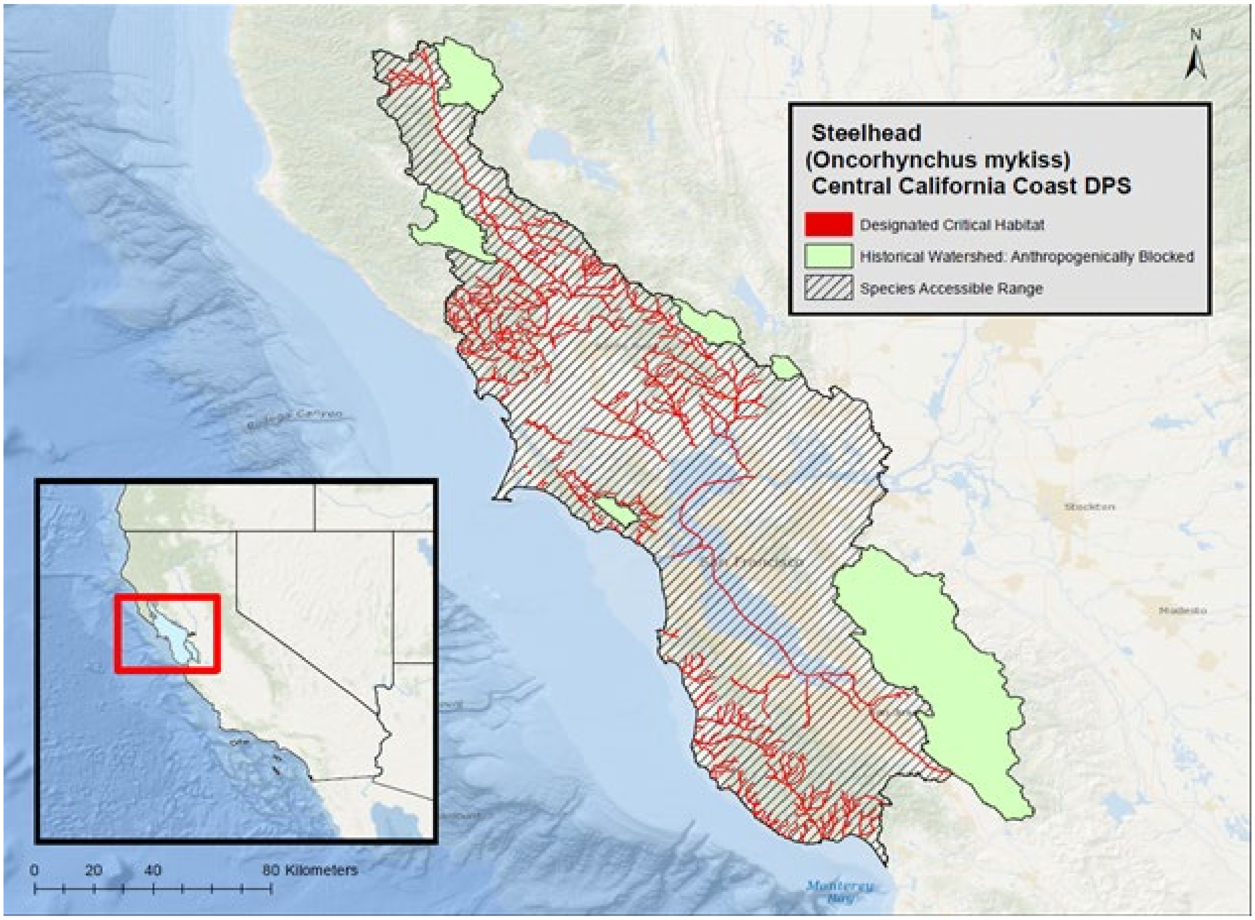

Figure 25. Geographic range and designated critical habitat of Central California Coast Steelhead.

Population Dynamics

Historically, the entire Central California Coast steelhead DPS may have consisted of an average runs size of 94,000 adults in the early 1960s (Good et al. 2005). Current abundance estimates for the California Central Coast DPS of steelhead are presented in

Table 20 below. Presence-absence data indicated that most (82 percent) sampled streams (a subset of all historical steelhead streams) had extant populations of juvenile *O. mykiss* (Adams 2000; Good et al. 2005).

Table 20. Current Abundance Estimates for the California Central Coast DPS of Steelhead (NMFS 2020a).

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

Though the information for individual populations is limited, available information strongly suggests that no population is viable. Long-term population sustainability is extremely low for the southern populations in the Santa Cruz mountains and in the San Francisco Bay (NMFS 2008a). Declines in juvenile southern populations are consistent with the more general estimates of declining abundance in the region (Good et al. 2005).

The interior Russian River winter-run steelhead has the largest runs with an estimate of an average of over 1,000 spawners. Due to this, Russian River winter-run steelhead may be able to be sustained over the long-term but hatchery management has eroded the population's genetic diversity (Bjorkstedt et al. 2005; NMFS 2008a).

Status

The Central California Coast steelhead consisted of nine historic functionally independent populations and 23 potentially independent populations (Bjorkstedt et al. 2005). Of the historic functionally independent populations, at least two are extirpated while most of the remaining are nearly extirpated. Current runs in the basins that originally contained the two largest steelhead populations for the DPS, the San Lorenzo and the Russian Rivers, both have been estimated at less than 15 percent of their abundances just 30 years earlier (Good et al. 2005). The Russian River is of particular importance for preventing the extinction and contributing to the recovery of Central California Coast steelhead (NOAA 2013b). Steelhead access to significant portions of the upper Russian River has also been blocked (Busby et al. 1996a; NMFS 2008a).

Critical Habitat

Critical habitat was designated for this species on September 2, 2005 (70 FR 52630). Critical habitat includes freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and estuarine areas. The PBFs that characterize these sites include water quality and quantity, natural cover, forage, adequate passage conditions, and floodplain connectivity necessary to support spawning, incubation and larval development, juvenile growth and mobility, and adult survival. Designated critical habitat for the Central California Coast steelhead does not overlap spatially with the action area and, therefore, will not be analyzed further in this opinion.

Recovery Goals

See the 2016 recovery plan for the Central California Coast steelhead DPS (NMFS 2016c) for complete down-listing/delisting criteria for recovery goals for the species. Recovery plan objectives are to:

- Reduce the present or threatened destruction, modification, or curtailment of habitat or range;
- Ameliorate utilization for commercial, recreational, scientific, or educational purposes;
- Abate disease and predation;

- Establish the adequacy of existing regulatory mechanisms for protecting Central California Coast steelhead now and into the future (i.e., post-delisting);
- Address other natural or manmade factors affecting the continued existence of Central California Coast steelhead;
- Ensure Central California Coast steelhead status is at a low risk of extinction based on abundance, growth rate, spatial structure and diversity.

8.22 Steelhead – Lower Columbia River DPS

The Lower Columbia River DPS of steelhead includes naturally spawned steelhead originating below natural and manmade impassable barriers from rivers between the Cowlitz and Wind Rivers (inclusive) and the Willamette and Hood Rivers (inclusive) and excludes such fish originating from the upper Willamette River basin above Willamette Falls (Figure 26). The Lower Columbia River DPS also includes steelhead from seven artificial propagation programs.

A physical description of steelhead is presented in Section 8.20. On March 19, 1998 NMFS listed the Lower Columbia River DPS of steelhead as threatened (63 FR 13347) and reaffirmed the DPS's status as threatened on January 5, 2006 (71 FR 834).

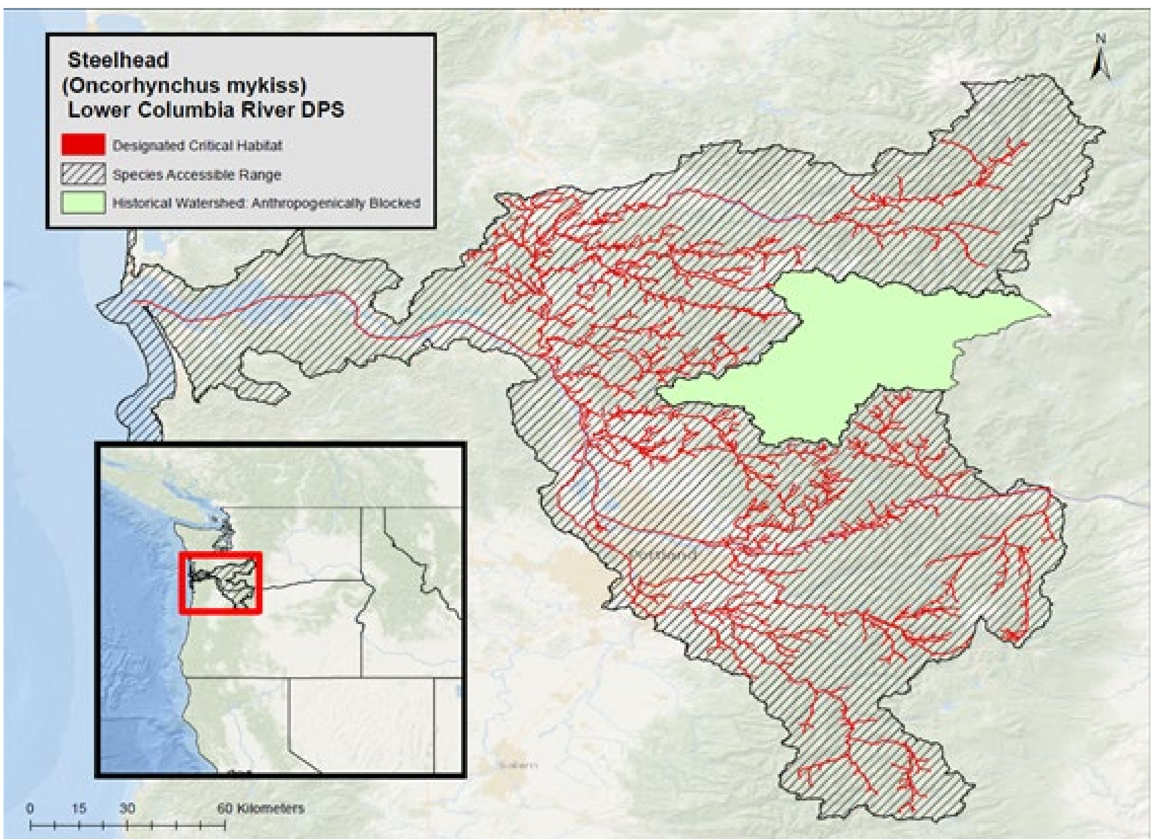

Figure 26. Geographic range and designated critical habitat of Lower Columbia River steelhead.

Life History

The Lower Columbia River steelhead DPS includes both summer- and winter-run stocks. Summer-run steelhead return sexually immature to the Columbia River from May to November, and spend several months in fresh water prior to spawning. Winter-run steelhead enter fresh water from November to April, are close to sexual maturation during freshwater entry, and spawn shortly after arrival in their natal streams. Where both races spawn in the same stream, summer-run steelhead tend to spawn at higher elevations than the winter-run. The female steelhead selects a site with good intergravel flow, digs a redd with her tail, usually in the coarse gravel of the tail of a pool or in a riffle, and deposits eggs while an attendant male fertilizes them. The preferred water temperature range for steelhead spawning is reported to be 30 degrees Fahrenheit to 52 degrees Fahrenheit (CDFW 2000). The eggs hatch in three to four weeks at 50 degrees Fahrenheit to 59 degrees Fahrenheit, and fry emerge from the gravel four to six weeks later (Shapovalov and Taft 1954). Regardless of life history strategy, for the first year or two of life steelhead are found in cool, clear, fast flowing permanent streams and rivers where riffles predominate over pools, there is ample cover from riparian vegetation or undercut banks, and invertebrate life is diverse and abundant (Moyle 2002). The smallest fish are most often found in riffles, intermediate size fish in runs, and larger fish in pools.

The majority of juvenile lower Columbia River steelhead remain for two years in freshwater environments before ocean entry in spring. Both winter- and summer-run adults normally return after two years in the marine environment. Unlike Pacific salmon, steelhead are capable of spawning more than once before they die. However, it is rare for steelhead to spawn more than twice before dying, and most that do so are females (Moyle 2002).

Population Dynamics

The Winter-run Western Cascade MPG includes native winter-run steelhead in 14 DIPs from the Cowlitz River to the Washougal River. Abundances have remained fairly stable and have remained low, averaging in the hundreds of fish. Notable exceptions to this were the Clackamas and Sandy River winter-run steelhead populations, that are exhibiting recent rises in NOR abundance and maintaining low levels of hatchery-origin steelhead on the spawning grounds (NMFS 2016b). In the Summer-run Cascade MPG, there are four summer-run steelhead populations. Absolute abundances have been in the hundreds of fish. In the Winter-run Gorge MPG both the Lower and Upper Gorge population surveys for winter steelhead are very limited and abundance levels in the Hood River have been low but relatively stable. In the Summer-run Gorge MPG adult abundance in the Wind River remains stable, but at a low level (hundreds of fish). Current abundance estimates for the Lower Columbia River DPS of steelhead are presented in Table 21 below. From 2015-2019, the geometric means for the releases from these hatcheries are 1,197,156 LHAC and 9,138 LHIA Lower Columbia River steelhead annually (Zabel 2015; Zabel 2017b; Zabel 2017a; Zabel 2018; Zabel 2020). To estimate abundance of juvenile natural Lower Columbia River steelhead, we calculate the geometric mean for outmigrating smolts over the past five years (2015-2019) by using annual abundance estimates provided by the NMFS'

Northwest Fisheries Science Center (Zabel 2015; Zabel 2017b; Zabel 2017a; Zabel 2018; Zabel 2020). For juvenile natural-origin Lower Columbia River steelhead, an estimated average of 352,146 juvenile steelhead outmigrated over the last five years.

Table 21. Current Abundance Estimates for the Lower Columbia River DPS of Steelhead (Zabel 2015; Zabel 2017b; Zabel 2017a; Zabel 2018; NMFS 2019d; Zabel 2020).

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

Population trends for the Winter-run Western Cascade MPG are fairly stable. Long and short term trends for three independent populations within the Summer-run Cascade MPG are positive; though the 2014 surveys indicate a drop in abundance for all three. Population trends in the Winter-run Gorge MPG is relatively stable. The overall status of the Summer-run Gorge MPG is uncertain.

Total steelhead hatchery releases in the Lower Columbia River Steelhead DPS have decreased since the last status review, declining from a total (summer and winter run) release of approximately 3.5 million to three million from 2008 to 2014. Some populations continue to have relatively high fractions of hatchery-origin spawners, whereas others (e.g., Wind River) have relatively few hatchery origin spawners.

There are four MPGs comprised of 23 DIPs, including six summer-run steelhead populations and 17 winter-run populations (NWFSC 2015b). Summer steelhead spawning areas in the Lower Columbia River are found above waterfalls and other features that create seasonal barriers to migration. There have been a number of large-scale efforts to improve accessibility (one of the primary metrics for spatial structure) in this DPS. Trap and haul operations were begun on the Lewis River in 2012 for winter-run steelhead, reestablishing access to historically-occupied habitat above Swift Dam. In 2014, 1033 adult winter steelhead (integrated program fish) were transported to the upper Lewis River; however, juvenile collection efficiency is still below target levels. In addition, there have been a number of recovery actions throughout the DPS to remove or improve culverts and other small-scale passage barriers.

Status

The Lower Columbia River steelhead had 17 historically independent winter steelhead populations and six independent summer steelhead populations (McElhany et al. 2003; Myers et al. 2006). All historic Lower Columbia River steelhead populations are considered extant. However, spatial structure within the historically independent populations, especially on the Washington side, has been substantially reduced by the loss of access to the upper portions of some basins due to tributary hydropower development. The majority of winter-run steelhead populations in this DPS continue to persist at low abundances (NWFSC 2015b). Hatchery interactions remain a concern in select basins, but the overall situation is somewhat improved compared to prior reviews. Summer-run steelhead DIPs were similarly stable, but at low abundance levels. Habitat degradation continues to be a concern for most populations. Even with modest improvements in the status of several winter-run populations, none of the populations appear to be at fully viable status, and similarly none of the MPGs meet the criteria for viability. The DPS therefore continues to be at moderate risk (NWFSC 2015b).

Critical Habitat

Critical habitat was designated for the Lower Columbia River steelhead on September 2, 2005. Critical habitat includes freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and estuarine areas. The PBFs that characterize these sites include water quality and quantity, natural cover, forage, adequate passage conditions, and floodplain connectivity necessary to support spawning, incubation and larval development, juvenile growth and mobility, and adult survival. Designated critical habitat for the Lower Columbia River steelhead does not overlap spatially with the action area and, therefore, will not be analyzed further in this opinion.

Recovery Goals

The Lower Columbia River DPS of steelhead are included in the Lower Columbia River recovery plan (NMFS 2013b). For this DPS, threats in all categories must be reduced, but the most crucial elements are protecting favorable tributary habitat and restoring habitat in the Upper Cowlitz, Cispus, North Fork Toutle, Kalama and Sandy subbasins (for winter steelhead), and the East Fork Lewis, and Hood, subbasins (for summer steelhead). Protection and improvement is also need among the South Fork Toutle and Clackamas winter steelhead populations.

8.23 Steelhead – Middle Columbia River DPS

The Middle Columbia River DPS of steelhead includes naturally spawned anadromous steelhead originating below natural and manmade impassable barriers from the Columbia River and its tributaries upstream of the Wind and Hood Rivers (exclusive) to and including the Yakima River and excludes such fish originating from the Snake River Basin (Figure 27). Further, this DPS includes steelhead from seven artificial propagation programs.

A physical description of steelhead is presented in Section 8.20. On March 25, 1999 NMFS listed the Middle Columbia River (MCR) DPS of steelhead as threatened (64 FR 14517) and reaffirmed the DPS's status as threatened on January 5, 2006 (71 FR 834).

Life History

Middle Columbia River steelhead populations are mostly of the summer-run type. Adult steelhead enter fresh water from June through August. The only exceptions are populations of inland winter-run steelhead which occur in the Klickitat River and Fifteenmile Creek (Busby et al. 1996a). The female steelhead selects a site with good intergravel flow, digs a redd with her tail, usually in the coarse gravel of the tail of a pool or in a riffle, and deposits eggs while an attendant male fertilizes them. The preferred water temperature range for steelhead spawning is reported to be 30 degrees Fahrenheit to 52 degrees Fahrenheit (CDFW 2000). The eggs hatch in three to four weeks at 50 degrees Fahrenheit to 59 degrees Fahrenheit and fry emerge from the gravel four to six weeks later (Shapovalov and Taft 1954). Regardless of life history strategy, for the first year or two of life steelhead are found in cool, clear, fast flowing permanent streams and rivers where riffles predominate over pools, there is ample cover from riparian vegetation or undercut banks, and invertebrate life is diverse and abundant (Moyle 2002). The smallest fish are most often found in riffles, intermediate size fish in runs, and larger fish in pools.

The majority of juveniles smolt and out-migrate as two-year olds. Most of the rivers in this region produce about equal or higher numbers of adults having spent one year in the ocean as adults having spent two years. However, summer-run steelhead in Klickitat River have a life cycle more like Lower Columbia River steelhead whereby the majority of returning adults have spent two years in the ocean (Busby et al. 1996a). Adults may hold in the river up to a year before spawning. Unlike Pacific salmon, steelhead are capable of spawning more than once before they die. However, it is rare for steelhead to spawn more than twice before dying, and most that do so are females (Moyle 2002).

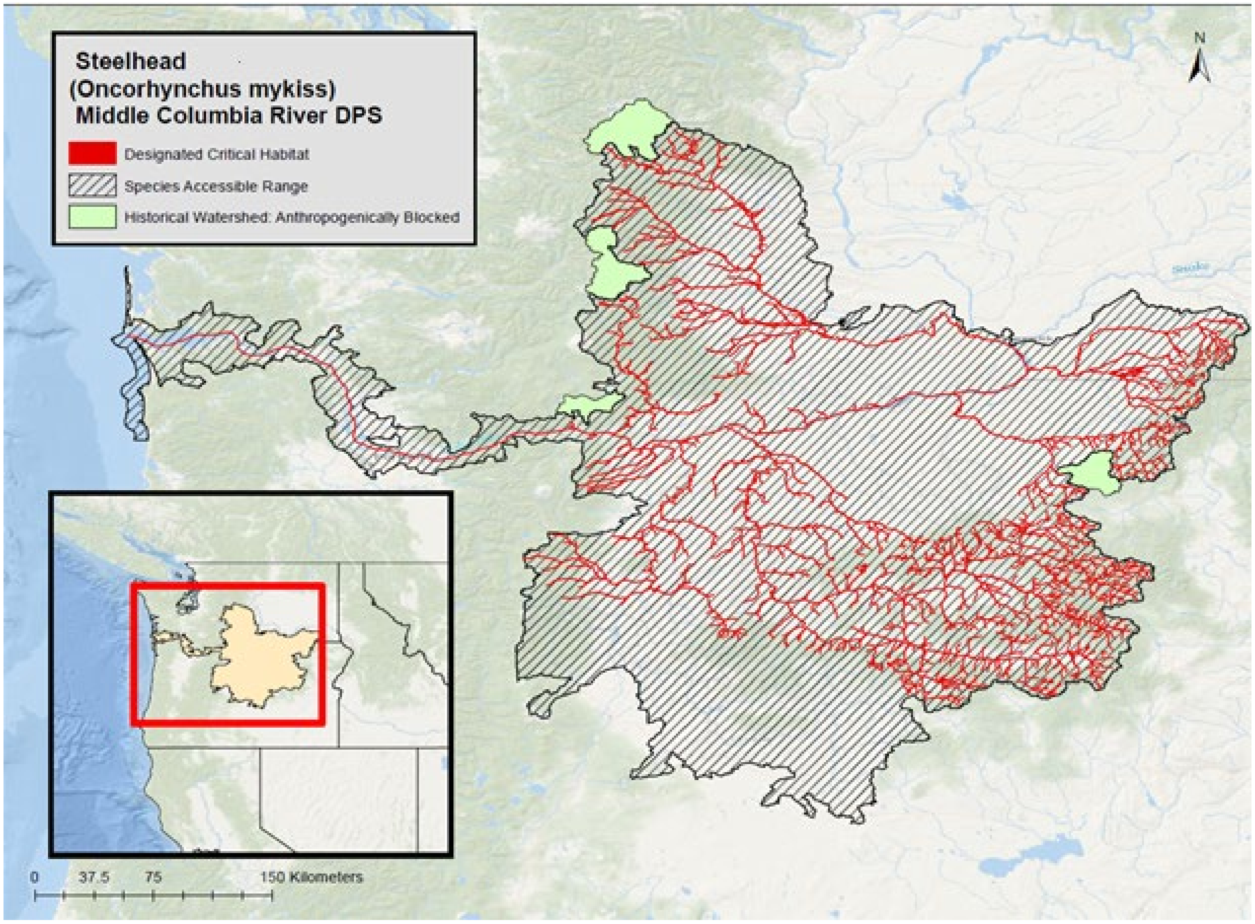

Figure 27. Geographic range and designated critical habitat of Middle Columbia River steelhead.

Population Dynamics

Historic run estimates for the Yakima River imply that annual species abundance may have exceeded 300,000 returning adults (Busby et al. 1996a). The five-year average (geometric mean) return of natural Middle Columbia River steelhead for 1997 to 2001 was up from basin estimates of previous years. Returns to the Yakima River, the Deschutes River, and sections of the John Day River system were substantially higher compared to 1992 to 1997 (Good et al. 2005). The five-year average for these basins is 298 and 1,492 fish, respectively (Good et al. 2005). Current abundance estimates for the Middle Columbia River DPS of steelhead are presented in Table 22 below.

Table 22. Current Abundance Estimates for the Middle Columbia River DPS of Steelhead (NMFS 2020a).

Production	Life Stage	Abundance
Natural	Adult	5,052
Natural	Juvenile	407,697
Listed Hatchery Adipose Clipped	Adult	448

Production	Life Stage	Abundance
Listed Hatchery Adipose Clipped	Juvenile	444,973
Listed Hatchery Intact Adipose	Adult	112
Listed Hatchery Intact Adipose	Juvenile	110,469

There have been improvements in the viability ratings for some of the component populations, but the Middle Columbia River Steelhead DPS is not currently meeting the viability criteria described in the Mid-Columbia Steelhead Recovery Plan.

The ICTRT identified 17 extant populations in this DPS (ICTRT 2003; McClure et al. 2005). The populations fall into four MPGs: Cascade eastern slope tributaries (five extant and two extirpated populations), the John Day River (five extant populations), the Walla Walla and Umatilla rivers (three extant and one extirpated populations), and the Yakima River (four extant populations.

Status

Within the Middle Columbia River DPS of steelhead, the ICTRT identified 16 extant populations in four major population groups (Cascades Eastern Slopes Tributaries, John Day River, Walla Walla and Umatilla Rivers, and Yakima River) and one unaffiliated independent population (Rock Creek) (ICTRT 2003). There are two extinct populations in the Cascades Eastern Slope major population group: the White Salmon River and the Deschutes Crooked River above the Pelton/Round Butte Dam complex. Present population structure is delineated largely on geographical proximity, topography, distance, ecological similarities or differences. Using criteria for abundance and productivity, the ICTRT modeled a gaps analysis for each of the four MPGs in this DPS under three different ocean conditions and a base hydro condition (most recent 20-year survival rate). The results showed that none of the MPGs would be able to achieve a five percent or less risk of extinction over 100 years without recovery actions. It is important to consider that significant gaps in factors affecting spatial structure and diversity also contribute to the risk of extinction for these fish.

Critical Habitat

Critical habitat was designated for this species on September 2, 2005 (70 FR 52630). Critical habitat includes freshwater spawning sites, freshwater rearing sites, and freshwater migration corridors. The PBFs that characterize these sites include water quality and quantity, natural cover, forage, adequate passage conditions, and floodplain connectivity necessary to support spawning, incubation and larval development, juvenile growth and mobility, and adult survival. Designated critical habitat for the Middle Columbia River steelhead does not overlap spatially with the action area and, therefore, will not be analyzed further in this opinion.

Recovery Goals

See the 2009 recovery plan for the Middle Columbia River steelhead DPS for complete down-listing/delisting criteria for recovery goals for the species (NMFS 2009b).

8.24 Steelhead – Northern California DPS

The Northern California DPS of steelhead includes naturally spawned steelhead originating below natural and manmade impassable barriers in California coastal river basins from Redwood Creek to and including the Gualala River (Figure 28).

A physical description of steelhead is presented in Section 8.20. On June 7, 2000 NMFS listed the Northern California DPS of steelhead as threatened (65 FR 36074) and reaffirmed the DPS's status as threatened on January 5, 2006 (71 FR 834).

Life History

The Northern California DPS of steelhead includes both winter- and summer –run steelhead. In the Mad and Eel Rivers, immature steelhead may return to fresh water as "half-pounders" after spending only two to four months in the ocean. Generally, a half-pounder will overwinter in fresh water and return to the ocean in the following spring.

Juvenile out-migration appears more closely associated with size than age but generally, throughout their range in California, juveniles spend two years in fresh water (Busby et al. 1996a). Smolts range from 14-21 cm in length. Juvenile steelhead may migrate to rear in lagoons throughout the year with a peak in the late spring/early summer and in the late fall/early winter period (Shapovalov and Taft 1954; Zedonis 1992).

Steelhead spend anywhere from one to five years in salt water, however, two to three years are most common (Busby et al. 1996a). Ocean distribution is not well known but coded wire tag recoveries indicate that most Northern California steelhead migrate north and south along the continental shelf (Barnhart 1986).

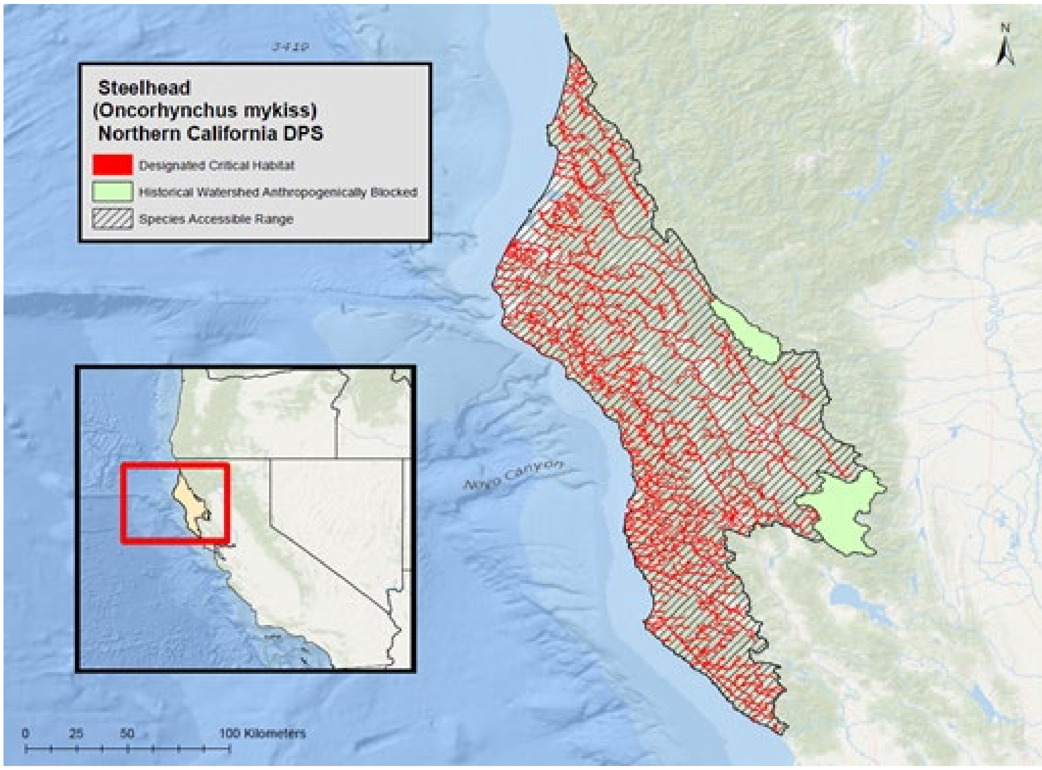

Figure 28. Geographic range and designated critical habitat of Northern California DPS steelhead.

Population Dynamics

Most populations for which there are population estimates available remain well below viability targets; however, the short-term increases observed for many populations, despite the occurrence of a prolonged drought in northern California, suggests this DPS is not at immediate risk of extinction. Current abundance estimates for the Northern California DPS of steelhead are presented in Table 23 below.

Table 23. Current Abundance Estimates for the Northern California DPS of Steelhead (NMFS 2019e).

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

Overall, the available data for winter-run populations— predominately in the North Coastal, North-Central Coastal, and Central Coastal strata— indicate that all populations are well below viability targets, most being between five percent and 13 percent of these goals. For the two Mendocino Coast populations with the longest time series, Pudding Creek and Noyo River, the 13-year trends have been negative and neutral, respectively (Spence 2016). However, the short-term (six-year) trend has been generally positive for all independent populations in the North-Central Coastal and Central Coastal strata, including the Noyo River and Pudding Creek (Spence

2016). Data from Van Arsdale Station likewise suggests that, although the long-term trend has been negative, run sizes of natural-origin steelhead have stabilized or are increasing (Spence 2016). Thus, we have no strong evidence to indicate conditions for winter-run populations in the DPS have worsened appreciably since the last status review (NMFS 2016a). Summer-run populations continue to be of significant concern because of how few populations currently exist. The Middle Fork Eel River population has remained remarkably stable for nearly five decades and is closer to its viability target than any other population in the DPS (Spence 2016). Although the time series is short, the Van Duzen River appears to be supporting a population numbering in the low hundreds. However, the Redwood Creek and Mattole River populations appear small, and little is known about other populations including the Mad River and other tributaries of the Eel River (i.e., Larabee Creek, North Fork Eel, and South Fork Eel).

Artificial propagation was identified as negatively affecting wild stocks of salmonids through interactions with non-native fish, introductions of disease, genetic changes, competition for space and food resources, straying and mating with native populations, loss of local genetic adaptations, mortality associated with capture for broodstock and palliating the destruction of habitat and concealing problems facing wild stocks.

Status

Data on the populations of Northern California DPS steelhead are discussed in the *Population Dynamics* section above. Most populations for which there are population estimates available remain well below viability targets; however, the short-term increases observed for many populations, despite the occurrence of a prolonged drought in northern California, suggests this DPS is not at an immediate risk of extinction.

Critical Habitat

NMFS designated critical habitat for Northern California DPS steelhead on September 2, 2005. Critical habitat includes freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and estuarine areas. The PBFs that characterize these sites include water quality and quantity, natural cover, forage, adequate passage conditions, and floodplain connectivity necessary to support spawning, incubation and larval development, juvenile growth and mobility, and adult survival. Designated critical habitat for the Northern California DPS steelhead does not overlap spatially with the action area and, therefore, will not be analyzed further in this opinion.

Recovery Goals

See the 2016 recovery plan for the Northern California steelhead DPS for complete down-listing/delisting criteria for recovery goals for the DPS (NMFS 2016c).

8.25 Steelhead – Puget Sound DPS

This DPS includes naturally spawned anadromous *O. mykiss* (steelhead) originating below natural and manmade impassable barriers from rivers flowing into Puget Sound from the Elwha

River (inclusive) eastward, including rivers in Hood Canal, South Sound, North Sound and the Georgia Strait (Figure 29), and also, steelhead from six artificial propagation programs.

A physical description of steelhead is presented in Section 8.20. On May 11, 2007 NMFS listed the Puget Sound DPS of steelhead as threatened (72 FR 26722).

Life History

The Puget Sound steelhead DPS contains both winter-run and summer-run steelhead. Adult winter-run steelhead generally return to Puget Sound tributaries from December to April (NMFS 2005). Spawning occurs from January to mid-June, with peak spawning occurring from mid-April through May. Prior to spawning, maturing adults hold in pools or in side channels to avoid high winter flows. Less information exists for summer-run steelhead as their smaller run size and higher altitude headwater holding areas have not been conducive for monitoring. Based on information from four streams, adult run time occur from mid-April to October with a higher concentration from July through September (NMFS 2005).

The majority of juveniles reside in the river system for two years with a minority migrating to the ocean as one or three-year olds. Smoltification and seaward migration occur from April to mid-May. The ocean growth period for Puget Sound steelhead ranges from one to three years in the ocean (Busby et al. 1996a). Juveniles or adults may spend considerable time in the protected marine environment of the fjord-like Puget Sound during migration to the high seas.

Population Dynamics

Abundance of adult steelhead returning to nearly all Puget Sound rivers has fallen substantially since estimates began for many populations in the late 1970s and early 1980s. Inspection of geometric means of total spawner abundance from 2010 to 2014 indicates that nine of 20 populations evaluated had geometric mean abundances fewer than 250 adults and 12 of 20 had fewer than 500 adults.

Smoothed trends in abundance indicate modest increases since 2009 for 13 of the 22 DIPs. Between the two most recent five-year periods (2005-2009 and 2010-2014), the geometric mean of estimated abundance increased by an average of 5.4 percent. For seven populations in the Northern Cascades MPG, the increase was three percent; for five populations in the Central & South Puget Sound MPG, the increase was 10 percent; and for six populations in the Hood Canal & Strait of Juan de Fuca MPG, the increase was 4.5 percent. However, several of these upward trends are not statistically different from neutral, and most populations remain small. Long-term (15-year) trends in natural spawners are predominantly negative (NWFSC 2015a). Current abundance estimates for the Puget Sound DPS of steelhead are presented in Table 24 and Table 25 below.

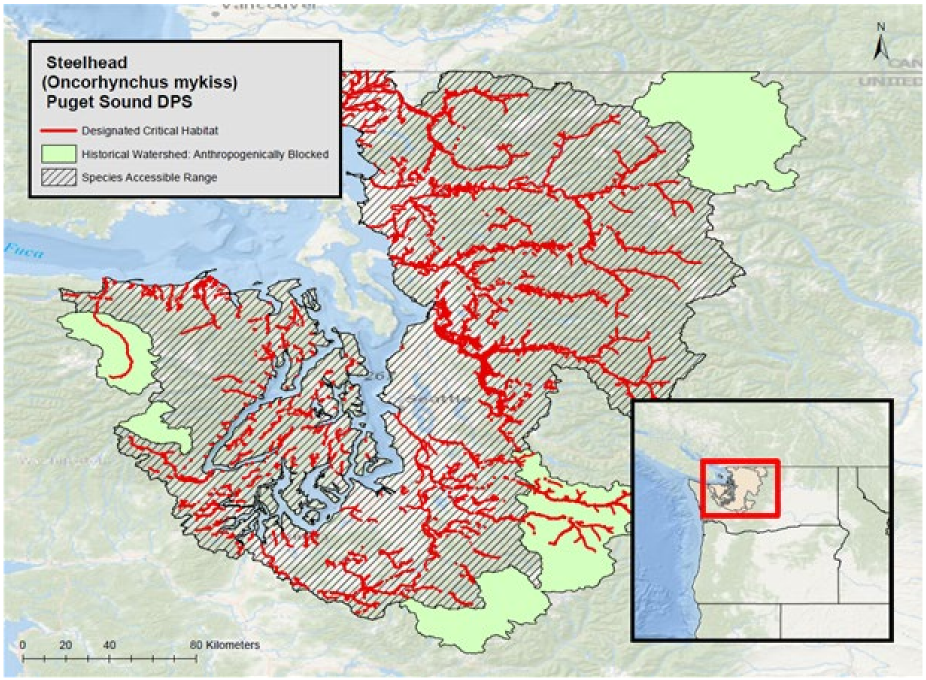

Figure 29. Geographic range and designated critical habitat of Puget Sound DPS steelhead.

Table 24. Expected 2019 Puget Sound steelhead listed hatchery releases (NMFS 2020a).

Subbasin	Artificial propagation program	Brood year	Run Timing	Clipped Adipose Fin	Intact Adipose Fin
Dungeness/Elwha	Dungeness	2018	Winter	10,000	-
	Hurd Creek	2018	Winter	-	34,500
Duwamish/Green	Flaming Geyser	2018	Winter	-	15,000
	Icy Creek	2018	Summer	50,000	-
			Winter	-	28,000
	Soos Creek	2018	Summer	50,000	-
Puyallup	White River	2018	Winter	-	35,000
Total Annual Release Number				**110,000**	**112,500**

Table 25. Abundance of Puget Sound steelhead spawner escapements (natural-origin and hatchery-production combined) from 2012-2016 (NMFS 2020a).

Demographically Independent Populations	Spawners	Expected Number of Outmigrants[b]
Central and South Puget Sound MPG		
Cedar River	3	391
Green River	977	111,179
Nisqually River	759	86,323
N. Lake WA/Lake Sammamish	-	-
Puyallup/Carbon River	603	68,646

Demographically Independent Populations	Spawners	Expected Number of Outmigrants[b]
White River	629	71,638
Hood Canal and Strait of Juan de Fuca MPG		
Dungeness River[c]	26	2,984
East Hood Canal Tribs.	89	10,120
Elwha River	878	99,954
Sequim/Discovery Bay Tribs.	19	2,186
Skokomish River	862	98,066
South Hood Canal Tribs.	73	8,304
Strait of Juan de Fuca Tribs.	173	19,697
West Hood Canal Tribs.	122	13,858
North Cascades MPG		
Nooksack River	1,790	203,631
Pilchuck River	868	98,709
Samish River/ Bellingham Bay Tribs.	977	111,167
Skagit River	8,038	914,353
Snohomish/Skykomish Rivers	1,053	119,762
Snoqualmie River	824	93,772
Stillaguamish River	476	54,170
Tolt River	70	7,988
TOTAL	**19,313**	**2,196,901**

Only two hatchery stocks genetically represent native local populations (Hamma and Green River natural winter-run). The remaining programs, which account for the vast preponderance of production, are either out-of-DPS derived stocks or were within-DPS stocks that have diverged substantially from local populations. The WDFW estimated that 31 of the 53 stocks were of native origin and predominantly natural production (Washington Department of Fish and Wildlife (WDFW) 1993).

Fifty-three populations of steelhead have been identified in this DPS, of which 37 are winter-run. Summer-run populations are distributed throughout the DPS but are concentrated in northern Puget Sound and Hood Canal; only the Elwha River and Canyon Creek support summer-run steelhead in the rest of the DPS. The Elwha River run, however, is descended from introduced Skamania Hatchery summer-run steelhead. Historical summer-run steelhead in the Green River and Elwha River were likely extirpated in the early 1900s.

Status

For all but a few putative demographically independent populations of steelhead in Puget Sound, estimates of mean population growth rates obtained from observed spawner or redd counts are declining—typically three to 10 percent annually. Extinction risk within 100 years for most populations in the DPS is estimated to be moderate to high, especially for draft populations in the putative South Sound and Olympic major population groups. Collectively, these analyses indicate that steelhead in the Puget Sound DPS remain at risk of extinction throughout all or a significant portion of their range in the foreseeable future, but are not currently in danger of imminent extinction. The Biological Review for the latest 5-Year Review of the Puget Sound DPS of steelhead identified degradation and fragmentation of freshwater habitat, with consequent effects on connectivity, as the primary limiting factors and threats facing the Puget Sound steelhead DPS. The status of the listed Puget Sound steelhead DPS has not changed substantially since the 2007 listing. Most populations within the DPS are showing continued downward trends in estimated abundance, a few sharply so. The limited available information indicates that this DPS remains at a moderate risk of extinction.

Critical Habitat

NMFS designated critical habitat for Puget Sound steelhead on February 2, 2016 (81 FR 9251). The specific areas designated for Puget Sound steelhead include approximately 2,031 stream miles (3,269 kilometers) within the geographical area presently occupied by this DPS (Figure 29). Designated critical habitat for the Puget Sound steelhead does not overlap spatially with the action area and, therefore, will not be analyzed further in this opinion.

Recovery Goals

NMFS published a final recovery plan for the Puget Sound DPS of steelhead on December 20, 2019 (NMFS 2019g). The recovery plan's primary goals are as follows:

- The Puget Sound steelhead DPS achieves biological viability and the ecosystems upon which the DPS depends are conserved such that it is sustainable and persistent and no longer needs federal protection under the ESA; and
- The five listing factors from the ESA, section 4 (a)(1) are addressed. The five listing factors from the ESA, section 4(a)(1), include:
    - The present or threatened destruction, modification, or curtailment of the species' habitat or range;
    - Overutilization for commercial, recreational, scientific, or educational purposes;
    - Disease or predation;
    - Inadequacy of existing regulatory mechanisms; and
    - Other natural or human-made factors affecting the species' continued existence.

Delisting criteria for the Puget Sound DPS of steelhead are detailed in NMFS (2019g).

8.26 Steelhead – Snake River Basin DPS

The Snake River Basin DPS of steelhead includes naturally spawned steelhead originating below natural and manmade impassable barriers from the Snake River Basin (Figure 30), and also steelhead from six artificial propagation programs.

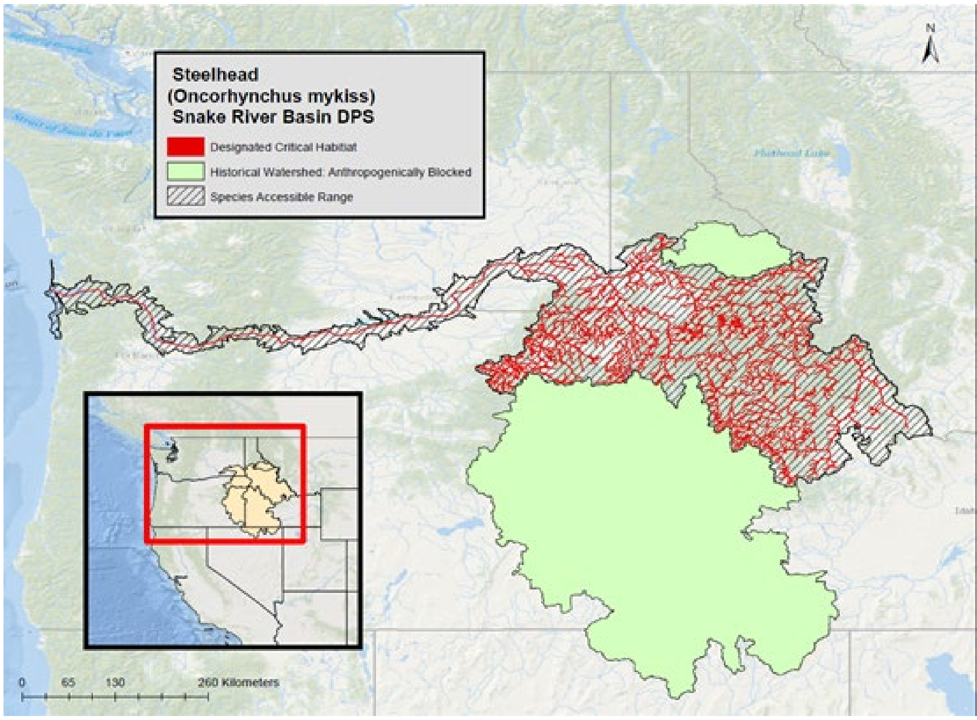

Figure 30. Geographic range and designated critical habitat of Snake River Basin steelhead.

A physical description of steelhead is presented in Section 8.20. On August 18, 1997 NMFS listed the Snake River Basin DPS of steelhead as threatened (62 FR 43937) and reaffirmed the DPS's status as threatened on January 5, 2006 (71 FR 834).

Life History

Snake River Basin steelhead are generally classified as summer-run fish. They enter the Columbia River from late June to October. After remaining in the river through the winter, Snake River Basin steelhead spawn the following spring (March to May). Managers recognize two life history patterns within this DPS primarily based on ocean age and adult size upon return: A-run or B-run. A-run steelhead are typically smaller, have a shorter freshwater and ocean residence (generally one year in the ocean), and begin their up-river migration earlier in the year. B-run steelhead are larger, spend more time in fresh water and the ocean (generally two years in ocean), and appear to start their upstream migration later in the year. Snake River Basin steelhead usually smolt after two or three years.

The female steelhead selects a site with good intergravel flow, digs a redd with her tail, usually in the coarse gravel of the tail of a pool or in a riffle, and deposits eggs while an attendant male fertilizes them. The preferred water temperature range for steelhead spawning is reported to be 30 degrees Fahrenheit to 52 degrees Fahrenheit (CDFW 2000). The eggs hatch in three to four weeks at 50 degrees Fahrenheit to 59 degrees Fahrenheit, and fry emerge from the gravel four to six weeks later (Shapovalov and Taft 1954). Regardless of life history strategy, for the first year or two of life steelhead are found in cool, clear, fast flowing permanent streams and rivers where riffles predominate over pools, there is ample cover from riparian vegetation or undercut banks, and invertebrate life is diverse and abundant (Moyle 2002). The smallest fish are most often found in riffles, intermediate size fish in runs, and larger fish in pools.

The majority of juveniles smolt and out-migrate as two-year olds. Adults may hold in the river up to a year before spawning. Unlike Pacific salmon, steelhead are capable of spawning more than once before they die. However, it is rare for steelhead to spawn more than twice before dying, and most that do so are females (Moyle 2002).

Population Dynamics

There is uncertainty for wild populations of Snake River Basin DPS steelhead given limited data for adult spawners in individual populations. Regarding population growth rate, there are mixed long- and short-term trends in abundance and productivity. Overall, the abundances remain well below interim recovery criteria. Current abundance estimates for the Snake River Basin DPS of steelhead are presented in Table 26 below.

Table 26. Current Abundance Estimates for the Snake River Basin DPS of Steelhead (NMFS 2020a).

Production	Life Stage	Abundance
Natural	Adult	10,547
Natural	Juvenile	798,341
Listed Hatchery Adipose Clipped	Adult	79,510
Listed Hatchery Adipose Clipped	Juvenile	3,300,152
Listed Hatchery Intact Adipose	Adult	16,137
Listed Hatchery Intact Adipose	Juvenile	705,490

Status

Four out of the five MPGs are not meeting the specific objectives in the draft recovery plan being written by NMFS based on the updated status information available for this review, and the status of many individual populations remains uncertain (NWFSC 2015b). The Grande Ronde MPG is tentatively rated as viable; more specific data on spawning abundance and the relative contribution of hatchery spawners for the Lower Grande Ronde and Wallowa populations would improve future assessments. A great deal of uncertainty still remains regarding the relative proportion of hatchery fish in natural spawning areas near major hatchery release sites within individual populations.

Critical Habitat

Critical habitat was designated for this species on September 2, 2005 (70 FR 52630). Critical habitat includes freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and estuarine areas. The PBFs that characterize these sites include water quality and quantity, natural cover, forage, adequate passage conditions, and floodplain connectivity necessary to support spawning, incubation and larval development, juvenile growth and mobility, and adult survival. Designated critical habitat for the Snake River Basin steelhead does not overlap spatially with the action area and, therefore, will not be analyzed further in this opinion.

Recovery Goals

NMFS published a final recovery plan for the Snake River Basin DPS of steelhead on November 30, 2017 (NMFS 2017d). The ESA recovery goal for Snake River Basin steelhead is that: The ecosystems upon which the steelhead depend are conserved such that the DPS is self-sustaining in the wild and no longer need ESA protection. More information on the Snake River Basin DPS' recovery goals and delisting criteria are found in NMFS (2017d).

8.27 Steelhead South-Central California DPS

The South-Central California Coast DPS of steelhead includes naturally spawned steelhead originating below natural and manmade impassable barriers from the Pajaro River to (but not including) the Santa Maria River (Figure 31). No artificially propagated steelhead populations that reside within the historical geographic range of this DPS are included in this designation. The two largest basins overlapping within the range of this DPS include the inland basins of the Pajaro River and the Salinas River.

A physical description of steelhead is presented in Section 8.20. On August 18, 1997 NMFS listed the South-Central California Coast DPS of steelhead as threatened (62 FR 43937) and reaffirmed the DPS's status as threatened on January 5, 2006 (71 FR 5248).

Life History

Only winter steelhead are found in the South-Central California Coast DPS of steelhead. Most spawning takes place from January through April. The female steelhead selects a site with good intergravel flow, digs a redd with her tail, usually in the coarse gravel of the tail of a pool or in a riffle, and deposits eggs while an attendant male fertilizes them. The preferred water temperature range for steelhead spawning is reported to be 30 degrees Fahrenheit to 52 degrees Fahrenheit (CDFW 2000). The eggs hatch in three to four weeks at 50 degrees Fahrenheit to 59 degrees Fahrenheit, and fry emerge from the gravel four to six weeks later (Shapovalov and Taft 1954). Regardless of life history strategy, for the first year or two of life steelhead are found in cool, clear, fast flowing permanent streams and rivers where riffles predominate over pools, there is ample cover from riparian vegetation or undercut banks, and invertebrate life is diverse and abundant (Moyle 2002). The smallest fish are most often found in riffles, intermediate size fish in runs, and larger fish in pools.

Steelhead typically migrate to marine waters after spending two years in fresh water. They reside in marine waters for typically two or three years prior to returning to their natal stream to spawn as four- or five-year olds. Unlike Pacific salmon, steelhead are capable of spawning more than once before they die. However, it is rare for steelhead to spawn more than twice before dying, and most that do so are females (Moyle 2002). There is limited life history information for steelhead in this DPS.

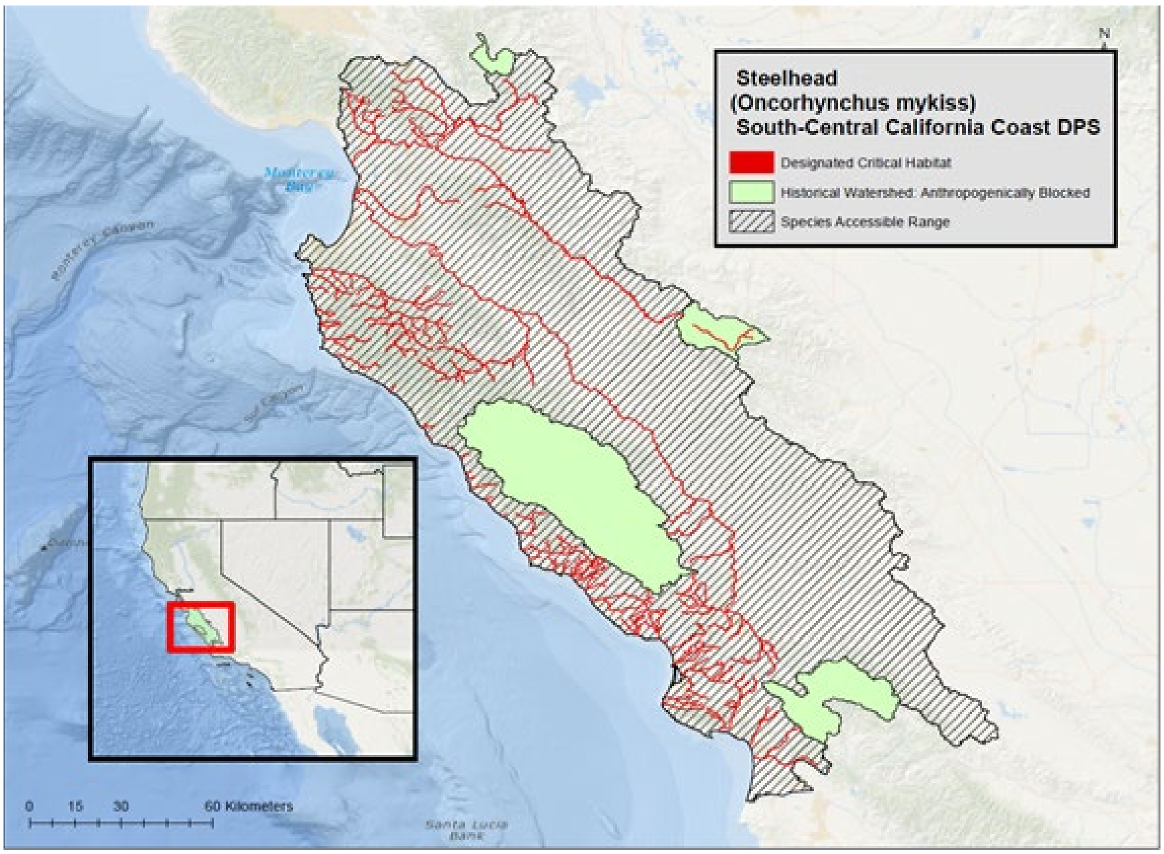

Figure 31. Geographic range and designated critical habitat of South-Central California Coast steelhead.

Population Dynamics

The data summarized in the most recent status review indicate small (generally <10 fish) but surprisingly persistent annual runs of anadromous *O. mykiss* are currently being monitored across a limited but diverse set of basins within the range of this DPS, but interrupted in years when the mouth of the coastal estuaries fail to open to the ocean due to low flows (Williams et al. 2011). Current abundance estimates for the South-Central California Coast DPS of steelhead are presented in Table 27 below.

Table 27. Current Abundance Estimates for the South-Central California Coast DPS of Steelhead (NMFS 2019e).

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

Status

Following the dramatic rise in South-Central California's human population after World War II and the associated land and water development within coastal drainages (particularly major dams and water diversions), steelhead abundance rapidly declined, leading to the extirpation of populations in many watersheds and leaving only sporadic and remnant populations in the remaining, more highly modified watersheds such as the Salinas River and Arroyo Grande Creek watersheds (NMFS 2013d). A substantial portion of the upper watersheds, which contain the majority of historical spawning and rearing habitats for anadromous *O. mykiss*, remain intact (though inaccessible to anadromous fish) and protected from intensive development as a result of their inclusion in the Los Padres National Forest (NMFS 2013d).

Critical Habitat

Critical habitat was designated for this species on September 2, 2005 (70 FR 52630). Critical habitat includes freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and estuarine areas. The PBFs that characterize these sites include water quality and quantity, natural cover, forage, adequate passage conditions, and floodplain connectivity necessary to support spawning, incubation and larval development, juvenile growth and mobility, and adult survival. Designated critical habitat for the South-Central California Coast steelhead does not overlap spatially with the action area and, therefore, will not be analyzed further in this opinion.

Recovery Goals

See the 2013 recovery plan for the South-Central California Coast steelhead DPS (NMFS 2013d) for complete down-listing/delisting criteria for recovery goals for the species.

8.28 Steelhead – Upper Columbia River DPS

The Upper Columbia River DPS of steelhead includes naturally spawned anadromous steelhead originating below natural and manmade impassable barriers from the Columbia River and its tributaries upstream of the Yakima River to the U.S.-Canada border (Figure 32). Also, the Upper Columbia River DPS includes steelhead from six artificial propagation programs.

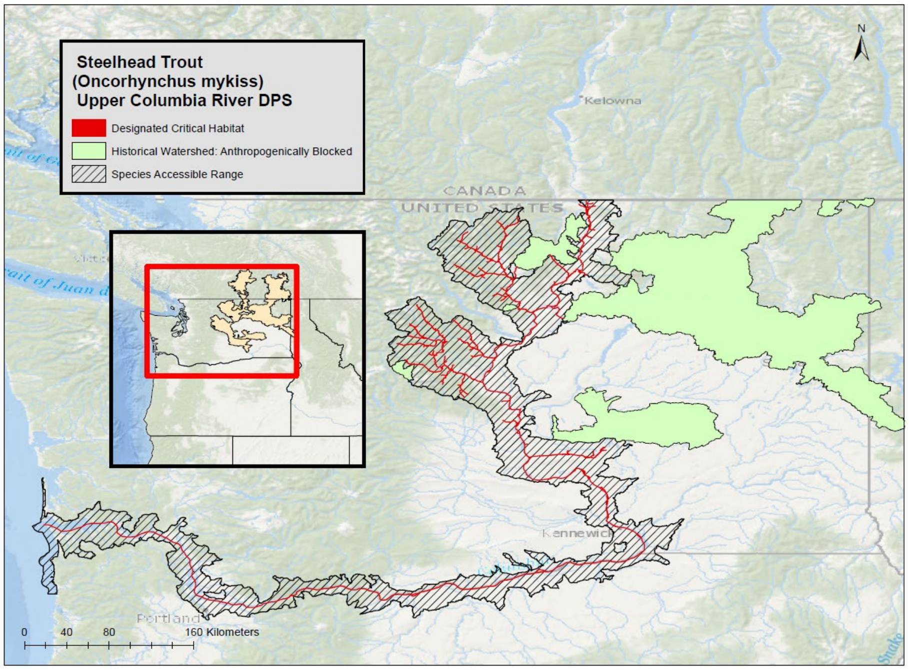

Figure 32. Geographic range and designated critical habitat of upper Columbia River steelhead.

A physical description of steelhead is presented in Section 8.20. On August 18, 1997 NMFS listed the Upper Columbia River DPS of steelhead as endangered (62 FR 43937) and reaffirmed the DPS's status as endangered on January 5, 2006 (71 FR 834).

Life History

All Upper Columbia River steelhead are summer-run steelhead. Adults return in the late summer and early fall, with most migrating relatively quickly to their natal tributaries. A portion of the returning adult steelhead overwinter in mainstem reservoirs, passing over upper-mid-Columbia dams in April and May of the following year. Spawning occurs in the late spring of the year following river entry. Juvenile steelhead spend one to seven years rearing in fresh water before migrating to sea. Smolt out migrations are predominantly year class two and three (juveniles), although some of the oldest smolts are reported from this DPS at seven years. Most adult steelhead return to fresh water after one or two years at sea.

Population Dynamics

The most recent estimates of natural-origin spawner abundance for each of the four populations in the Upper Columbia River DPS of steelhead show fairly consistent patterns throughout the years. None of the populations have reached their recovery goal numbers during any of the years (500 for the Entiat, 2,300 for the Methow, 2,300 for the Okanogan, and 3,000 for Wenatchee). Current abundance estimates for the Upper Columbia River DPS of steelhead are presented in Table 28 below.

Table 28. Current Abundance Estimates for the Upper Columbia River DPS of Steelhead (NMFS 2020a).

Production	Life Stage	Abundance
Natural	Adult	3,988
Natural	Juvenile	169,120
Listed Hatchery Adipose Clipped	Juvenile	662,848
Listed Hatchery Intact Adipose	Adult	2,403
Listed Hatchery Intact Adipose	Juvenile	144,067

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. In spite of recent increases, natural origin abundance and productivity remain well below viability thresholds for three out of the four populations, and the Okanogan River natural-origin spawner abundance estimates specifically are well below the recovery goal for that population. Three of four extant natural populations are considered to be at high risk of extinction and one at moderate risk.

All populations are at high risk for diversity, largely driven by chronic high levels of hatchery spawners within natural spawning areas and lack of genetic diversity among the populations.

The Upper Columbia River steelhead DPS is composed of three MPGs, two of which are isolated by dams. With the exception of the Okanogan population, the Upper Columbia River populations were rated as low risk for spatial structure.

Status

Current estimates of natural origin spawner abundance increased relative to the levels observed in the prior review for all three extant populations, and productivities were higher for the Wenatchee and Entiat and unchanged for the Methow (NWFSC 2015b). However abundance and productivity remained well below the viable thresholds called for in the Upper Columbia Recovery Plan for all three populations. Short-term patterns in those indicators appear to be largely driven by year-to year fluctuations in survival rates in areas outside of these watersheds. All three populations continued to be rated at low risk for spatial structure but at high risk for diversity criteria. Although the status of the DPS is improved relative to measures available at the time of listing, all three populations remain at high risk (NWFSC 2015b).

Critical Habitat

Critical habitat was designated for the Upper Columbia River DPS of steelhead on September 2, 2005 (70 FR 52630). Critical habitat includes freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and estuarine areas. The PBFs that characterize these sites include water quality and quantity, natural cover, forage, adequate passage conditions, and floodplain connectivity necessary to support spawning, incubation and larval development, juvenile growth and mobility, and adult survival. Designated critical habitat for the Upper Columbia River steelhead does not overlap spatially with the action area and, therefore, will not be analyzed further in this opinion.

Recovery Goals

See the 2007 recovery plan for the Upper Columbia River steelhead DPS for complete down-listing/delisting criteria for recovery goals for the species (NMFS 2007b).

8.29 Steelhead – Upper Willamette River DPS

This DPS includes naturally spawned anadromous winter-run *O. mykiss* (steelhead) originating below natural and manmade impassable barriers from the Willamette River and its tributaries upstream of Willamette Falls to and including the Calapooia River (Figure 33).

A physical description of steelhead is presented in Section 8.20. On March 25, 1999 NMFS listed the Upper Willamette River DPS of steelhead as threatened (64 FR 14517) and reaffirmed the DPS's status as threatened on January 5, 2006 (71 FR 834).

Life History

Native steelhead in the Upper Willamette are a late-migrating winter group that enters fresh water in January and February (Howell et al. 1985). Upper Willamette River steelhead do not ascend to their spawning areas until late March or April, which is late compared to other West Coast winter steelhead. Spawning occurs from April to June 1. The unusual run timing may be an adaptation for ascending the Willamette Falls, which may have facilitated reproductive isolation of the stock. The smolt migration past Willamette Falls also begins in early April and proceeds into early June, peaking in early- to mid-May (Howell et al. 1985). Smolts generally migrate through the Columbia via Multnomah Channel rather than the mouth of the Willamette River. As with other coastal steelhead, the majority of juvenile smolts outmigrate after two years; adults return to their natal rivers to spawn after spending two years in the ocean. Repeat spawners are predominantly female and generally account for less than 10 percent of the total run size (Busby et al. 1996a).

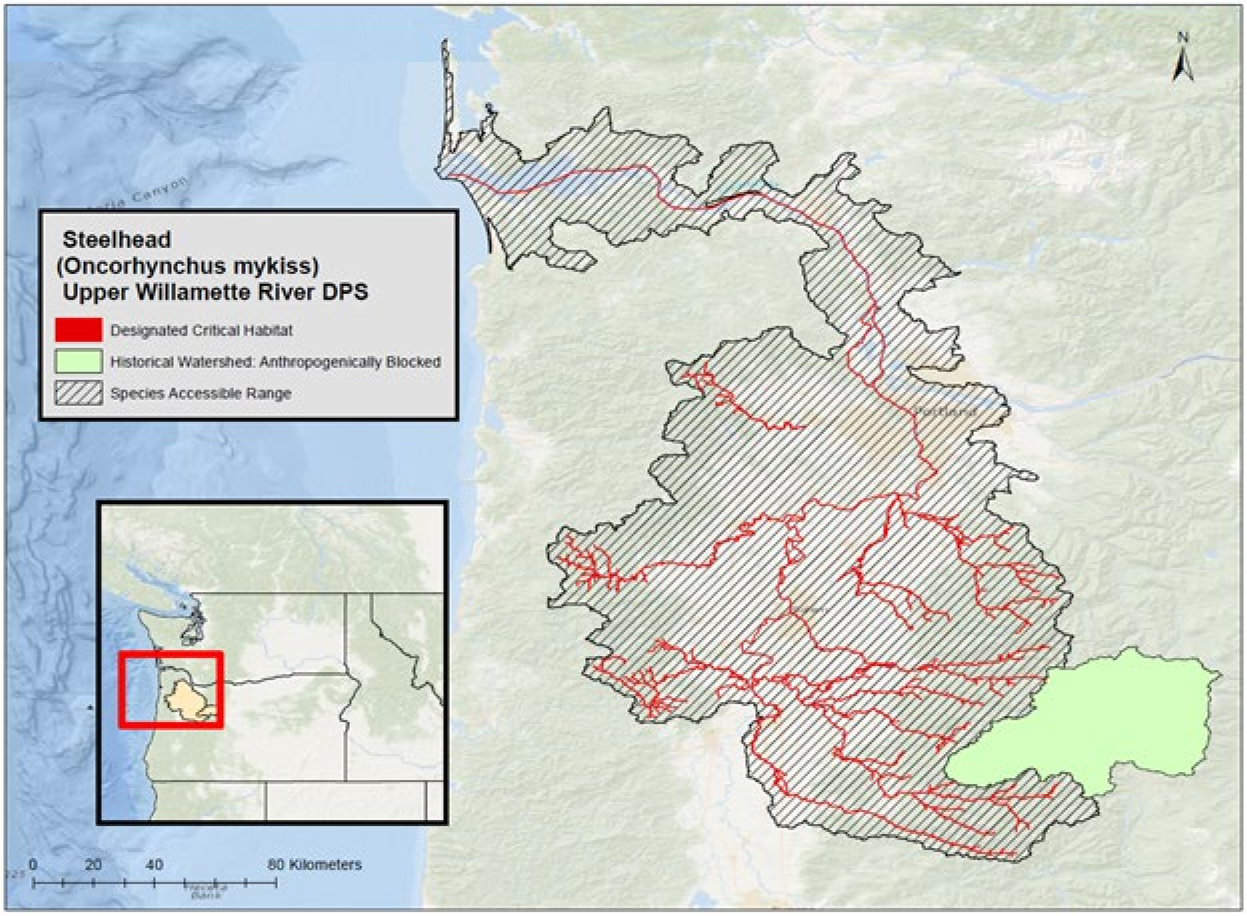

Figure 33. Geographic range and designated critical habitat of upper Willamette River steelhead.

Population Dynamics

For the Upper Willamette River steelhead DPS, the declines in abundance noted during the previous status review continued through 2010 to 2015, and accessibility to historical spawning habitat remains limited, especially in the North Santiam River. Although the recent magnitude of these declines is relatively moderate, NMFS Northwest Fisheries Science Center (NWFSC 2015b) notes that continued declines would be a cause for concern.

Recent estimates of escapement in the Molalla River indicate abundance is stable but at a depressed level, and the lack of migration barriers indicates this limitation is likely due to habitat degradation (NWFSC 2015b). In the North Santiam, radio-tagging studies and counts at Bennett Dam between 2010 and 2014 estimate the average abundance of returning winter-run adults is following a long-term negative trend (NWFSC 2015b). In the South Santiam live counts at Foster Dam indicate a negative trend in abundance from 2010-2014, and redd survey data indicate consistent low numbers of spawners in tributaries (NWFSC 2015b). Radio-tagging studies in the Calapooia from 2012-2014 suggest that abundances have been depressed but fairly stable, however long-term trends in redd counts conducted since 1985 are generally negative

(NWFSC 2015b). Current abundance estimates for the Upper Willamette River DPS of steelhead are presented in Table 29 below.

Table 29. Current Abundance Estimates for the Upper Willamette River DPS of Steelhead (NMFS 2019d).

Production	Life Stage	Abundance
Natural	Adult	2,912
Natural	Juvenile	143,898

Genetic analysis suggests that there is some level introgression among native late-winter steelhead and summer-run steelhead (Van Doornik et al. 2015), and up to approximately 10 percent of the juvenile steelhead at Willamette Falls and in the Santiam Basin may be hybrids (Johnson et al. 2013). While winter-run steelhead have largely maintained their genetic distinctiveness over time (Van Doornik et al. 2015), there are still concerns that hybridization will decrease the overall productivity of the native population. In addition, releases of large numbers of hatchery-origin summer steelhead may temporarily exceed rearing capacities and displace winter-run juvenile steelhead (NWFSC 2015b).

There are four DIPs within the Upper Willamette River DPS of steelhead. Historical observations, hatchery records, and genetics suggest that the presence of Upper Willamette River DPS steelhead in many tributaries on the west side of the upper basin is the result of recent introductions. Nevertheless, the Willamette/Lower Columbia Technical Recovery Team recognized that although west side Upper Willamette River DPS steelhead does not represent a historical population, those tributaries may provide juvenile rearing habitat or may be temporarily (for one or more generations) colonized during periods of high abundance. Hatchery summer-run steelhead that are released in the subbasins are from an out-of-basin stock, and are not part of the DPS, nor are stocked summer steelhead that have become established in the McKenzie River (ODFW and NMFS 2011).

Status

Four basins on the east side of the Willamette River historically supported independent populations for the Upper Willamette River DPS steelhead, all of which remain extant. Data indicate that currently the two largest populations within the DPS are the Santiam River populations. Mean spawner abundance in both the North and South Santiam River is about 2,100 native winter-run steelhead. However, about 30 percent of all habitat has been lost due to human activities (McElhany et al. 2007). The North Santiam population has been substantially affected by the loss of access to the upper North Santiam basin. The South Santiam subbasin has lost habitat behind non-passable dams in the Quartzville Creek watershed. Notwithstanding the lost spawning habitat, the DPS continues to be spatially well distributed, occupying each of the four major subbasins.

Overall, the declines in abundance noted during the previous review continued through the period from 2010 to 2015 (NWFSC 2015b). There is considerable uncertainty in many of the abundance estimates, except for perhaps the tributary dam counts. Radio-tagging studies suggest that a considerable proportion of winter-run steelhead ascending Willamette Falls do not enter the DIPs that constitute this DPS; these fish may be nonnative early winter-run steelhead that appear to have colonized the western tributaries, misidentified summer-run steelhead, or late winter-run steelhead that have colonized tributaries not historically part of the DPS.

Critical Habitat

NMFS designated critical habitat for this species on September 2, 2005. Critical habitat includes freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and estuarine areas. Designated critical habitat for the Upper Willamette River steelhead DPS does not overlap spatially with the action area and, therefore, will not be analyzed further in this opinion.

Recovery Goals

See the 2011 recovery plan for the Upper Willamette River steelhead DPS (NMFS 2011e) for complete down-listing/delisting criteria for recovery goals for the species. To qualify for delisting, the recovery plan recommends biologically based viability criteria, defined at the level of the DPS, strata (spatially related populations), and component populations. The viability criteria has five essential elements: stratified approach, the number of viable populations, the presence and status of representative populations, non-deterioration (i.e., all extant populations are maintained), and safety factors (i.e., buffering against risk of catastrophic events to ensure a population's viability).

9 ENVIRONMENTAL BASELINE

The "environmental baseline" is 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 consultation, 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).

A number of human activities have contributed to the status of populations of ESA-listed species that are likely to be adversely affected by the proposed action (Section 8) within the action area. Some human activities are ongoing and appear to continue to affect marine mammal populations in the action area for this consultation. Some of these activities, most notably commercial whaling, occurred extensively in the past and continue at low levels that no longer appear to significantly affect marine mammal populations, although the effects of past reductions in numbers persist today. The following discussion summarizes the impacts, which include climate change, oceanic temperature regimes, unnatural mortality events, whaling and subsistence harvest, vessel strike, whale watching, fisheries (fisheries interactions and aquaculture), pollution (marine debris, pesticides and contaminants, and hydrocarbons), aquatic nuisance species, anthropogenic sound (vessel sound and commercial shipping, aircraft, seismic surveys, and marine construction), military activities, and scientific research activities.

9.1 Climate Change

There is a large and growing body of literature on past, present, and future impacts of global climate change, exacerbated and accelerated by human activities. Climate change effects include changes in air and water temperatures, changes in precipitation and drought patterns, increased frequency and magnitude of severe weather events, and sea level rise; all of which are likely to impact ESA resources. Annual average temperatures have increased by 1.8 degrees Celsius across the contiguous U.S. since the beginning of the 20th century with Alaska warming faster than any other state and twice as fast as the global average since the mid-20th century (Jay et al. 2018). Globally, there have been more frequent heatwaves in most land regions and an increase in the frequency and duration of marine heatwaves (IPCC 2018). Additional consequences of climate change include increased ocean stratification, decreased sea-ice extent, altered patterns of ocean circulation, and decreased ocean oxygen levels (Doney et al. 2012). NOAA's climate information portal provides basic background information on these and other measured or anticipated climate change effects (see https://climate.gov).

Climate change has the potential to impact species abundance, geographic distribution, migration patterns, and susceptibility to disease and contaminants, as well as the timing of seasonal activities and community composition and structure (MacLeod et al. 2005; Robinson et al. 2005; Kintisch 2006; Learmonth et al. 2006; McMahon and Hays 2006; Evans and Bjørge 2013; IPCC 2014). Marine species' ranges are expected to shift as they align their distributions to match their physiological tolerances under changing environmental conditions (Doney et al. 2012). Hazen et al. (2012) examined top predator distribution and diversity in the Pacific Ocean in light of rising sea surface temperatures using a database of electronic tags and output from a global climate model. They predicted up to a 35 percent change in core habitat area for some key marine predators in the Pacific Ocean, with some species predicted to experience gains in available core habitat and some predicted to experience losses. McMahon and Hays (2006) predicted increased ocean temperatures would expand the distribution of leatherback turtles into more northern latitudes. The authors noted this is already occurring in the Atlantic Ocean. Willis-Norton et al. (2015) acknowledged there would be both habitat loss and gain, but overall climate change could result in a 15 percent loss of core pelagic habitat for leatherback turtles in the eastern South Pacific Ocean. MacLeod (2009) estimated, based upon expected shifts in water temperature, 88 percent of cetaceans will be affected by climate change, with 47 percent predicted to experience unfavorable conditions (e.g., range contraction).

Changes in the marine ecosystem caused by global climate change (e.g., ocean acidification, salinity, oceanic currents, dissolved oxygen levels, nutrient distribution) could influence the distribution and abundance of lower trophic levels (e.g., phytoplankton, zooplankton, submerged aquatic vegetation, crustaceans, mollusks, forage fish), ultimately affecting primary foraging areas of ESA-listed species including marine mammals, sea turtles, and fish. For example, blue whales, as predators that specialize in eating krill, are likely to change their distribution in response to changes in the distribution of krill (Payne et al. 1986; Payne et al. 1990; Clapham et al. 1999). Pecl and Jackson (2008) predicted climate change will likely result in squid that hatch out smaller and earlier, undergo faster growth over shorter life-spans, and mature younger at a smaller size. This could have negative consequences for species such as sperm whales whose diet is primarily squid and cephalopods. For leatherback sea turtles and ESA-listed whales which undergo long migrations, if either prey availability or habitat suitability is disrupted by changing ocean temperatures or regimes, the timing of migration can change or negatively impact population sustainability (Simmonds and Eliott 2009).

As carbon dioxide concentrations increase in the atmosphere, more carbon dioxide is absorbed by the oceans, causing lower pH and reduced availability of calcium carbonate. Because of the increase in carbon dioxide in the atmosphere since the Industrial Revolution, ocean acidity has increased by 26 percent since the beginning of the industrial era and is predicted to increase considerably between now and 2100 throughout the world's oceans (IPCC 2014). Ocean acidification negatively affects organisms such as crustaceans, crabs, mollusks, and other calcium carbonate-dependent organisms such as pteropods (free-swimming pelagic sea snails and sea slugs), the latter being an important part of the food web in Alaska waters. Reduction in prey items can create a collapse of the zooplankton populations and thereby result in potential cascading reduction of prey at various levels of the food web, thereby reducing the availability of the larger prey items of marine mammals.

While it is difficult to accurately predict the precise consequences of climate change to a particular species or habitat, especially highly mobile marine species (Simmonds and Isaac 2007a), a range of consequences are expected that are likely to change the status of the species and the condition of their habitats. For example, Pacific salmonids could be affected by rising water temperatures in streams, impacting habitat suitability and salmon growth, development, smoltification, and egg development (Crozier et al. 2008). It is also likely that consequences of climate change will overlap and result in synergistic impacts. For example, in sea turtles, sex is determined by the ambient sand temperature (during the middle third of incubation) with female offspring produced at higher temperatures and males at lower temperatures within a thermal tolerance range of 25 to 35 degree Celsius (Ackerman 1997). Increases in global temperature could skew future sex ratios toward higher numbers of females (NMFS and USFWS 2007aa; NMFS and USFWS 2007bb; NMFS and USFWS 2013aa; NMFS and USFWS 2013bb; NMFS and USFWS 2015). This impact on population dynamics will be exacerbated by the loss of nesting beach habitat due to sea level rise and erosion from changing winds, currents and storms (Antonelis et al. 2006; Baker et al. 2006).

9.2 Oceanic Temperature Regimes

Oceanographic conditions in the Pacific Ocean can be altered due to periodic shifts in atmospheric patterns (of high and low pressure systems) caused by the Southern oscillation in the Pacific Ocean, which leads to El Niño and La Niña events and the Pacific decadal oscillation. These climatic events can alter habitat conditions and prey distribution for ESA-listed species in the action area (Beamish 1993; Mantua et al. 1997; Hare and Mantua 2001; Benson and Trites 2002; Stabeno et al. 2004; Mundy and Cooney 2005).

The Pacific decadal oscillation is the leading mode of variability in the North Pacific Ocean and operates over longer periods than the Southern Oscillation events of El Niño, or La Niña, and is capable of altering sea surface temperature, surface winds, and sea level pressure (Mantua and Hare 2002; Stabeno et al. 2004). During positive Pacific decadal oscillations, the northeastern Pacific experiences above-average sea surface temperatures while the central and western Pacific Ocean undergoes below-normal sea surface temperatures (Royer 2005). Warm Pacific decadal oscillation regimes tend to decrease productivity along the U.S. west coast as upwelling typically diminishes, similar to El Niño events (Hare et al. 1999; Childers et al. 2005).

El Niño periods can influence reproductive success by altering prey availability, probably linked to a decline in primary productivity in coastal areas, as evidenced by Steller sea lions (Trites et al. 2007). Data suggests that sperm whale females have lower rates of conception following these periods of warmer surface temperatures (Whitehead et al. 1997).

These periodic shifts in oceanic conditions are complex and the resultant changes in habitat and productivity can be difficult to predict especially when trying to incorporate the longer term anthropogenic related changes in climate (Kintisch 2006; Simmonds and Isaac 2007b). Vulnerable populations of listed species are going to be sensitive to climatic variability that impacts the resources they need. Climate change may be driving the natural oscillation in environmental conditions to greater extremes, which poses more risk to the stability of a vulnerable population.

9.3 Unusual Mortality Event

As discussed in Section 8.7, elevated gray whale strandings have occurred along the west coast of North America. While the majority of strandings have occurred outside of the proposed action area, several strandings have occurred off the coast of British Columbia and Southeast Alaska near the proposed tracklines[8].

[8] https://www.fisheries.noaa.gov/national/marine-life-distress/2019-2021-gray-whale-unusual-mortality-event-along-west-coast-and (Accessed 1/08/21)

9.4 Whaling and Subsistence Harvesting

Prior to current prohibitions on whaling, most large whale species were depleted to the extent necessary to list them as endangered under the Endangered Species Preservation Act of 1966. The International Whaling Commission (IWC) issued a moratorium on commercial whaling beginning in 1986 and currently there is no legal commercial whaling by IWC Member Nations party to the moratorium, however, whales are still killed commercially by countries that field objections to the moratorium (i.e., Iceland and Norway). Presently three types of whaling take place: (1) aboriginal subsistence whaling to support the needs of indigenous people; (2) special permit whaling; and (3) commercial whaling conducted under objection or reservation to the moratorium. The reported catch and catch limits of large whale species from aboriginal subsistence whaling, special permit whaling, and commercial whaling can be found on the International Whaling Commission's website at: https://iwc.int/whaling. Additionally, the Japanese whaling fleet carries out whale hunts under the guise of "scientific research," though very few published peer-reviewed papers have resulted from the program, and meat from the whales killed under the program is processed and sold at fish markets. These whaling expeditions occur in the north Pacific and the species hunted include fin, sei, and sperm whales, populations of which are known to occur in the action area of this consultation.

9.4.1 Subsistence Harvest of Stellar Sea Lions

It is possible for Alaska subsistence harvest of Steller sea lions to occur within the action area. Since subsistence harvest surveys began in 1992, the number of households hunting and harvesting Steller sea lions has remained relatively constant at low levels (Wolfe et al. 2013). The Steller Sea Lion Recovery Plan (NMFS 2008b) ranked subsistence harvest as a low threat to the recovery of the Western DPS.

9.4.2 Sea Turtle Harvesting

As discussed in Section 8.9, the harvest of leatherback sea turtles and their eggs has been a significant factor causing the decline of the species. While it is a large concern for the species as a whole, there is little to no data on leatherback sea turtle harvesting within the action area. However, sea turtle harvesting is prohibited within the United States and Canada.

9.4.3 Subsistence Harvest of Salmon

Salmon comprise a considerable portion of subsistence harvests with cultural significance to indigenous groups across Alaska and Pacific Canada. Subsistence harvest (fisheries and hunting) make up only a small fraction of the annual wild harvest across Alaska, about 0.9 percent, as compared to 98.6 percent taken by commercial fisheries, but subsistence fishing provides a crucial food source for rural Alaskan communities, providing on average about 155 pounds of food per person annually (Fall et al. 2020). Salmon are the most targeted subsistence fish species in Alaska and 862,930 salmon were harvested for subsistence in 2017 (Fall et al. 2020). Most of the salmon harvest consisted of chum salmon *O. keta* (37.7 percent), followed by sockeye *O. nerka* (35.7 percent), coho *O. kisutch* (10.7 percent), Chinook *O. tshawytscha* (9.5 percent), and pink *O. gorbuscha* (6.3 percent) (Fall et al. 2019). The Southeastern regional management area took 5.3 percent (45,320 salmon) of the total subsistence salmon harvest in 2017 (Fall et al. 2020). Salmon is also the main subsistence fishing of indigenous First Nations in Canada, due to their nutritional, cultural, and spiritual significance (Weatherdon et al. 2016).

9.5 Illegal Shooting

Illegal shooting of sea lions was thought to be a potentially significant source of mortality prior to the listing of sea lions as threatened under the ESA in 1990. The Steller Sea Lion Recovery Plan (NMFS 2008b) ranked illegal shooting as a low threat to the recovery of the Western DPS. There have been no cases of illegal shooting successfully prosecuted since 1998 (NMFS, Alaska Enforcement Division), although the NMFS Alaska Stranding Program documents 60 Steller sea lions with suspected or confirmed firearm injuries from 2000 through 2016 in Southeast Alaska. On June 1, 2015, the NMFS AKR Stranding Response Program received reports of at least five dead Steller sea lions on the Copper River Delta. Two NMFS biologists recorded at least 18 pinniped carcasses, most of which were Steller sea lions, on June 2, 2015. A majority of the carcasses had evidence that humans had intentionally killed them. Subsequent surveys resulted in locating two additional Steller sea lions, some showing evidence suggestive that they had been intentionally killed. Therefore, NMFS Alaska Region designed a 2016 survey plan for the Copper River Delta focused on the time period of greatest overlap between the salmon driftnet fishery and marine mammals. The purpose of the surveys was to determine if the intentional killing observed in 2015 continued, and to collect cause of death evidence and samples for health assessments. Outside, but only several hundred miles near the western portion of the action area, intentional killings of Steller sea lions by humans appears to continue and was the leading cause of death of the pinnipeds NMFS assessed on the Copper River Delta from May 10 through August 9, 2016. Without continuous monitoring in past years, it is impossible to know if the lack of reported carcasses in the decade prior to 2015 accurately reflects past intentional killings by humans. Numbers of marine mammals found dead with evidence of human interaction dropped between 2015 and 2017, but intentional illegal killing is still occurring (Wright 2018). Although illegal killings of Steller sea lions may not directly occur within the action area, they could impact potential populations within the action area as some individual juvenile sea lions may make long-distance movements over long periods of time. For example, sea lions marked as pups in Kodiak, Alaska, have been sighted in British Columbia, Canada (Loughlin and Gelatt 2018).

9.6 Vessel Activity

Vessels have the potential to affect animals through strikes (discussed below), sound, and disturbance associated with their physical presence. Responses to vessel interactions include interruption of vital behaviors and social groups, separation of mothers and young, and abandonment of resting areas (Mann et al. 2000; Samuels et al. 2000; Boren et al. 2001; Constantine 2001; Nowacek 2001). The action area is in a region with vessel activity from cargo and commercial shipping, cruise ships, and commercial fishing, to whale watching and recreational vessels.

The Port of Vancouver, Fraser Port, and the Port of Prince Rupert account for more than 95 percent of the international trade moving through the British Columbian port system (Transportation 2005). The second largest port, the Port of Prince Rupert in northern British Columbia, is near the middle of the action area. Further, the action area overlaps the Alaska Marine Highway System in Southeast Alaska where Alaskan ferry vessels transported a total of 69,562 passenger vehicles and 188,054 passengers in 2018 (AMHS 2018).

Cruise ships constitute a large amount of vessel traffic in the region. In 2019, 288 cruise ships entered the Port of Vancouver, with over a million passengers embarking and disembarking. This is about a 20 percent increase from 2018, which saw 241 vessels, and 889,162 passengers. Cruise ship activity was greatest in May through September (Vancouver 2019). The action area includes southeast Alaska, which has major cruise destinations, ferry and fishing ports. Juneau accounted for 29 percent of all cruise based tourism in Alaska last year, with just over 1.14 million visits, and Ketchikan accounted for 27 percent, with 1.05 million visits[9].

In 2017, there were 2,372 registered fishing vessels in the Canadian Pacific (DFO 2018), and almost three times that number of resident owned fishing vessels in Alaska. Wholesale value of landings at commercial fishing ports near the action area in Alaska has Sitka as fifth in the state at 121 million dollars, with Ketchikan at 93 million dollars and Juneau at 53 million dollars[10].

9.6.1 Whale Watching

Whale watching is a rapidly-growing industry with more than 3,300 operators worldwide, serving 13 million participants in 119 countries and territories (O'Connor et al. 2009). As of 2010, commercial whale watching was a one billion dollar per year global industry (Lambert et al. 2010). Private vessels may partake in this activity as well. Although considered by many to be a non-consumptive use of marine mammals with economic, recreational, educational and scientific benefits, whale watching is not without potential negative impacts (reviewed in Parsons 2012).

Several studies have examined the short-term effects of whale watch vessels on marine mammals. (Watkins 1986; Corkeron 1995; Au and Green 2000; Felix 2001; Erbe 2002b; Magalhaes et al. 2002; Williams et al. 2002; Richter et al. 2003; Scheidat et al. 2004; Simmonds 2005). The whale's behavioral responses to whale watching vessels depended on the distance of the vessel from the whale, vessel speed, vessel direction, vessel sound, and the number of vessels. In some circumstances, whales do not appear to respond to vessels, but in other circumstances, whales change their vocalizations, respiration rates, surface and dive times, swimming speed or direction, social interactions, feeding and breeding behavior. Whale

[9] https://akcruise.org/cruising-in-alaska/overview/ (Accessed 3/17/20)
[10] https://www.mcdowellgroup.net/wp-content/uploads/2017/10/ak-seafood-impacts-sep2017-final-digital-copy.pdf (Accessed 3/17/20)

watching has the potential to harass or even injure the animal if vessels get too close. Animals may also become more vulnerable to vessel strikes if they habituate to vessel traffic (Swingle et al. 1993; Wiley et al. 1995). Disturbance by whale watching vessels has also been noted to cause newborn calves to separate briefly from their mother's sides, which leads to greater physiological stress and energy expenditures by the calves (NMFS 2006b). Preferred habitats could also be abandoned if disturbance levels by whale watching vessels are too high.

Whale watching is a popular activity in the region of the action area, specifically coastal northern BC and southeast Alaska. Although it is difficult to quantify and estimate the magnitude of stress posed to the whales subject to these activities, we assume disturbance and other impacts associated with whale watching activities are ongoing within the action area.

9.6.2 Vessel Strike

Marine Mammals. Vessel strike is a considerable threat that is widespread to ESA-listed marine mammals (especially large whales). The threat is increasing as commercial shipping lanes cross important breeding and feeding habitats and as whale populations recover and populate new areas or areas where they were previously extirpated (Swingle et al. 1993; Wiley et al. 1995). As vessels become faster and more widespread, an increase in vessel interactions with cetaceans is to be expected. All sizes and types of vessels can hit whales, but most lethal and severe injuries are caused by vessels 80 meters (262.5 feet) or longer (Laist et al. 2001). Studies show that the probability of fatal injuries to whales from vessel strikes increases as vessels operate at speeds above 26 kilometers per hour (14 knots) (Laist et al. 2001).

Evidence suggests that not all whales killed as a result of vessel strike are detected, particularly in offshore waters, and some detected carcasses are never recovered while those that are recovered may be in advanced stages of decomposition that preclude a definitive cause of death determination (Glass et al. 2010). The vast majority of commercial vessel strike mortalities of cetaceans are likely undetected and unreported, as most are likely never reported and animals killed by vessel strike likely end up sinking rather than washing up on shore (Cassoff et al. 2011). The number of documented cetacean mortalities related to vessel strikes is likely much lower than the actual number of moralities associated with vessel strikes, especially for less buoyant species such as blue, humpback, and fin whales (Rockwood et al. 2017). Kraus et al. (2005) estimated that only 17 percent of vessel strikes are actually detected. Rockwood et al. (2017) modeled vessel strike mortalities of blue, humpback, and fin whales off California using carcass recovery rates of five and 17 percent and conservatively estimated that vessel strike mortality may be as high as 7.8, 2.0, and 2.7 times the recommended limit for blue, humpback, and fin whale stocks, respectively.

Fin whales are the mostly commonly struck species in the northern hemisphere (Laist et al. 2001), however, all whale species have the potential to be affected by vessel strikes. Vessel traffic within the action area can come from both private (e.g., commercial, recreational) and federal vessels (e.g., military, research), but commercial shipping traffic is most likely to result in vessel strikes. The potential lethal effects of vessel strikes are particularly profound on species with low abundance. The latest five-year average mortalities and serious injuries related to vessel strikes for the ESA-listed cetacean stocks within U.S. waters likely to be found in the action area are provided in Table 30 below (Carretta et al. 2019; Muto et al. 2019). Data are broken down by NMFS regional stock areas with known (observed) mortalities and serious injuries. The estimated column is from the Rockwood *et al*. 2017 study that estimated ship strike mortality for whales in the U.S. West Coast EEZ using an encounter theory model that combined whale species density distributions with vessel traffic characteristics (size + speed + spatial use), along with whale movement patterns obtained from satellite-tagged animals, to estimate whale/vessel interactions that would result in mortality. The estimated number of annual ship strike deaths includes only the period July – November when whales are most likely to be present in the U.S. West Coast EEZ and the time of year that overlaps with cetacean habitat models generated from line-transect surveys (Becker et al. 2016; Rockwood et al. 2017). Estimates were based on an assumption of a moderate level of vessel avoidance (55 percent) by whales, as measured by the behavior of satellite-tagged whales in the presence of vessels (McKenna et al. 2015). Detected levels of vessel strikes for blue, fin and humpback whales are quite low when compared with estimated vessel strikes, generally less than 10 percent and closer to 1 percent for fin whales.

Table 30. Five-year annual average mortalities and serious injuries related to vessel strikes for Endangered Species Act-listed cetaceans within the action area.

Species	Alaska Stocks	Pacific Stocks	
	Obs.	Obs.	Est.
Blue Whale	NA	0.2	18
Fin Whale	0.4	1.6	43
North Pacific right whale	NA	NV	NV
Humpback Whale– Multiple ESA-listed DPSs	2.5	2.1	22
Sei Whale	NA	0.2	NA
Sperm Whale	NV	NA	NA

Obs=observed, Est=estimated, DPS=Distinct Population Segment, NA=Not Applicable, NV=No Value reported

Sea Turtles. Vessel strikes are a poorly-studied threat to sea turtles, but have the potential to be highly significant given that they can result in serious injury and mortality (Work et al. 2010). Sea turtles must surface to breathe and several species will bask at the surface for long periods. Although sea turtles can move somewhat rapidly, they apparently are not adept at avoiding vessels that are moving at more than four kilometers per hour (2.6 knots); most vessels move much faster than this in open water (Hazel and Gyuris 2006; Hazel et al. 2007; Work et al. 2010). Both live and dead sea turtles are often found with deep cuts and fractures indicative of a collision with a vessel hull or propeller (Hazel et al. 2007). Although it is possible to occur, data on vessel strikes of leatherback sea turtles in the action area is lacking.

Fishes

Vessel strikes are a less pronounced threat to fishes in the action area, as fish are mostly expected to be able to sense and maneuver away from vessels.

9.7 Fisheries

Fisheries constitute an important and widespread use of the ocean resources throughout the action area. Fisheries can adversely affect targeted fish populations, other species, and habitats. Direct effects of fisheries interactions on marine mammals and sea turtles include entanglement and entrapment, which can lead to fitness consequences or mortality resulting from injury or drowning. Indirect effects include reduced prey availability, including overfishing of targeted species, and destruction of habitat.

Marine Mammals. Entrapment and entanglement in fishing gear is a frequently documented source of human-caused mortality in cetaceans (see Dietrich et al. 2007); in an extensive analysis of global risks to marine mammals, incidental catch was identified as the most common threat category (Avila et al. 2018). Materials entangled tightly around a body part may cut into tissues, enable infection, and severely compromise an individual's health (Derraik 2002). Entanglements also make animals more vulnerable to additional threats (e.g., predation and vessel strikes) by restricting agility and swimming speed. The majority of cetaceans that die from entanglement in fishing gear likely sink at sea rather than strand ashore, making it difficult to determine the extent of such mortalities. Between 1970 and 2009, two-thirds of mortalities of large whales in the Northwest Atlantic Ocean were attributed to human causes, primarily vessel strike and entanglement (Van der Hoop et al. 2013). In excess of 97 percent of entanglement is caused by derelict fishing gear (Baulch and Perry 2014).

Marine mammals can ingest fishing gear, likely mistaking it for prey, which can lead to fitness consequences and mortality. Necropsies of stranded whales have found that ingestion of net pieces, ropes, and other fishing debris has resulted in gastric impaction and ultimately death (Jacobsen et al. 2010). As with vessel strikes, entanglement or entrapment in fishing gear likely has the greatest impact on populations of ESA-listed species with the lowest abundance (e.g., Kraus et al. 2016). Nevertheless, all marine mammals may face threats from derelict fishing gear. The latest five-year average mortalities and serious injuries related to fisheries interactions for the ESA-listed marine mammals within U.S. waters likely to be found in the action area are given in Table 31 below (Carretta et al. 2016a; Henry et al. 2016; Carretta et al. 2017; Helker et al. 2017). Data represent only known mortalities and serious injuries; more, undocumented moralities and serious injuries for these and other marine mammals found within the action area have likely occurred.

Table 31. Five-year mortalities and serious injuries related to fisheries interactions for Endangered Species Act-listed mammals within the action area.

Species	Alaska Stocks	Pacific Stocks
Blue Whale	NA	0.9
Fin Whale	0.2	≥ 0.5
North Pacific right whale	NA	NV
Humpback Whale – Multiple ESA-listed DPSs	19	15.7
Sei Whale	NA	0
Sperm Whale	4.4	NA
Steller Sea Lion, Western	36	NA

NA=Not Applicable, NV=No Value reported

In addition to these direct impacts, cetaceans may also be subject to indirect impacts from fisheries that have a profound influence on fish populations. In a study of retrospective data, Jackson et al. (2001) concluded that ecological extinction caused by overfishing precedes all other pervasive human disturbance of coastal ecosystems, including pollution and anthropogenic climatic change. Many cetacean species (particularly fin and humpback whales) are known to feed on species of fish that are harvested by humans (Carretta et al. 2016b). Marine mammals probably consume at least as much fish as is harvested by humans (Kenney et al. 1985). Thus, competition with humans for prey is a potential concern. Even species that do not directly compete with human fisheries could be indirectly affected, by changes in ecosystem dynamics through fishing activities. However, the effects of fisheries on whales through changes in prey abundance remain largely unknown in the action area.

Sea Turtles. Fishery interactions remain a major factor affecting sea turtle recovery. Wallace et al. (2010) estimated that worldwide, 447,000 sea turtles are killed each year from bycatch in commercial fisheries. Although sea turtle excluder devices and other bycatch reduction devices have significantly reduced the level of bycatch of sea turtles and other marine species in U.S. waters, mortality still occurs. Leatherback turtles in the Pacific Ocean migrate about 11,265.4 kilometers (6,082.9 nautical miles) from nesting beaches in the tropical Pacific Ocean (e.g., Indonesia, Papua New Guinea, Costa Rica, Mexico) to foraging grounds (e.g., off the U.S. West Coast). This migration puts leatherback turtles in proximity to numerous fisheries, especially longlines, increasing bycatch risk. Roe (2014) found areas of sea turtle bycatch risk near the action area, especially within the North and Central Pacific Ocean.

Fish

ESA-listed salmon are incidentally caught in several fisheries that operate in the action area targeting non-listed salmon or other species. These include:

- Groundfish fisheries off the coasts of Washington, Oregon and California that operate under the Pacific Coast Groundfish Fishery Management Plan;
- Coastal pelagic species (i.e., northern anchovy, squid, Pacific sardine, Pacific mackerel, and jack mackerel) managed by the Pacific Fisheries Management Council under the Coastal Pelagic Species Fisheries Management Plan;
- Commercial salmon fisheries that operate under the Pacific Salmon Treaty;
- Salmon fisheries that are managed by the U.S. Pacific Fisheries Management Council under the Pacific Coast Management Plan;
- Recreational fisheries that operate in the action area
- Tribal ceremonial and subsistence (gillnet, dip net and hook and line) fisheries in Puget Sound

Fisheries management plans developed for federally regulated fisheries with ESA-listed species bycatch are required to undergo section 7 consultation, including a NMFS issued opinion and an ITS. The ITS includes the anticipated amount of take (lethal and nonlethal) and RPMs with specific terms and conditions for mitigating and minimizing the adverse effects of the proposed action on ESA-listed species and designated critical habitat. Section 7 consultations also evaluate the secondary effects of fisheries removals on ESA-listed species that prey on fish (e.g., Southern Resident killer whales).

Pacific salmon fisheries provide for commercial, recreational, and tribal harvest in ocean and inland waters. Commercial ocean fisheries targeting Pacific salmon primarily use troll or hook-and-line gear, but gill nets are also used in commercial and tribal freshwater fisheries in inland waters. The broad geographic range and migration routes of salmon, from the inland tributaries to offshore areas, require comprehensive management by several stakeholder groups representing federal, state, tribal, and Canadian interests (NMFS 2019f).

The whiting fishery (including at-sea, shore-based, and Tribal fisheries), which is a sector of the Pacific Coast groundfish fisheries, is estimated to have caught an average of 7,718 chinook each year from 2011 through 2015 (NMFS 2017c). Incidental capture of chinook salmon in the bottom trawl sector of the groundfish fishery has sharply declined in recent years from an annual average over 15,000 from 2002-2003 to around 557 per year from 2011-2015 (NMFS 2017c). ESA section 7 consultations aim to limit the impact of ocean salmon fisheries on ESA-listed stocks. For example, the maximum age-3 impact rate for 2015 ocean salmon fisheries on Sacramento River winter Chinook is 19 percent (PFMC 2015).

Coastal pelagic fisheries also have the potential to impact Pacific salmon through incidental capture or by removing prey biomass from the ecological system (Pacific Fishery Management

Council 2014). Pelagic fisheries primarily operate off southern and central California, but there is a large sardine fishery off Oregon and Washington, as well as California. Pacific sardine is an important source of forage for a large number of birds, marine mammals, and fish. The directed Pacific sardine fishery has been closed since July 1, 2015 because of low biomass, but small-scale directed fishing can still take place (NMFS 2019f).

In 2017, there were 2,372 registered fishing vessels in the Canadian Pacific, landing 822,349 metric tons in the commercial sea fisheries (DFO 2018). Major species landed in British Columbia between 2015 and 2017 included groundfish (e.g., hake (Family Merlucciidae), rockfish (*Sebastes spp.*), and arrowtooth flounder (*Atheresthes stomias*)), herring (*Clupea pallasii*), and wild Pacific salmon (*Oncorhynchus spp.*), with farm-raised Atlantic salmon landed in far greater numbers that wild-caught Pacific salmon (DFO 2017a).

9.7.1 Aquaculture

Within the action area, aquaculture has the potential to impact protected species via entanglement and/or other interaction with aquaculture gear (i.e., buoys, nets, and lines), introduction or transfer of pathogens, impacts to habitat and benthic organisms, and water quality (Lloyd 2003; Clement 2013; Price and Morris 2013; Price et al. 2017). In 2010, aquaculture operations in British Columbia amounted to a total harvested value of almost $534 million dollars, the majority ($511.5 million) being from finfish, primarily salmon. Cultured salmon is British Columbia's largest agricultural export[11] and there are currently about 50 operations. [12] There is evidence suggesting salmon aquaculture is detrimental to wild native salmon populations, causing reductions in survival or abundance in wild populations (Ford and Myers 2008). Finfish farming is banned in Alaska by state statute since 1990, although shellfish and oyster aquaculture operations exist.

Salmon aquaculture in sea pens brings with it several concerns, chief among them being impacts from the accidental release of a nonnative species. On December 20, 2019, damage caused to a sea pen by an electrical fire at a fish farm at Robertson Island north of Vancouver Island caused an estimated 20,000 Atlantic salmon to escape into Queen Charlotte Strait.[13] There have been documented cases of accidentally released Atlantic salmon successfully reproducing in British Columbia, raising concerns about the possible establishment of the species, which could cause harm to native Pacific salmon (Volpe et al. 2000). An introduced species could outcompete native species for resources, or carry pathogens and parasites, causing native species' populations to decline or suffer. Canadian Prime Minister Justin Trudeau has pledged to move British Columbia's sea-based fish farms onto land by 2025.[14]

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[11] https://www.dfo-mpo.gc.ca/aquaculture/pacific-pacifique/index-eng.html (Accessed 1/27/20).
[12] https://www.cbc.ca/news/canada/british-columbia/fish-farming-bc-leases-1.4704626 (Accessed 1/28/20).
[13] https://mowi.com/caw/blog/2019/12/21/news-release-incident-at-robertson-island-causes-potential-fish-escape/ (Accessed 1/27/20).
[14] https://www.alaskapublic.org/2019/12/27/fire-at-b-c-fish-farm-releases-thousands-of-atlantic-salmon/ (Accessed 1/27/2020).

Piscine orthoreovirus is a virus found in salmon, often associated with aquaculture, that causes pathological conditions like heart and skeletal inflammation and could cause fitness consequences for native Pacific salmon populations that are already in decline. A study of farmed Atlantic salmon in British Columbia found that piscine orthoreovirus was detected in 95 percent of Atlantic salmon, and 35 to 47 percent of wild Pacific salmon, with the proportion of wild fish infected with the virus related to exposure to the fish farms (Morton et al. 2017).

The parasite, salmon lice (*Lepeophtheirus salmonis*) occurs naturally in salmon. Sea pens can create advantageous conditions for salmon lice to grow and transmit more expansively than they could under natural conditions. In severe cases of infection, salmon lice can cause erosion of the epidermis and exposure of the dermis, although mortality in wild salmon from salmon lice infection is rare. Sub-lethal effects include stress, changes in blood glucose or electrolytes, reduced hemocrits, and reduced swimming ability (Torrissen et al. 2013). Different species of Pacific salmon respond differently to salmon lice; coho and pink salmon appear to more rapidly reject salmon lice than Chinook and chum (Johnson and Albright 1992; Jones et al. 2007). The abundance of salmon lice has increased in years with abnormally warm water temperatures, possibly indicating that more frequent and stronger outbreaks can be expected as climate change persists (Torrissen et al. 2013). Aquaculture facilities regularly apply parasite treatments to manage salmon lice, giving rise to concerns about selection pressure and treatment resistance (Torrissen et al. 2013). There are some concerns about the indirect effects of common chemical treatments for salmon lice to other species like echinoderms, kelp, and spot prawns (*Pandalus platyceros*) (Strachan 2018).

Current data suggest that interactions and entanglements of ESA-listed marine mammals and sea turtles with aquaculture gear are rare (Price et al. 2017). This may be because worldwide the number and density of aquaculture farms are low, and thus there is a low probability of interactions, or because they pose little risk to ESA-listed marine mammals and sea turtles. Some aquaculture gear is similar to gear used in commercial fisheries, such as longlines used in mussel farming, and may have a similar threat of entanglement. There are very few reports of marine mammal interactions with aquaculture gear in the U.S. Pacific Ocean, although it is not always possible to determine if the gear animals become entangled in is from aquaculture or commercial fisheries (Price et al. 2017). There are relatively few studies on the impacts of aquaculture on sea turtles.

9.8 Pollution

Within the action area, pollution poses a threat to ESA-listed marine mammals. Pollution can come in the form of marine debris, pesticides, contaminants, and hydrocarbons.

9.8.1 Marine Debris

Marine debris is an ecological threat that is introduced into the marine environment through ocean dumping, littering, or hydrologic transport of these materials from land-based sources (Gallo et al. 2018). Even natural phenomena, such as tsunamis and continental flooding, can cause large amounts of debris to enter the ocean environment (Watters et al. 2010). Plastic debris is a major concern because it degrades slowly and many plastics float. The floating debris is transported by currents throughout the oceans and is accumulating in oceanic gyres (Law et al. 2010). Despite debris removal and outreach to heighten public awareness, marine debris has not been reduced in the environment (NRC 2008) and continues to accumulate in the ocean and along shorelines within the action area.

Marine debris affects marine habitats and marine life worldwide, primarily by entangling or choking individuals that encounter it (Gall and Thompson 2015). Entanglement in marine debris can lead to injury, infection, reduced mobility, increased susceptibility to predation, decreased feeding ability, fitness consequences, and mortality for ESA-listed species in the action area. Entanglement can also result in drowning for air breathing marine species, such as mammals and sea turtles.

The ingestion of marine debris can result in blockage or obstruction of the mouth, stomach lining and digestive tract of various species and lead to serious internal injury or mortality (Derraik 2002). Over half of cetacean species (including fin, sei, and sperm whales) are known to ingest marine debris (mostly plastic), with up to 31 percent of individuals in some populations containing marine debris in their guts and being the cause of death for up to 22 percent of individuals found stranded on shorelines (Baulch and Perry 2014). In 2008, two sperm whales stranded along the California coast, with an assortment of fishing related debris (e.g., net scraps, rope) and other plastics inside their stomachs (Jacobsen et al. 2010). One whale was emaciated, and the other had a ruptured stomach. Gastric impactions were suspected as the cause of both deaths. Jacobsen et al. (2010) speculated the debris likely accumulated over many years, possibly in the North Pacific gyre that will carry derelict Asian fishing gear into eastern Pacific Ocean waters. In January and February 2016, 30 sperm whales stranded along the coast of the North Sea (in Germany, the Netherlands, Denmark, France, and Great Britain); of the 22 dissected specimens, nine had marine debris in their gastro-intestinal tracts. Most of it (78 percent) was fishing-related debris (e.g., nets, monofilament line) and the remainder (22 percent) was general debris (plastic bags, plastic buckets, agricultural foils) (Unger et al. 2016).

Ingestion of marine debris can also be a serious threat to sea turtles. When feeding, sea turtles (e.g., leatherback turtles) can mistake debris (e.g., tar and plastic) for natural food items, especially jellyfish, which are a primary prey. Plastic ingestion is very common in leatherback turtles and can block gastrointestinal tracts leading to death (Mrosovsky et al. 2009).

Marine mammals and sea turtles are expected to be exposed to marine debris in the action area through the duration of the project and we assume similar effects from marine debris documented within other regions could occur. The lack of detailed marine debris data specific to the action area makes it difficult to conclude the level of risk and degree of impacts on the ESA-listed species populations considered in this consultation, however we assume that impacts from marine debris may exacerbate other stressors for any vulnerable species.

9.8.2 Contaminants

Exposure to pollution and contaminants have the potential to cause adverse health effects in marine species. Marine ecosystems are subject to pollutants at local, regional, and international scales; their levels and sources are therefore difficult to identify and monitor (Grant and Ross 2002). Marine pollutants come from multiple sources, including municipal, industrial, and household sources (Iwata 1993; Grant and Ross 2002; Garrett 2004; Hartwell 2004). Contaminants may be introduced by rivers or coastal runoff, from atmospheric transport and wind, ocean dumping, dumping of raw sewage by boats, and various industrial activities, including offshore oil and gas or mineral exploitation (Grant and Ross 2002; Garrett 2004; Hartwell 2004).

The accumulation of persistent organic pollutants, including polychlorinated-biphenyls (better known as PCBs), dibenzo-p-dioxins, dibenzofurans and related compounds, through trophic transfer may cause mortality and sub-lethal effects in long-lived higher trophic level animals (Waring et al. 2016), including immune system abnormalities, endocrine disruption, and reproductive effects (Krahn et al. 2007). Persistent organic pollutants may also facilitate disease emergence and lead to the creation of susceptible "reservoirs" for new pathogens in contaminated marine mammal populations (Ross 2002). Recent efforts have led to improvements in regional water quality and declines in levels of monitored pesticide, although the persistent chemicals are still detected and expected to endure for years (Mearns 2001; Grant and Ross 2002).

Plastics lodged in the alimentary tract could facilitate the transfer of pollutants into the bodies of whales and dolphins (Derraik 2002). Plastic waste chemically attracts hydrocarbon pollutants such as PCBs and dichlorodiphenyltrichloroethane. Marine mammals, sea turtles, and fish can mistakenly consume these wastes containing elevated levels of toxins instead of their prey.

Numerous factors can affect concentrations of persistent pollutants in marine mammals, such as age, sex and birth order, diet, and habitat use (Mongillo et al. 2012). In marine mammals, pollutant contaminant load for males increases with age, whereas females can pass on contaminants to offspring during pregnancy and lactation (Addison and Brodie 1987; Borrell et al. 1995). Pollutants can be transferred from mothers to offspring at a time when their bodies are undergoing rapid development, putting juveniles at risk of immune and endocrine system dysfunction later in life (Krahn et al. 2009).

Persistent organic pollutants, including organochlorines, have been found in sea turtle tissues. Organochlorines can cause deficiencies in endocrine, developmental, and reproductive health (Storelli et al. 2007) and are known to depress immune function in loggerhead turtles (Keller et al. 2006). PCB concentrations in sea turtles are reportedly equivalent to those in some marine mammals, with liver and adipose levels of at least one congener being exceptionally high (PCB 209: 500-530 ng/g wet weight; Davenport 1990; Oros 2009). PCBs have been found in leatherback turtles at concentrations lower than expected to cause acute toxic effects, but might cause sub-lethal effects on hatchlings (Stewart 2011).

The amount of heavy metals (e.g., arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver and zinc) found in sea turtle tissues increase with sea turtle size (Godley et al. 1999; Saeki et al. 2000; Anan et al. 2001; Fujihara et al. 2003; Gardner et al. 2006; Storelli et al. 2008; Barbieri 2009; Garcia-Fernandez et al. 2009). Cadmium has been found in leatherback turtles at the highest concentration compared to any other marine vertebrate (Gordon et al. 1998; Caurant et al. 1999).

Accumulation of PCBs has been shown in Chinook and coho salmon in the Pacific, and PCBs have been found in all species of Pacific salmon in southeast Alaska. The effects of accumulation of PCBs to salmon are unknown, though it is thought possible that if the PCBs are passed to the eggs, it could affect reproductive success, or inhibit immune response in juveniles (O'Neill et al. 1998).

While exposure to contaminants is likely to continue for marine mammals, sea turtles, and fishes, the level of risk and degree of impact within the action area are unknown due to the lack of data for potential contaminants specific to the action area through the project duration.

9.8.3 Hydrocarbons

Exposure to hydrocarbons released into the environment via oil spills and other discharges poses risks to marine species. Much known about the effects of oil spills on marine animals comes from studies of large oil spills, such as the *Deepwater Horizon* oil spill, since there is a lack of information on the effects from small-scale oil spills. There is no large-scale oil spill known in the action area, but numerous small-scale vessel spills likely occur. A nationwide study examined oil spills from numerous types of vessels (e.g., barges, tankers, tugboats, and recreational and commercial vessels) from 2002 through 2006 found that over 1.8 million gallons of oil were spilled from vessels in U.S. waters (Dalton and Jin 2010).

Marine mammals are generally able to metabolize and excrete limited amounts of hydrocarbons, but exposure to large amounts of hydrocarbons and chronic exposure over time pose greater risks (Grant and Ross 2002). Cetaceans have a thickened epidermis that reduces the likelihood of petroleum toxicity from skin contact with oils (Geraci 1990), but they may inhale these compounds at the water's surface and ingest them while feeding (Matkin and Saulitis 1997). Acute exposure of marine mammals to petroleum products causes changes in behavior and may directly injure animals (Geraci 1990). Oil can also be hazardous to sea turtles, with fresh oil causing significant mortality and morphological changes in hatchlings (Fritts and McGehee 1981). Hydrocarbons can also potentially impact prey populations, and therefore may affect ESA-listed species indirectly by reducing food availability. Risk to ESA-listed species exists throughout the world's oceans, and, as such, is also a concern for species within the action area.

9.9 Aquatic Nuisance Species

Aquatic nuisance species are aquatic and terrestrial organisms introduced into new habitats that produce harmful impacts on aquatic ecosystems and native species (http://www.anstaskforce.gov). They are also referred to as invasive, alien, or non-indigenous species. Invasive species are considered one of the top four threats to the world's oceans (Raaymakers and Hilliard 2002; Raaymakers 2003; Terdalkar et al. 2005; Pughiuc 2010). Introduction of these species is cited as a major threat to biodiversity, second only to habitat loss (Wilcove et al. 1998). A variety of vectors are thought to have introduced non-native species, including but not limited to aquarium and pet trades, recreation, and ballast water discharges from ocean-going vessels.

Common impacts of invasive species are alteration of habitat and nutrient availability, as well as altering species composition and diversity within an ecosystem (Strayer 2010). These impacts can shift the base of food webs and fundamentally alter predator-prey dynamics in food chains (Moncheva and Kamburska 2002). They have been implicated in the endangerment of 48 percent of ESA-listed species (Czech and Krausman 1997).

Currently, there is little information on aquatic nuisance species in the action area through the duration of the project, therefore, the level of risk and degree of impact to ESA-listed species considered in this consultation is unknown.

9.10 Anthropogenic Sound

The ESA-listed species in the action area can be impacted by increased levels of anthropogenic-induced background sound or high intensity, short-term anthropogenic sounds. The ESA-listed species in the action area are regularly exposed to several sources of anthropogenic sounds including, but not limited to, maritime activities, aircraft, seismic surveys (exploration and research), and marine construction (dredging and pile-driving). These activities occur to varying degrees throughout the year. Cetaceans generate and rely on sound to navigate, hunt, and communicate with other individuals and anthropogenic sound can interfere with these important activities (Nowacek et al. 2007). Noise generated by human activity has the potential to affect sea turtles, although those effects are not as well understood.

Many researchers have described behavioral responses of marine mammals to sounds produced by vessels, aircraft, and construction or dredging (and Nowacek et al. 2007; reviewed in Gomez et al. 2016). Most observations are short-term behavioral responses, which include avoidance behavior and temporary cessation of feeding, resting, or social interactions. Masking may also occur, in which an animal may not be able to detect, interpret, and/or respond to biologically relevant sounds. Masking can reduce the range of communication, particularly long-range communication, such as that for blue, fin, and sei whales. This can have a variety of implications for an animal's fitness including, but not limited to, predator avoidance and the ability to reproduce successfully (MMC 2007). Recent scientific evidence suggests that marine mammals, including several baleen whales, compensate for masking by changing the frequency, source level, redundancy, or timing of their signals, but the long-term implications of these adjustments are currently unknown (Parks 2003; McDonald et al. 2006a; Parks 2009a). In addition to marine mammals, it is noted that continued exposure to existing high levels of pervasive anthropogenic noise in vital habitats could affect sea turtle and fish behavior and ecology (Samuel et al. 2005b;

Harding et al. 2018). We assume similar impacts have occurred and will continue to affect marine mammals, leatherback sea turtles, and salmonids in the action area.

Despite potential impacts to individual ESA-listed marine mammals, leatherback sea turtles, and ESA-listed salmonids, information is not currently available to determine the potential population level effects of anthropogenic sound levels in the marine environment (MMC 2007) within the action area. For example, we currently lack empirical data on how sound impacts growth, survival, reproduction, and vital rates, nor do we understand the relative influence of such effects on the populations being considered in this opinion.

9.10.1 Vessel Sound and Commercial Shipping

Much of the increase in sound in the ocean environment is due to increased shipping, as vessels become more numerous and of larger tonnage (NRC 2003b; Hildebrand 2009b; McKenna et al. 2012). Commercial shipping is a major source of low-frequency sound in the ocean and the majority of vessel traffic occurs in the Northern Hemisphere. Measurements made over the period 1950 through 1970 indicated low frequency (50 hertz) vessel traffic sound in the eastern North Pacific Ocean and western North Atlantic Ocean was increasing by 0.55 dB per year (Ross 1976; Ross 1993; Ross 2005). Most data indicate vessel sound is likely still increasing (Hildebrand 2009a). Efforts are underway to better document changes in ambient sound (Haver et al. 2018), which will help provide a better understanding of current and future impacts of vessel sound on ESA-listed species.

Although large vessels emit predominantly low frequency sound, studies report broadband sound from large cargo vessels above two kilohertz. The low frequency sounds from large vessels overlap with many mysticetes' predicted hearing ranges (7 hertz to 35 kilohertz) (NOAA 2018) and may mask their vocalizations and cause stress (Rolland et al. 2012a). The broadband sounds from large vessels may interfere with important biological functions of odontocetes, including foraging (Holt 2008; Blair et al. 2016). At frequencies below 300 hertz, ambient sound levels are elevated by 15 to 20 dB when exposed to sounds from vessels at a distance (McKenna et al. 2013). Analysis of sound from vessels revealed that their propulsion systems are a dominant source of radiated underwater sound at frequencies less than 200 hertz (Ross 1976). Additional sources of vessel sound include rotational and reciprocating machinery that produces tones and pulses at a constant rate. Other commercial and recreational vessels also operate within the action area and may produce similar sounds, although to a lesser extent given their much smaller size.

Vessels produce acoustic signatures that can change with vessel speed, vessel load, and activities taking place on the vessel. Peak spectral levels for individual commercial vessels are in the frequency band of 10 to 50 hertz and range from 195 dB re: μPa^2-s at 1 meter for fast-moving (greater than 37 kilometers per hour [20 knots]) supertankers to 140 dB re: μPa^2-s at 1 meter for small fishing vessels (NRC 2003b). Small boats with outboard or inboard engines produce sound that is generally highest in the mid-frequency (one to five kilohertz) range and at moderate (150 to 180 dB re: 1 μPa at 1 meter) source levels (Erbe 2002b; Gabriele et al. 2003; Kipple and

Gabriele 2004). Typically, sound levels are higher for the larger vessels and increased vessel speeds result in higher sound levels.

Sonar systems are used on commercial, recreational, and military vessels and may also affect ESA-listed marine species (NRC 2003a). The action area may host many of these vessel types during any time of the year. The action area is a high vessel density area with many ships travelling around the Queen Charlotte Fault. Although little information is available on potential effects of multiple commercial and recreational sonars to ESA-listed marine species, the distribution of these sounds will be small because of their short durations and the fact that the high frequencies of the signals attenuate quickly in seawater (Nowacek et al. 2007). However, military sonar, particularly low frequency active sonar, often produces intense sounds at high source levels, and these may impact cetacean behavior (Southall et al. 2016). For further discussion of military sound on the ESA-listed species located within the action area and, considered in this opinion, see Section 9.11.

9.10.2 Aircraft

Aircraft within the action area may consist of small commercial or recreational airplanes, helicopters, or large commercial airliners. These aircraft produce a variety of sounds that could potentially enter the water and impact ESA-listed species. While it is difficult to assess these impacts, several studies have documented what appear to be minor behavioral disturbances in response to aircraft presence (Nowacek et al. 2007). Erbe et al. (2018) recorded underwater noise from commercial airplanes reaching as high as 36 decibels above ambient noise. Sound pressure levels received at depth were comparable to cargo and container ships traveling at distances of one to three kilometers (0.5 to 1.6 nautical miles) away, although the airplane noises ceased as soon as the planes left the area, which was relatively quickly compared to a cargo vessel. While such noise levels are relatively low and brief, they still have the potential to be heard by ESA-listed species due to their large overlap in frequency between the functional hearing frequency ranges of ESA-listed marine mammals, leatherback sea turtles, and ESA-listed salmonids in the action area (Kuehne et al. 2020).

9.10.3 Seismic Surveys

There are seismic survey activities involving towed airgun arrays that may occur within the action area. They are the primary exploration technique to locate oil and gas deposits, fault structure, and other geological hazards. These activities may produce noise that could impact ESA-listed species such as marine mammals, leatherback sea turtles, and ESA-listed salmonids within the action area. These airgun arrays generate intense low-frequency sound pressure waves capable of penetrating the seafloor and are fired repetitively at intervals of ten to 20 seconds for extended periods (NRC 2003b). Most of the energy from the airguns is directed vertically downward, but significant sound emission also extends horizontally. Peak sound pressure levels from airguns usually reach 235 to 240 dB at dominant frequencies of five to 300 hertz (NRC 2003a). Most of the sound energy is at frequencies below 500 hertz, which is within the hearing range of baleen whales (Nowacek et al. 2007). In the U.S., all seismic surveys involving the use of airguns with the potential to take marine mammals are covered by incidental take authorizations under the MMPA, and if they involve ESA-listed species, undergo formal ESA section 7 consultation. In addition, the Bureau of Ocean Energy Management authorizes oil and gas activities in domestic waters, and the National Science Foundation and U.S. Geological Survey fund and/or conduct these activities in domestic, international, and foreign waters, and in doing so, these agencies undertake ESA section 7 consultation with NMFS. More information on the effects of these activities on ESA-listed species, including exempted take, can be found in recent biological opinions. Within or in the vicinity of the action area, biological opinions include NMFS (2017b), NMFS (2018a), the NMFS (2019b), NMFS (2019c), and NMFS (2021). Each of the seismic survey projects were issued an IHA and received a corresponding biological opinion on each respective survey. These biological opinions concluded the surveys were not likely to jeopardize the continued existence of ESA-listed species, or result in the destruction or adverse modification of designated critical habitat.

9.10.4 Marine Construction

Marine construction that produces sound includes drilling, dredging, pile-driving, cable-laying, and explosions. These activities are known to cause behavioral disturbance and physical damage (NRC 2003a). While most of these activities are coastal, offshore construction does occur. All or some of these activities may occur within the action area and could affect ESA-listed marine mammals, leatherback sea turtles, and ESA-listed salmonids.

9.11 Military Activities

The U.S. Navy conducts training, testing, and other military readiness activities on range complexes throughout coastal and offshore areas in the United States and on the high seas. The U.S. Navy's Northwest Training and Testing area (Washington State down to northern California) is to the south of the seismic survey action area and to the north is the Navy's Gulf of Alaska Training area. Training uses weapon systems and tactics in realistic situations to simulate and prepare for combat. Activities include routine gunnery, missile, surface fire support, amphibious assault and landing, bombing, sinking, torpedo, tracking, and mine exercises. Testing activities are conducted for different purposes and include at-sea research, development, evaluation, and experimentation. The U.S. Navy performs testing activities to ensure that the latest technologies and techniques are ready for use by their forces. Most of these activities are similar to what the U.S. Navy has conducted in the same areas for decades, therefore the ESA-listed species located within the action area have been exposed to these military activities often and repeatedly.

The U.S. Navy's activities produce sound and visual disturbance to marine mammals, sea turtles, and fishes throughout the action area. Anticipated impacts from harassment due to the U.S. Navy's activities include changes from foraging, resting, milling, and other behavioral states that require low energy expenditures to traveling, avoidance, and behavioral states that require higher energy expenditures. Based on the currently available scientific information, behavioral responses that result from stressors associated with these training and testing activities are expected to be temporary and will not affect the reproduction, survival, or recovery of these species. Sound produced during U.S. Navy activities is also expected to result in instances of TTS and PTS to marine mammals, sea turtles, and fishes. The U.S. Navy's activities constitute a federal action and take of ESA-listed marine mammals, sea turtles, and fishes considered for these activities have previously undergone ESA section 7 consultations. Through these consultations with NMFS, the U.S. Navy has implemented monitoring and conservation measures to reduce the potential effects of underwater sound from activities on ESA-listed resources in the Pacific Ocean. Conservation measures include employing visual observers and implementing mitigation zones during activities using active sonar and explosives.

9.12 Scientific Research Activities

Regulations for section 10(a)(1)(A) of the ESA allow issuance of permits authorizing take of certain ESA-listed species for the purposes of scientific research. Prior to the issuance of such a permit, the proposal must be reviewed for compliance with section 7 of the ESA. Scientific research permits issued by NMFS currently authorize studies of ESA-listed species in the Northeast Pacific Ocean, some of which extend into portions of the action area for the proposed action. Marine mammals and sea turtles have been the subject of field studies for decades. The primary objective of most of these field studies has generally been monitoring populations or gathering data for behavioral and ecological studies. Over time, NMFS has issued dozens of permits on an annual basis for various forms of "take" of marine mammals, sea turtles, and fishes in the action area from a variety of research activities.

Authorized research on ESA-listed marine mammals includes aerial and vessel surveys, close approaches, photography, videography, behavioral observations, active acoustics, remote ultrasound, passive acoustic monitoring, biological sampling (i.e., biopsy, breath, fecal, sloughed skin), and tagging. Research activities involve non-lethal "takes" of these marine mammals.

Authorized research on sea turtles includes close approach, capture, handling and restraint, tagging, blood and tissue collection, lavage, ultrasound, imaging, antibiotic (tetracycline) injections, captive experiments, laparoscopy, and mortality. Most research activities involve authorized sub-lethal "takes," with some resulting mortality.

Authorized research on fish includes capture, handling and restraint, tagging, blood and tissue sampling, and mortality. Most research activities involve authorized sub-lethal "takes", with some resulting in mortality.

Research permits for ESA-listed fish are authorized under section 10(a)(1)(A) and issued at the West Coast Region, or the research is authorized under section 4(d) rules, for threatened fish. The consultations which took place on the issuance of these ESA scientific research permits each found that the authorized research activities will have no more than short-term effects and were not determined to result in jeopardy to the species or destruction or adverse modification of designated critical habitat.

Additional MMPA "take" is likely to be authorized in the future within the action area, as additional permits are issued, along with corresponding ESA consultations for any ESA-listed species affected by the issuance of those permits.

9.13 Synthesis of Environmental Baseline Impacts on Endangered Species Act-Listed Species

Collectively, the stressors described above have had, and likely continue to have, lasting impacts on the ESA-listed species considered in this consultation. Some of these stressors result in mortality or serious injury to individual animals (e.g., vessel strikes and whaling), whereas others result in more indirect (e.g., fishing that impacts prey availability) or non-lethal (e.g., whale watching) impacts.

Assessing the aggregate impacts of these stressors on the species considered in this opinion is difficult. This difficulty is compounded by the fact that many of the species in this opinion are wide-ranging and subject to stressors in locations throughout and outside the action area.

We consider the best indicator of the aggregate impacts of stressors in the *Environmental Baseline* on ESA-listed resources to be the status and trends of those species. As noted in Section 8, some of the species considered in this consultation are experiencing increases in population abundance, some are declining, and for others, their status remains unknown. Taken together, this indicates that the *Environmental Baseline* is impacting species in different ways. The species experiencing increasing population abundances are doing so despite the potential negative impacts of the activities described in the *Environmental Baseline*. Therefore, while the *Environmental Baseline* may slow their recovery, recovery is not being prevented. For the species that may be declining in abundance, it is possible that the suite of conditions described in the *Environmental Baseline* is preventing their recovery. However, it is also possible that their populations are at such low levels (e.g., due to historical commercial whaling) that even when the species' primary threats are removed, the species may not be able to achieve recovery. At small population sizes, species may experience phenomena such as demographic stochasticity, inbreeding depression, and 'Allee' effects, among others, that cause their limited population size to become a threat in and of itself. A thorough review of the status and trends of each species is discussed in the *Status of Species Likely to be Adversely Affected* section of this opinion and what this means for the populations and critical habitats is discussed in the *Integration and Synthesis* (Section 12).

10 Effects of the Action

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 C.F.R. §402.02).

This section follows the stressor, exposure, response, and risk assessment framework described in Section 2. The effects analyses describe the potential stressors associated with the proposed action, the probability of individuals of ESA-listed species being exposed to these stressors based on the best scientific and commercial data available, and the probable responses of those individuals, given probable exposures. As described in Section 10.3, for any responses that would be expected to reduce an individual's fitness (i.e., growth, survival, annual reproductive success, or lifetime reproductive success), the assessment will consider the risk posed to the viability of the population(s) those individuals comprise and to the ESA-listed species those populations represent. For this consultation, we are particularly concerned about behavioral and stress-related physiological disruptions and potential unintentional mortality that may result in animals that fail to feed, reproduce, or survive because these responses could have population-level consequences.

10.1 Stressors Associated with the Proposed Action

As discussed in Section 5, we determined that the following stressors may result from the National Science Foundation seismic survey and associated NMFS IHA authorization:

1. Pollution by oil, fuel leakage, trash, and other debris;
2. Vessel strike;
3. Vessel noise;
4. Entanglement in towed hydrophone streamer;
5. Sound fields produced by the multi-beam echosounder, and sub-bottom profiler, acoustic Doppler current profiler, and pinger; and
6. Sound fields produced by airgun array.

Based on a review of available information, during consultation we determined which of these possible stressors will be likely to occur and which will be discountable or insignificant for the species affected by these activities. These stressors and species were discussed in Sections 6, 7, and 8. As discussed in Section 7.1, the only stressor we expect to result in adverse effects to ESA-listed marine mammals, leatherback sea turtles, and fishes presented in Section 8 are sound levels found within the sound fields produced by the airgun arrays. These effects are discussed in the *Exposure and Response Analysis* sections below in Section 10.3.

10.2 Mitigation Measures to Minimize or Avoid Exposure

As described in the *Description of the Proposed Action* (Section 3), the National Science Foundation and Lamont-Doherty Earth Observatory's proposed action and NMFS Permits and Conservation Division's proposed IHA require monitoring and mitigation measures that includes the use of proposed exclusion and buffer zones, power-down procedures, shut down procedures, ramp-up procedures, visual monitoring with NMFS-approved PSOs, passive acoustic monitoring, vessel strike avoidance measures, and additional mitigation measures considered in the presence of ESA-listed marine mammals and sea turtles to minimize or avoid exposure. The

NMFS Permits and Conservation Division's proposed IHA is provided in Appendix A (see Section 17.1).

10.3 Exposure and Response Analysis

In the previous sections, we described the stressors resulting from the action and determined that noise from the airgun array is likely to adversely affect ESA-listed blue, fin, Western North Pacific gray, North Pacific right, Mexico DPS humpback, sei, and sperm whales, Western DPS Steller sea lions, leatherback sea turtles, Chinook salmon (Snake River fall-run, Snake River spring/summer-run, Lower Columbia River, Upper Willamette River, Upper Columbia River spring-run, and Puget Sound ESUs), sockeye salmon (Snake River and Ozette River ESUs), chum salmon (Hood Canal summer-run and Columbia River ESUs), and steelhead (South-Central California Coast, Central California Coast, California Central Valley, Northern California, Upper Columbia River, Snake River Basin, Lower Columbia River, Upper Willamette River, Middle Columbia River, and Puget Sound DPSs) in the action area. The exposure analysis identifies the ESA-listed species that are likely to co-occur with the action's effects on the environment in space and time, and identifies the nature of that co-occurrence with the sound exposure. The exposure analysis identifies, as possible, the number, age or life stage, and gender of the individuals likely to be exposed to the action's effects and the population(s) or sub-populations(s) those individuals represent. The response analysis evaluates the available evidence to determine how individuals of those ESA-listed species are likely to respond given their probable exposure. The response analysis also considers information on the potential for stranding and the potential effects on the prey of ESA-listed marine mammals in the action area.

10.3.1 Definition of Take, Harm, and Harass

Section 3 of the ESA defines take as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct. We categorize two forms of take, lethal and sublethal take. Lethal take is expected to result in immediate, imminent, or delayed but likely mortality. Sublethal take occurs when effects of the action are below the level expected to cause death, but are still expected to cause injury, harm, or harassment. As defined by regulation, harm, in the definition of 'take' in the ESA means "an act which actually kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation which actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including, breeding, spawning, rearing, migrating, feeding or sheltering." (50 C.F.R. 222.102). Thus, for sublethal take we are concerned with harm that does not result in mortality but is still likely to injure an animal.

NMFS has not defined "harass" under the ESA by regulation. However, on October 21, 2016, NMFS issued interim guidance on the term "harass," defining it as to "create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering." For this consultation, we rely on this definition of harass when assessing effects to all ESA-listed species, with the qualifications noted below.

NMFS guidance issued on October 21, 2016, states that our "interim ESA harass interpretation does not specifically equate to MMPA Level A or Level B harassment, but shares some similarities with both levels in the use of the terms 'injury/injure' and a focus on a disruption of behavior patterns. NMFS has not defined 'injure' for purposes of interpreting Level A and Level B harassment but in practice has applied a physical test for Level A harassment." Under the MMPA, harassment is defined as any act of pursuit, torment, or annoyance which:

- Has the potential to injure a marine mammal or marine mammal stock in the wild (Level A Harassment); or
- 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 (Level B Harassment).

The National Science Foundation and NMFS Permits and Conservation Division estimate the exposure to the sounds from the airgun array that will result in take, as defined under the MMPA for all marine mammal species, including those listed under the ESA. Because our ESA analysis relies on NMFS' interim guidance on the ESA term "harass," our conclusions may differ from those reached by the NMFS Permits and Conservation Division in their MMPA analysis. Given the differences between the MMPA and ESA standards for harassment, there may be circumstances in which an act is considered harassment and "take" under the MMPA, but not take under the ESA.

We use the numbers of individuals expected to be taken from the MMPA's definition of Level A and Level B harassment to estimate the number of individuals of ESA-listed species that may be adversely affected by sound from the survey. This is a conservative approach, because not all harassment under the MMPA constitutes take under the ESA.

Harassment under the ESA is expected to occur during the seismic survey activities and may involve a wide range of behavioral responses for ESA-listed marine mammals including, but not limited to, avoidance, and disruption or changes in: vocalizations, dive patterns, feeding, migration or reproductive behaviors. The MMPA Level B harassment exposure estimates do not differentiate between the types of behavioral responses, nor do they provide information regarding the potential fitness or other biological consequences of the responses on the affected individuals. Accordingly, the number of takes under the ESA may be different than the number of takes authorized under the MMPA. Therefore, in the following sections, we consider the available scientific evidence to estimate exposure of ESA-listed species and determine the likely nature of their behavioral responses and the potential fitness consequences in accordance with the definitions of "take" under the ESA.

10.3.2 Exposure Analysis of Endangered Species Act-Listed Marine Mammals in the Action Area

Our exposure analysis relies on two basic components: (1) information on species distribution (i.e., density within the action area), and (2) information on the level of exposure to sound at which species are likely to be affected (i.e., exhibit some response). Using this information, and information on the proposed seismic survey (e.g., active acoustic sound source specifications, trackline locations, months of operation, etc.), we then estimate the number of instances in which an ESA-listed species may be exposed to sound fields from the airgun array that are likely to result in adverse effects such as harm or harassment. In many cases, estimating the potential exposure of animals to anthropogenic stressors is difficult due to limited information on animal density estimates in the action area and overall abundance, the temporal and spatial location of animals, and proximity to and duration of exposure to the sound source. For these reasons, we evaluate the best available data and information in order to reduce the level of uncertainty in making our final exposure estimates.

As discussed in the *Status of Species Likely to be Adversely Affected* section, there are seven ESA-listed marine mammal species that are likely to be adversely affected by the proposed action: blue, fin, Mexico DPS of humpback, Western North Pacific DPS of gray, sei, and sperm whales, and Western DPS Steller sea lions. As discussed previously, the stressor of primary concern from the proposed action is the acoustic impacts of the airgun arrays.

Airguns contribute a massive amount of anthropogenic energy to the world's oceans (3.9×10^{13} Joules cumulatively), second only to nuclear explosions (Moore and Angliss 2006). Although most energy is in the low-frequency range, airguns emit a substantial amount of energy up to 150 kilohertz (Goold and Coates 2006). The National Science Foundation, Lamont-Doherty Earth Observatory, and NMFS Permits and Conservation Division provided estimates of the expected number of ESA-listed marine mammals exposed to received levels of airguns greater than or equal to 160 dB re: 1 μPa (rms). Our exposure estimates stem from the best available scientific and commercial information on marine mammal densities and a predicted radius (rms; Table 36 and Table 37) along the seismic survey tracklines. Based upon information presented in the *Response Analysis* below, ESA-listed marine mammals exposed to these sound sources could be harmed, harassed, exhibit changes in behavior, suffer stress, or even strand.

The National Science Foundation and Lamont-Doherty Earth Observatory applied acoustic thresholds to determine at what point during exposure to the airgun arrays marine mammals are "harassed," based on the definition of "harassment" provided in the MMPA (16 U.S.C. §1362(18)(a)). We used the same values to determine the type and extent of take for ESA-listed marine mammals, while recognizing that harassment under the ESA and the MMPA are not synonymous as described above.

During the development of the IHA, the NMFS Permits and Conservation Division conducted an independent exposure analysis that was informed by comments received during the required public comment period for the proposed IHA. The exposure analysis included estimates of the number of ESA-listed marine mammals likely to be exposed to received levels at MMPA Level A harassment thresholds in the absence of monitoring and mitigation measures.

For our ESA section 7 consultation, we conducted an evaluation of both the National Science Foundation and the NMFS Permit and Conservation Division's estimates of ESA-listed marine mammals that will be exposed to acoustic levels that may cause harassment under the ESA. In this opinion, we adopted the Permits and Conservation Division's exposure analysis because it utilized the best available scientific information and methods to evaluate exposure of ESA-listed marine mammals. Below we describe the exposure analysis for ESA-listed marine mammals.

Acoustic Thresholds

To determine the point that marine mammals are considered "harassed" under the MMPA during exposure to airgun arrays (and other active acoustic sources), NMFS applies certain acoustic thresholds. These thresholds are used in the development of radii for exclusion zones around a sound source and the necessary mitigation requirements necessary to limit marine mammal exposure to harmful levels of sound (NOAA 2018). The references, analysis, and methodology used in the development of these thresholds are described in *NOAA 2018 Revision to Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing* (NOAA 2018), which is available online at https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-acoustic-technical-guidance. For Level B harassment under the MMPA, and behavioral responses under the ESA, NMFS has historically relied on an acoustic threshold for 160 dB re: 1 μPa (rms). This value is based on observations of behavioral responses of mysticetes, but is used for all marine mammal species. For the proposed action, the NMFS Permits and Conservation Division continued to rely on this historic NMFS acoustic threshold to estimate the number of takes by MMPA Level B harassment, and accordingly, take of ESA-listed marine mammals that are proposed in the IHA.

For physiological responses to active acoustic sources, such as hearing impairment from TTS and PTS, the NMFS Permits and Conservation Division relied on NMFS' technical guidance for auditory injury of marine mammals (NOAA 2018). Unlike NMFS' 160 dB re: 1 μPa (rms) MMPA Level B harassment threshold (which does not include TTS or PTS), these TTS and PTS auditory thresholds differ by species hearing group (Table 32). Furthermore, these acoustic threshold criteria are a dual metric for impulsive sounds. One threshold, the peak sound pressure level (0 to peak SPL) criterion, does not include the duration of exposure. The other metric, the cumulative sound exposure level criterion, incorporates auditory weighting functions based upon a species group's hearing sensitivity, and thus susceptibility to TTS and PTS, over the exposed frequency range and duration of exposure. The metric that results in the largest distance from the sound source (i.e., produces the largest field of exposure) is used in estimating total range to potential exposure and effects, which would encompass all anticipated harmful effects resulting from sound exposures.

In using these acoustic thresholds to estimate the number of individuals that may experience auditory injury, the NMFS Permits and Conservation Division classify any exposure equal to or above the acoustic threshold for the onset of PTS (see Table 32) as auditory injury, and thus MMPA Level A harassment, and harm under the ESA. Any exposure below the threshold for the onset of PTS, but equal to or above the 160 dB re: 1 μPa (rms) acoustic threshold is classified as MMPA Level B harassment, which will also be considered ESA harassment. Among ESA harassment (MMPA Level B harassment) exposures, the NMFS Permits and Conservation Division does not distinguish between those individuals that are expected to experience TTS and those that will only exhibit a behavioral response.

Table 32. Functional hearing groups, generalized hearing ranges, and acoustic thresholds identifying the onset of PTS and TTS for ESA-listed marine mammals exposed to impulsive sounds during the proposed Queen Charlotte Survey (NOAA 2018).

Hearing Group	Generalized Hearing Range*	Permanent Threshold Shift Onset	Temporary Threshold Shift Onset
Low-Frequency Cetaceans (Baleen Whales) (LE,LF,24 hour)	7 hertz to 35 kilohertz	$L_{pk,flat}$: 219 dB $L_{E,LF,24h}$: 183 dB	213 dB peak SPL 168 dB SEL
Mid-Frequency Cetaceans (Sperm Whale) (LE,MF,24 Hour)	150 hertz to 160 kilohertz	$L_{pk,flat}$: 230 dB $L_{E,MF,24h}$: 185 dB	224 dB peak SPL 170 dB SEL
Otariid Pinnipeds (Steller Sea Lions) (LE,MF,24 Hour) – Underwater	60 hertz to 39 kilohertz	$L_{pk,flat}$: 232 dB $L_{E,MF,24h}$: 203 dB	212 dB peak SPL 170 dB SEL

LE, X, 24 Hour=Frequency Sound Exposure Level (SEL) Cumulated over 24 Hour
LF=Low-Frequency
MF=Mid-Frequency
*Represents the generalized hearing range for the entire group as a composite (i.e., all species within the group), where individual species' hearing ranges are typically not as broad. Generalized hearing range chosen based on approximately 65 dB threshold from normalized composite audiogram, with the exception for lower limits for low frequency cetaceans (Southall et al. 2007a) (approximation).
Note: Dual metric acoustic thresholds for impulsive sounds (peak and/or SEL_{cum}): Use whichever results in the largest (most conservative for the ESA-listed species) isopleth for calculating PTS onset. If a non-impulsive sound has the potential of exceeding the peak sound pressure level thresholds associated with impulsive sounds, these thresholds should also be considered.
Note: Peak sound pressure (Lpk) has a reference value of 1 µPa, and cumulative sound exposure level (LE) has a reference value of 1 $\mu Pa^2 s$. In this table, thresholds are abbreviated to reflect American National Standards Institute standards (ANSI 2013). However, peak sound pressure is defined by ANSI as incorporating frequency weighting, which is not the intent for this technical guidance. Hence, the subscript "flat" is being included to indicate peak sound pressure should be flat weighted or unweighted within the generalized hearing range. The subscript associated with cumulative sound exposure level thresholds indicates the designated marine mammal auditory weighting function and that the recommended accumulation period is 24 hours. The cumulative sound exposure level thresholds could be exceeded in a multitude of ways (i.e., varying exposure levels and durations, duty cycle). When possible, it is valuable for action proponents to indicate the conditions under which these acoustic thresholds will be exceeded.

Modeled Sound Fields of Airguns

In this section, we first evaluate the likelihood that marine mammals will be exposed to sound from the proposed seismic airgun activities at or above 160 dB re: 1 µPa (rms) based upon the information described above, and the acoustic thresholds correlating to onset of PTS or TTS provided in Table 32. If we find that such exposure above any particular threshold is likely, we then estimate the number of instances in which we expect marine mammals to be exposed to these sound levels, based on the ensonified areas at or above these sound levels and information on marine mammal density.

The methodology for estimating the number of ESA-listed species that might be exposed to the sound field used by the National Science Foundation, Lamont-Doherty Earth Observatory, and NMFS Permits and Conservation Division were largely the same. The National Science Foundation, Lamont-Doherty Earth Observatory, and NMFS Permits and Conservation Division estimated the number of marine mammals predicted to be exposed to sound levels that will result in MMPA Level B and Level A harassment by using radial distances to predicted isopleths (See Table 34 and Table 35). In the case of this opinion, MMPA Level B harassment and MMPA Level A harassment for marine mammals corresponds to the thresholds for ESA harassment and harm, respectively.

Based on information provided by the National Science Foundation, Lamont-Doherty Earth Observatory, and NMFS Permits and Conservation Division, we have determined that ESA-listed cetaceans are likely to be exposed to sound levels at or above the threshold at which PTS, TTS, and behavioral harassment will occur. From modeling by the Lamont-Doherty Earth Observatory, the National Science Foundation and Lamont-Doherty Earth Observatory provided sound source levels of the airgun array (Table 33) and estimated distances to harassment thresholds (160 dB re: 1 μPa (rms)) as well as injury thresholds, which include 219 dBpeak for low frequency cetaceans, 230 dBpeak for mid frequency cetaceans, and 232 dBpeak for otariid pinnipeds, generated by the two airgun array configurations and water depth. The predicted and modeled radial distances for the various harassment and injury thresholds for cetaceans for the R/V *Langseth*'s airgun arrays can be found in Table 34 and Table 35.

Table 33. Modeled sound source levels (decibels) for the R/V *Langseth* airgun array.

Functional Hearing Group	Single (40 in^3) Airgun Array (Peak SPL_{flat})	Single (40 in^3) Airgun Array (SEL_{cum})	36 (6,600 in^3) Airgun Array (Peak SPL_{flat})	36 (6,600 in^3) Airgun Array (SEL_{cum})
Low Frequency Cetaceans (L_{pk} flat: 219 dB; LE,LF,24_h: 183 dB)	223.93 dB	202.99 dB	252.06 dB	232.98 dB
Mid Frequency Cetaceans (L_{pk} flat: 230 dB; LE,MF,24_h: 185 dB)	224.09 dB	202.89 dB	252.65 dB	232.83 dB
Otariid Pinnipeds (L_{pk} flat: 232 dB; LE,MF,24_h: 203 dB)	223.95 dB	202.35 dB	252.52 dB	232.07 dB

in³=cubic inches

Table 34. Predicted radial distances in meters from the R/V *Langseth* seismic sound sources to isopleth corresponding to greater than or equal to 160 decibels re: 1 μPa (rms) threshold.

Source	Volume (in³)	Maximum Tow Depth (meters)	Water Depth (meters)	Predicted Distance to Threshold (160 dB re: 1 μPa [rms]) (meters)[1]
Single Bolt Airgun	40	12	>1,000	431[1]
Single Bolt Airgun	40	12	100–1000 m	647[2]
Single Bolt Airgun	40	12	<100 m	1,041[3]
36 Airguns	6,600	12	>1,000	6,733[1]
36 Airguns	6,600	12	100–1000 m	9,468[4]
36 Airguns	6,600	12	<100 m	12,650[4]

in³=cubic inches
m=meters
[1] Distance is based on Lamont-Doherty Earth Observatory model results.
[2] Distance is based on Lamont-Doherty Earth Observatory model results with a 1.5 × correction factor between deep and intermediate water depths.
[3] Distance is based on empirically derived measurements in the GOM with scaling applied to account for differences in tow depth
[4] Based on empirical data from Crone et al. (2014); see Appendix A of NSF and LDEO (2020) for details.

Table 35. Modeled threshold distances in meters from the R/V Langseth's four string, 36 airgun, array and a shot interval of 50 m[1], corresponding to Marine Mammal Protection Act Level A harassment thresholds. The largest distance (in bold) of the dual metric criteria (SEL_{cum} or Peak SPL_{flat}) was used to calculate takes and MMPA Level A harassment threshold distances.

Functional Hearing Group	LF Cetaceans	MF Cetaceans	Otariid Pinnipeds/Otters
PTS SEL_{cum}[2]	**320.2**	0	0
Peak SPL_{flat}	38.9	**13.6**	**10.6**

[1] Using the 50-m shot interval provides more conservative distances than the 278-m shot interval. [2] Results from NMFS user spreadsheet tool (NOAA 2018), based on modeled source levels and survey parameters.

Note: The largest distance of the dual criteria (SELcum or Peak SPLflat) were used to calculate takes and harm (MMPA Level A harassment) threshold distances. Because of some of the assumptions included in the methods used, isopleths produced may be overestimates to some degree, which will ultimately result in some degree of overestimate of takes by harm (MMPA Level A harassment). However, these tools offer the best way to predict appropriate isopleths when more sophisticated three-dimensional modeling methods are not available, and NMFS continues to develop ways to quantitatively refine these tools and will qualitatively address the output where appropriate. For mobile sources, such as the proposed seismic surveys, the NMFS user spreadsheet predicts the closest distance at which a stationary animal will not incur PTS if the sound source traveled by the animal in a straight line at a constant speed. Only Low-frequency, Mid-frequency, and otariid Level A thresholds are shown since these are the only thresholds that correspond to the ESA-listed species likely to be adversely affected by the proposed action.

Exposure Estimates based upon Density Estimates

We reviewed available cetacean densities with the National Science Foundation and the NMFS Permits and Conservation Division, and agreed upon which densities constituted the best available scientific and commercial information available for each ESA-listed species. The NMFS Permits and Conservation Division adopted these estimates for use in their proposed IHA and we have adopted them for our ESA exposure analysis.

For the National Science Foundation's environmental assessment and IHA application, two density data sources were used to calculate take of ESA-listed mammals that might be encountered in the proposed project area. For the majority of species, a combination of habitat-based stratified marine mammal densities developed by the U.S. Navy for assessing potential impacts of training activities in the Gulf of Alaska (Navy 2021) and densities for Behm Canal in Southeast Alaska (Navy 2019a) were used. Based on our recommendations, Gulf of Alaska densities were used for offshore areas, and the Behm Canal densities were used for coastal waters. Consistent with Navy (2021), four strata were defined by (Navy 2021) for the Gulf of Alaska, including (1) Inshore: all waters <1000 meters deep; (2) Slope: from 1000 meters water depth to the Aleutian trench/subduction zone; (3) Offshore: waters offshore of the Aleutian trench/subduction zone; and (4) Seamount: waters within defined seamount areas. For cetaceans, the preferred densities for coastal waters (shallow and intermediate depths) were from Behm Canal; "Offshore" densities from the Gulf of Alaska were used for offshore waters (Navy 2019a). If no densities were available for Behm Canal, then "Inshore" densities from Navy (2021) were used for coastal waters (shallow and intermediate depths); "Offshore" densities were used for offshore waters. For Western DPS Steller sea lions, densities from Behm Canal, when available, were used for shallow water; "Inshore" densities from Navy (2021) were used for intermediate-depth water; and "Offshore" densities from Navy (2021) were used for offshore waters. For North Pacific right whale, densities from the Gulf of Alaska (Navy 2021) were used based on similar numbers of individuals recently observed off the coast of British Columbia compared to the Gulf of Alaska. Since 2008, there have been four individuals sighted off the coast of British Columbia (Kloster 2021) and four off the coast of Kodiak and the Gulf of Alaska (Muto et al. 2019).

As densities for Behm Canal are for inland waters and are therefore expected to be much greater than densities off the coast, we did not use the Behm Canal densities for intermediate-depth waters. All marine mammal densities corresponding to the various strata in the Gulf of Alaska and single density values for Behm Canal were based on data from several different sources, including Navy funded line-transect surveys in the GOA, as described in Appendix B of NSF and LDEO (2020).

Table 36. Densities of ESA-listed cetaceans in the action area during National Science Foundation and Lamont-Doherty Earth Observatory's seismic survey in the North Pacific Ocean.

Species	Reported Density (<100 meters) (number per square kilometer)	Reported Density (100-1,000 meters) (number per square kilometer)	Reported Density (>1,000 meters) (number per square kilometer)	Density Reference
Blue Whale	0.0001	0.0001	0.0005	(Navy 2021)
Fin Whale	0.0001	0.0001	0.016	(Navy 2019a; Navy 2021)
Gray Whale	0.04857	0.04857	0	(Navy 2021)
Humpback Whale	0.01170	0.01170	0.001	(Navy 2019a; Navy 2021)
North Pacific Right Whale	0	0	.000003	(Navy 2021)
Sei Whale	0.0004	0.0004	0.0004	(Navy 2021)
Sperm Whale	0	0.002	0.0013	(Navy 2021)
Western DPS Steller Sea Lion	0.31616	0.057	0.0000	(Navy 2019a; Navy 2021)

*Rounded to nearest whole number

Blue Whale - In the North Pacific, blue whale calls are detected year-round (Monnahan et al. 2014), and Stafford et al. (2009) reported that sea-surface temperature is a good predictor variable for blue whale call detections. However, no detections of blue whales had been made in the Gulf of Alaska since the late 1960s (Calambokidis et al. 2009) until blue whale calls were recorded in the area during 1999–2002 (Stafford et al. 2007). Call types from both northeastern and northwestern Pacific blue whales were recorded from July through December in the GOA, suggesting that two stocks used the area at that time (Stafford et al. 2007). Call rates peaked from

August through November (Moore et al. 2006). More recent acoustic studies using fixed PAM have confirmed the presence of blue whales from both the Central and Eastern North Pacific stocks in the Gulf of Alaska concurrently (Rice et al. 2015). Blue whale calls were recorded in all months, at all shelf, slope, and seamount sites; and during all years (2011–2015) of those studies.

In July 2004, three blue whales were sighted in the Gulf of Alaska. The first blue whale was seen on 14 July approximately 185 kilometers southeast of Prince William Sound; two more blue whales were seen approximately 275 kilometers southeast of Prince William Sound (Calambokidis et al. 2009). These whales were thought to be part of the California feeding population (Calambokidis et al. 2009). In August 2004, 19 sightings of more than 40 blue whales were seen during a Lamont-Doherty Earth Observatory survey off southern Prince of Wales Island, Southeast Alaska, in Dixon Entrance and Cordova Bay (MacLean and Koski 2005). Rone et al. (2017) reported five blue whale sightings (seven animals) in 2013 and 13 blue whale sightings (13 animals) in 2015 in the U.S. Navy training area east of Kodiak.

Fin Whale- Fin whale calls are recorded in the North Pacific year-round, including in the Gulf of Alaska (Edwards et al. 2015). In the central North Pacific, the GOA, and the Aleutian Islands, call rates peak during fall and winter (Stafford et al. 2009).

Acoustic detections have been made throughout the year in pelagic waters west of Vancouver Island (Edwards et al. 2015). Calls were detected from February through July 2006 at Union Seamount off northwestern Vancouver island, and from May through September at La Pérouse Bank (Ford et al. 2010a). Gregr and Trites (2001) proposed that the area off northwestern Vancouver Island and the continental slope may be critical habitat for fin whales because of favorable feeding conditions; however, no critical habitat has been designated (Parks Canada 2016). The waters off western Haida Gwaii and Dixon Entrance were also identified as fin whale important areas by PNCIMAI (2011).

Gray Whale- Gray whales are common off Haida Gwaii and western Vancouver Island (Williams and Thomas 2007), in particular during their migration. Whales travel southbound along the coast of British Columbia during their migration to Baja California between November and January, with a peak off Vancouver Island during late December; during the northbound migration, whales start appearing off Vancouver Island during late February, with a peak in late March, with fewer whales occurring during April and May (Ford 2014). Northbound migrants typically travel within approximately five kilometers from shore (Ford 2014), although some individuals have been sighted more than 10 kilometers from shore (Ford et al. 2010b). Based on acoustic detections described by Meyer (2017 in COSEWIC 2017), the southward migration also takes place in shallow shelf waters. During surveys in British Columbia waters during summer, most sightings were made within 10 kilometers from the coast in water shallower than 100 meters (Ford et al. 2010b). According to NMFS (2019a), approximately 0.1 percent of gray whales occurring in Southeast Alaska and northern British Columbia are likely to be from the Western North Pacific DPS; the rest would be from the Eastern North Pacific DPS.

North Pacific Right Whale

North Pacific right whales have been scarce in British Columbia since 1900 (Ford 2014). In the 1900s, there were only six records of right whales for British Columbia, all of which were catches by whalers (Ford et al. 2016); five occurred to the west of Haida Gwaii (Ford 2014). Since 1951, there have been four confirmed records. A sighting of one individual 15 kilometers off the west coast of Haida Gwaii was made on June 9, 2013 and another sighting occurred on 25 October 2013 on Swiftsure Bank near the entrance to the Strait of Juan de Fuca. The third and fourth sightings were made off Haida Gwaii in June 2018 and June 2021 (Kloster 2021). There have been two additional unconfirmed records for British Columbia, including one off Haida Gwaii in 1970 and another for the Strait of Juan de Fuca in 1983 (Ford 2014).

Sei Whale- Sei whales are now considered rare in Pacific waters of the U.S. and Canada and there were no sightings in the late 1900s after whaling ceased (Gregr et al. 2006). A single sei whale was seen off southeastern Moresby Island in Hecate Strait coastal surveys in the summers of 2004/2005 (Williams and Thomas 2007). Ford (2014) only reported two sightings for sei whale, both of those far offshore from Haida Gwaii. Possible sei whale vocalizations were detected off the west coast of Vancouver Island during spring and summer 2006 and 2007 (Ford et al. 2010a). Gregr and Trites (2001) proposed that the area off northwestern Vancouver Island and the continental slope may be critical habitat for sei whales because of favorable feeding conditions; however, no critical habitat has been designated (Parks Canada 2016). The waters off western Haida Gwaii were identified as sei whale important areas by PNCIMAI (2011). Sei whales could be encountered during the proposed survey, although this species is considered rare in these waters.

Sperm Whale- Sperm whales are distributed widely across the North Pacific (Rice 1989). Males can migrate north in the summer to feed in the GOA, Bering Sea, and waters around the Aleutian Islands (Rice 1989). Most of the information regarding sperm whale distribution in the Gulf of Alaska (especially the eastern GOA) and Southeast Alaska has come from anecdotal observations from fishermen and reports from fisheries observers aboard commercial fishing vessels (Rice 1989). Fishery observers have identified interactions (e.g., depredation) between longline vessels and sperm whales in the Gulf of Alaska and Southeast Alaska since at least the mid-1970s (Sigler et al. 2008), with most interactions occurring in the West Yakutat and East Yakutat/Southeast regions (Perez 2006; Hanselman et al. 2008). Sigler et al. (2008) noted high depredation rates in West Yakutat, East Yakutat/ Southeast region, as well as the central Gulf of Alaska. Sperm whales are commonly sighted during surveys in the Aleutians and the central and western Gulf of Alaska (Rone et al. 2017). In contrast, there are fewer reports on the occurrence of sperm whales in the eastern Gulf of Alaska (Rone et al. 2017).

Sperm whales have been sighted and detected acoustically in British Columbia waters throughout the year, with a peak during summer (Ford 2014). Acoustic detections at La Pérouse Bank off southwestern Vancouver Island have been recorded during spring and summer (Ford et al. 2010a). Sightings west of Vancouver Island and Haida Gwaii indicate that this species still occurs in British Columbia in small numbers (Ford 2014). Based on whaling data, Gregr and Trites (2001) proposed that the area off northwestern Vancouver Island and the continental slope may be critical habitat for male sperm whales because of favorable feeding conditions; however, no critical habitat has been designated (Parks Canada 2016). The waters off western Haida Gwaii were also identified as sperm whale important areas by PNCIMAI (2011).

Humpback Whale- North Pacific humpback whales summer in feeding grounds along the Pacific Rim and in the Bering and Okhotsk seas (Bettridge et al. 2015). Humpbacks winter in four different breeding areas: (1) the coast of Mexico; (2) the coast of Central America; (3) around the main Hawaiian Islands; and (4) in the western Pacific, particularly around the Ogasawara and Ryukyu islands in southern Japan and the northern Philippines (Bettridge et al. 2015). These breeding areas are recognized as the Mexico, Central America, Hawaii, and Western Pacific DPSs, but feeding areas have no DPS status (Bettridge et al. 2015). There is potential for mixing of the western and eastern North Pacific humpback populations on their summer feeding grounds, but several sources suggest that this occurs to a limited extent (Muto et al. 2020). NMFS is currently reviewing the global humpback whale stock structure in light of the revisions to their ESA listing and identification of 14 DPSs (Bettridge et al. 2015). Individuals encountered in the proposed survey area would likely be from the Hawaii DPS, followed by the Mexico DPS; individuals from the Central America DPS are unlikely to feed in northern British Columbia and Southeast Alaska (Ford 2014). According to Wade (2017), approximately 3.8 percent of humpbacks occurring in Southeast Alaska and northern British Columbia are likely to be from the Mexico DPS; the rest would be from the Hawaii DPS.

Steller Sea Lion

Steller sea lions are present in Alaska year-round, with centers of abundance in the Gulf of Alaska and Aleutian Islands. There are several rookeries in Southeast Alaska, including Hazy Island, White Sisters Island, Forrester Island near Dixon Entrance, Graves Rock along the outer coast of Glacier Bay National Park & Reserve (GBNPP), and Biali Rock (Sweeney et al. 2017). The rookeries at Hazy Island, White Sisters Island, and Forrester Island as well as several major haulouts are designated as critical habitat. Numerous other haulouts occur through Southeast Alaska (Sweeney et al. 2017). During a Lamont-Doherty Earth Observatory seismic survey off Southeast Alaska, numerous sightings were made north of the survey area during September 2004 (MacLean and Koski 2005). Juvenile sea lions branded as pups on Forrester Island have been observed at South Marble Island in GBNPP (Mathews 1996), and some juveniles from the Western stock have been observed at South Marble Island and Graves Rocks in GBNPP (Raum-Suryan 2001).

In British Columbia there are six main rookeries, which are situated at the Scott Islands off northwestern Vancouver Island, the Kerouard Islands near Cape St. James at the southern end of Haida Gwaii, North Danger Rocks in eastern Hecate Strait, Virgin Rocks in eastern Queen Charlotte Sound, Garcin Rocks off southeastern Moresby Island in Haida Gwaii, and Gosling

Rocks on the central mainland coast (Ford 2014). The Scott Islands and Cape St. James rookeries are the two largest breeding sites with 4000 and 850 pups born in 2010, respectively (Ford 2014). Some adults and juveniles are also found on sites known as year-round haulouts during the breeding season. Haulouts are located along the coasts of Haida Gwaii, the central and northern mainland coast, the west coast of Vancouver Island, and the Strait of Georgia; some are year-round sites whereas others are only winter haul outs (Ford 2014). Pitcher et al. (2007) reported 24 major haulout sites (>50 sea lions) in British Columbia, but there are currently around 30 (Ford 2014). The total pup and non-pup count of Steller sea lions in British Columbia in 2002 was 15,438; this represents a minimum population estimate (Pitcher et al. 2007). The highest pup counts in British Columbia occur in July (Bigg 1988). According to Hastings et al. (2020), approximately 2.2 percent of Steller sea lions occurring in the proposed action area are likely to be from the Western DPS; the rest would be from the Eastern DPS.

Total Ensonified Area

As shown in Table 37, the total daily ensonified area calculated by the National Science Foundation and Lamont-Doherty Earth Observatory is based on survey type (i.e., speed of survey), water depth, and the relevant isopleth for MMPA Level A and Level B harassment. The National Science Foundation and Lamont-Doherty Earth Observatory used the relevant isopleth for each survey speed, water depth, and MMPA threshold to create a buffer around specific trackline segments of the proposed survey using ArcGIS software. These buffered trackline segments are representative of a day's worth of survey effort at each specific water depth, survey speed, and MMPA threshold. The total geodesic area for each of these buffers were calculated to obtain the total daily ensonified area. The total daily ensonified areas were then multiplied by the number of survey days for which daily ensonification at the same speed, water depth, and MMPA threshold level is proposed to occur. To account for possible delays during the seismic survey (e.g., weather, equipment malfunction) and additional seismic survey activities, a 25 percent contingency (associated with turns, airgun array testing, and repeat coverage for any areas where initial data quality is sub-standard) was multiplied by the daily ensonification and number of proposed survey days to get the total ensonified area. Further, Table 37 also distinguishes the portions of the survey that are located both inside and outside of Canada's territorial waters. This is used to calculate take for ESA-listed species within and outside of Canada's territorial waters that are within the action area.

Table 37. Relevant isopleths for marine mammals, daily ensonified area, number of survey days, percent increase, and total ensonified areas during the National Science Foundation and Lamont-Doherty Earth Observatory's seismic survey in the North Pacific.

Water Depth (meters)	Relevant isopleth (meters)	Daily Ensonified Area (square kilometers)**	Total Survey Days*	25 Percent Increase	Total Ensonified Area (square kilometers)

Level B Harassment (160 dB)					
<100 meters in in Survey Areas **outside** of Canadian Waters	12,650	131.3	16	1.25	2,625.6
100-1000 meters in Survey Areas within US and Canadian non territorial waters	9,468	1,422.6	27	1.25	28,154.1
> 1000 meters in Areas Survey Areas within US and Canadian non territorial waters	6,733	3,419.8	27	1.25	57,149.5
<100 meters in Survey Areas **inside** of Canadian Territorial Waters	12,650	414.1	11	1.25	5,694.2
100-1000 meters in Survey Areas **inside** of Canadian Territorial Waters	9,468	609.3	11	1.25	8,377.2
> 1000 meters in Survey Areas **inside** of Canadian Territorial Waters	6,733	311.1	11	1.25	4277.7
Level A Harassment					
LF cetacean Level A Harassment Zones in Survey Areas **outside** of Canadian Territorial Waters	320.2	210.8	27	1.25	3,649
MF cetacean Level A Harassment Zones in Survey Areas **outside** of Canadian Territorial Waters	13.6	8.9	27	1.25	154.7
Otariid Level A Harassment Zones in Survey Areas **outside** of	10.6	176.6	27	1.25	120.5

Canadian Territorial Waters					
LF cetacean Level A Harassment Zones in Survey Areas **inside** of Canadian Territorial Waters	320.2	29.6	11	1.25	407.3
MF cetacean Level A Harassment Zones in Survey Areas **inside** of Canadian Territorial Waters	13.6	1.2	11	1.25	17
Otariid Level A Harassment Zones in Survey Areas **inside** of Canadian Territorial Waters	10.6	1	11	1.25	13.3

*Total Survey effort in areas outside of Canada's Territorial Waters
**Based on percentage of survey effort occurring in each depth strata

Calculating Exposures

The method applied by the National Science Foundation, Lamont-Doherty Earth Observatory, and NMFS Permits and Conservation Division multiplied the total area of ensonification for survey areas outside of Canada's territorial waters presented in Table 37 by the cetacean density estimates presented in Table 36. The total number of estimated exposures of ESA-listed cetaceans to ESA harassment is presented in Table 38 below. As discussed in Section 4, parts of the action area take place in the territorial waters of Canada, and we must estimate the number of individuals of each ESA-listed species that could be exposed throughout the entire action area in making our jeopardy determination; in this case, that means the entire ensonified area for the proposed action.

Table 38. Estimated exposures of Endangered Species Act-listed cetaceans calculated by the National Science Foundation, Lamont-Doherty Earth Observatory, and National Marine Fisheries Service Permits and Conservation Division during the proposed seismic survey in the North Pacific Ocean.

	National Science Foundation	NMFS Permits and Conservation Division

Species	Potential Temporary Threshold Shift and Behavioral Harassment (Inside Canadian Territorial Sea/ Outside Canadian Territorial Sea)	Potential Permanent Threshold Shift and Harm(Inside Canadian Territorial Sea/ Outside Canadian Territorial Sea)	Total (Inside Canadian Territorial Sea/ Outside Canadian Territorial Sea)	Potential Temporary Threshold Shift and Behavioral Harassment (Inside Canadian Territorial Sea/ Outside Canadian Territorial Sea)	Potential Permanent Threshold Shift and Harm (Inside Canadian Territorial Sea/ Outside Canadian Territorial Sea)	Total (Inside Canadian Territorial Sea/ Outside Canadian Territorial Sea)
Blue Whale	4/31	0/1	4/32	4/31	0/1	4/32
Fin Whale	69/873	1/44	70/917	69/873	1/44	70/917
Gray Whale – Western North Pacific DPS	1/2*	0	1/2*	1/2*	0	1/2*
Humpback Whale – Mexico DPS	6/15**	0/0	6/15**	6/15**	0/0	6/15**
North Pacific Right Whale	0/2	0/0	0/2	0/2	0/0	0/2
Sei Whale	7/34	0/1	7/35	7/34	0/1	7/35

Sperm Whale	22/131	0/0	22/131	22/131	0/0	22/131
Steller Sea Lion – Western DPS	50/54	0/0	50/54	50/54	0/0	50/54

*Western North Pacific DPS gray whales were proportioned using data from NMFS (2019a)
**Mexico DPS humpback whales were proportioned using data from Wade (2017)
***Western DPS Steller Sea Lions were proportioned using data from Hastings et al. (2020)
1 The proposed IHA does not separate humpback whales into DPSs.
DPS=Distinct Population Segment.

The total estimates of exposed individuals for each endangered species by the National Science Foundation and NMFS Permits and Conservation Division are the same. Given that the proposed seismic survey will be conducted from July to August 2021, whales are expected to be feeding, traveling, or migrating in the action area and some females could have young-of-the-year accompanying them. These individuals could be exposed to the proposed seismic survey activities while they are transiting through the action area. We assume that sex distribution is even for the animals that could be exposed, except sperm whales are more likely to be males. Adult male sperm whales are generally more solitary and more likely to migrate toward the northern portion of their range, poleward of about 40 to 50 degrees latitude (Muto et al. 2019).

Exposures as a Percentage of Population

Blue Whale. There are 36 total expected instances of exposure for blue whales, which is less than 2.2 percent of the Eastern North Pacific stock (current best estimate N=1,696) (Carretta et al. 2020a).

Fin Whales. There are 987 total expected instances of exposure for fin whales. There is no current reliable estimate for the entire Northeast Pacific stock.

Western North Pacific Gray Whale. There are three potential instance of take by harassment under the ESA for the Western North Pacific DPS of gray whales, which is only 1.03 percent of the abundance estimate for that gray whale population (approximately 290; Cooke et al. 2017).

North Pacific Right Whale. There are two potential instances of take by harassment under the ESA for the North Pacific Right Whale. There is not sufficient data to estimate the abundance of the Eastern North Pacific stock (Muto et al. 2020).

Mexico DPS Humpback Whale. There are 21 total expected instances of exposure for the Mexico DPS of humpback whales, which is less than 0.7 percent of the current abundance estimate of approximately 3,264 individuals for that population segment of humpbacks (81 FR 62259).

Sei Whale. There are 42 total expected instances of exposure for sei whales, which is about eight percent of the estimated 519 individuals in the Eastern North Pacific stock (Carretta et al. 2019).

Sperm Whale. There are 153 total expected instances of exposure for sperm whales. There is not sufficient data to estimate the population abundance of the North Pacific stock.

Western DPS Steller Sea Lion. There are 104 total expected instances of exposure for Steller Sea Lions, which is less than 0.2 percent of the estimated 53,624 individuals in the Western DPS of Steller sea lions in Alaska (Muto et al. 2020).

10.3.3 Exposure Analysis for Leatherback Sea Turtles in the Action Area

As discussed in the *Status of Species Likely to be Adversely Affected* section, there is one ESA-listed sea turtle species that is likely to be adversely affected by the proposed action: leatherback turtles.

During the proposed action, leatherback sea turtles may be exposed to sound from the airgun array. The National Science Foundation provided estimates of the expected number of leatherback sea turtles exposed to received levels greater than or equal to 175 dB re: 1 μPa (rms).

Acoustic Thresholds

In order to estimate exposure of leatherback sea turtles to sound fields generated by the airgun arrays, we relied on the available scientific literature. Currently, the best available data come from studies by O'Hara and Wilcox (1990) and McCauley et al. (2000b), who experimentally examined behavioral responses of sea turtles in response to airgun arrays. O'Hara and Wilcox (1990) found that loggerhead turtles exhibited avoidance behavior at estimated sound levels of 175 to 176 dB re: 1 μPa (rms) (or slightly less) in a shallow canal. McCauley et al. (2000b) reported a noticeable increase in swimming behavior for both green and loggerhead turtles at received levels of 166 dB re: 1 μPa (rms). At 175 dB re: 1 μPa (rms), both green and loggerhead turtles displayed increased swimming speed and increasingly erratic behavior (McCauley et al. 2000b). Based on these data, we assume that sea turtles will exhibit a behavioral response when exposed to received levels of 175 dB re: 1 μPa (rms) and higher. The predicted distances to which sound levels of 175 dB re: 1 μPa (rms) will be received from the single (40 cubic inch), 36 airgun arrays for sea turtles during the seismic activities were presented in Table 4. To summarize, the predicted distances to the 175 dB re: 1 μPa (rms) threshold in shallow, intermediate, and deep waters are 3,924 meters, 2,542 meters, and 1,864 meters, respectively.

For sea turtles, the thresholds for PTS are 204 dB re 1 $\mu Pa^2 \cdot s$ $SEL_{cum;}$ and 232 dB re: 1 μPa SPL (0-pk). With a source level at the frequency of greatest energy, which is within the sensitive hearing range of sea turtles, the animal will almost have to be directly under the sound source exactly when it fires. Further, PTS may not ever be realized at close distances due to near-field interactions. The airgun array will be shut down if a leatherback sea turtle is in or about to enter the 100-meter exclusion zone; the calculated isopleth distance to the PTS threshold for sea turtles is 20.5 meters. In addition, the overall density of sea turtles in the action area will be relatively low (0.000114 per square kilometer), further decreasing the chances of PTS occurring.

Density Estimates and Modeled Exposure

The Lamont-Doherty Earth Observatory used a similar method to calculate exposure for leatherback sea turtles as they did to calculate exposure for marine mammals. In the case of leatherback sea turtles, the Lamont-Doherty Earth Observatory used harassment and injury thresholds, 175 dB re: 1 μPa (rms), to create a buffer in GIS representing the ensonified area within each of the three water depth categories (< 100 meters, 100 to 1000 meters, and >1000 meters). The Lamont-Doherty Earth Observatory used density estimates from (Navy 2019b) (0.000114 per square kilometer) to obtain an estimated three leatherback sea turtles exposed at the 175 dB re: 1 μPa (rms) level, and none at the 195 dB re: 1 μPa (rms) level. Less conservative density data for leatherback sea turtles from Navy (2021) were considered. However due to the species' range and higher prevalence in Southeast Alaskan and British Columbia waters as opposed to the Gulf of Alaska (Robert Parker and Wing 2000), data from Navy (2019b) were deemed more appropriate.

The modeled exposures are all expected to occur outside Canadian territorial waters. This is expected because leatherback sea turtles forage in deeper waters (200 meters deep or more), and these waters are past the 12 nautical mile line of Canadian territorial waters.

In U.S. Pacific waters, leatherbacks forage in shelf waters between the 200-meter and 2,000-meter isobaths (77 FR 4169). An examination of 122 opportunistic sightings of leatherback sea turtles in Canadian Pacific waters showed that most of them were in waters from the continental shelf to 200 meters deep, with fewer in waters 1,500 meters deep and offshore waters (Gregr 2015). There is considerable bias associated with these sightings as they were not part of a systemic survey, but they do allow us to conclude that leatherback sea turtles are likely to be exposed to seismic activities during the proposed action. Depth is considered a factor in leatherback sea turtle occurrence in the Canadian Pacific, as there is evidence that indicates they preferentially forage in on-shelf areas. Sea surface temperature is also an important factor in predicting occurrence (with a potential thermal limit of 13 degrees Celsius; Benson et al. 2011a; Gregr 2015).

Leatherback sea turtles arrive on foraging grounds off the U.S. West Coast primarily in April through July (Benson et al. 2011a). The majority of sightings in the Canadian Pacific are between July and September (Gregr 2015). Because of the timing and location of the action, we expect that exposed leatherback sea turtles would be foraging or transiting to foraging areas at the time of the action. Adults of both sexes could be exposed to the proposed action.

10.3.4 Exposure Analysis for Endangered Species Act-Listed Pacific Salmonids in the Action Area

As discussed in the *Status of Species Likely to be Adversely Affected* section, there are four ESA-listed fish species that are likely to be adversely affected by the proposed action: ESA-listed ESUs or DPSs of Chinook, chum, sockeye, and steelhead (See Section 8).

During the proposed action, ESA-listed fishes may be exposed to sound from the airgun array. The National Science Foundation, Lamont-Doherty Earth Observatory, and NMFS Permits and

Conservation Division did not provide estimates of the expected number of ESA-listed fishes exposed to received levels for these sound sources.

Salmonid Presence in the Marine Environment

The seismic survey will take place over a broad range of ocean habitats, including the nearshore, shallow waters off the coasts of British Columbia and Southeast Alaska, the continental shelf and the offshore oceanic area beyond the slope. This action area will encompass a variety of habitats for ESA-listed species, and different habitats are more likely to host one species or another based on the species' habitat requirements. For the ESA-listed fish species considered in this consultation, the continental shelf is a very important habitat. The continental shelf off the U.S. West Coast is the area from the intertidal zone to the 200 meter depth contour (656 feet), which is typically eight to 60 kilometers from shore (NMFS 2015c). The survey tracklines come close to shore, as close as about nine kilometers in some places, and the furthest tracklines are over 200 kilometers from shore.

The total number of tracklines proposed for the survey is about 4,250 kilometers. About 361 kilometers will take place in waters less than 200 meters deep in the waters of the continental shelf (8.5 percent of the total survey).

The survey will take place starting in July, and last for 27 days. The timing and location of the survey means that ESA-listed fishes of different life stages will be exposed.

Salmonids

There are several ESA-listed DPSs or ESUs of Pacific salmonids that could occur in the action area during their oceanic life phase, including:

- Snake River Spring/Summer Run ESU of Chinook salmon,
- Snake River Fall Run ESU of Chinook salmon,
- Lower Columbia River ESU of Chinook salmon,
- Puget Sound ESU of Chinook salmon,
- Upper Willamette River ESU of Chinook salmon,
- Upper Columbia River Spring Run ESU of Chinook salmon,
- Puget Sound DPS of steelhead trout,
- Northern California DPS of steelhead
- California Central Valley DPS of steelhead
- Central California Coast DPS of steelhead,
- South-Central California Coast DPS of steelhead,
- Upper Columbia River DPS of steelhead, and

- Columbia River ESU of chum salmon,
- Hood Canal Summer Run of chum salmon,
- Ozette Lake ESU of sockeye salmon,
- Snake River ESU of sockeye salmon,
- Lower Columbia River DPS of steelhead trout,
- Middle Columbia River DPS of steelhead trout,
- Upper Willamette River DPS of steelhead

There is some uncertainty about precisely where in the Pacific Ocean these (or any) salmonids go (Meyers 1998). Based on what we do understand, the DPSs or ESUs noted above are likely to be present, because salmon form mixed stock aggregations during their time in the ocean (Bellinger et al. 2015). The following sections will discuss the life stages likely to be exposed and the distributions of the Pacific salmon ESUs and steelhead DPSs in relation to the proposed action area.

Salmon Life Stages Present

Due to the timing and location of the proposed seismic survey, we expect both juvenile and adult salmon and steelhead to be exposed to the action. The marine environment represents very important habitat for salmon and steelhead during critical phases of their life cycle. This includes:

- Juveniles when they are entering the marine environment from their natal rivers,
- Juveniles already in the marine environment for their growth phase, and
- Pre-spawning adults that are returning to their natal rivers to spawn.

Pacific salmonids spend a few years in the ocean during their growth phase, and could be exposed to the proposed seismic activities then. Estuaries represent important habitat for both juvenile and adult salmon. Adults use coastal areas near their natal rivers as staging areas before moving into freshwater to spawn. Residence times for adults in staging areas can vary from one to six weeks. Juveniles can remain in the estuaries for four days (chum) to up to six months (Chinook) before entering the marine environment (Simenstad et al. 1982), likely using the areas to adjust to higher salinity water. Where the action area overlaps with the staging areas for various salmon populations, both juveniles and adults could be exposed.

Juvenile salmon and steelhead may be exposed after they enter the marine environment during their migration to their preferred marine growth location. For example, juvenile sockeye enter the ocean and use coastal waters to migrate northward to southeast Alaska, and juvenile chum move northward to the Gulf of Alaska.

The specific spawning migration and entry timing varies by species and DPS or ESU. See the tables below for information on migration timing by species. Here, we refer to adult salmonids present in their natal rivers and moving upriver to spawn as "adult spawning migration timing" and juveniles leaving their natal rivers to enter the ocean for their growth phase as "juvenile entry into marine environment".

As discussed earlier, Pacific salmonids form mixed stock aggregations in the marine environment. In the case of Chinook salmon, individuals from a broad area are found in the coastal waters of the action area.

In a fishery-dependent study from May to September in the coastal waters of Oregon and northern California, Bellinger et al. (2015) identified Chinook salmon from numerous river systems from Alaska to the Central Valley, California. Stock richness was higher in the northern part of the sampling area than in the south.

Based on this information, we are examining Chinook salmon DPSs or ESUs from a broad area. The timing of their spawning runs and entry into the ocean are shown in Table 39.

Table 39. Spawning Migration and Entry Timing for Chinook Salmon DPSs/ESUs

Chinook ESU	Chinook Adult Spawning Migration Timing	Chinook Juvenile Entry into Marine Environment
Puget Sound	April to May: Spring-run June to July: Summer-run Fall-run: August to September (Myers 1998)	Spring-run: May to June Summer and fall-run: April to July (Myers 1998)
Upper Columbia River Spring Run	Late March to May, peak in mid-May.	April to June; Peak numbers in May. All enter Canadian waters by end of June. (Myers 1998; Fisher et al. 2014a)
Lower Columbia River	March to June: Spring-run August to October: Fall-run	March to September (Peak numbers April to June): Spring-run

Chinook ESU	Chinook Adult Spawning Migration Timing	Chinook Juvenile Entry into Marine Environment
		March to September (Peak numbers in September): Fall-run (Fisher et al. 2014a)
Upper Willamette River	February to August, peak from April to late May. (Myers 1998)	March to September, peak numbers in June. (Myers 1998; Fisher et al. 2014a)
Snake River Spring-Summer	March to May. Spawning adults present along the Washington Coast and Columbia River plume. Peak numbers in May. (DART 2013)	April to June, peak numbers in May. All entering Canadian waters by June. (Myers 1998; Fisher et al. 2014a)
Snake River Fall Run	August to October: Spawning adults present along the Washington Coast and Columbia River plume (Peak numbers in September). (DART 2013)	June to November: No significant peak. All entering Canadian waters by end of November. (Myers 1998; Fisher et al. 2014a)

Adult individuals from DPSs or ESUs that migrate to spawn after July and August would likely be moving to or already in coastal staging areas, in estuaries or in the mouths of rivers within the action area, preparing to move upstream later in the season. These individuals could be exposed to the seismic survey and include:

- Puget Sound ESU, Summer and fall runs
- Lower Columbia River ESU, Spring and fall runs
- Upper Willamette River ESU
- Upper Columbia River ESU, Spring run

- Snake River Fall Run ESU, Summer and fall runs

The survey would occur in July and into August. The information presented in Table 39 for adult spawning migration timing refers the periods when adults are in their natal rivers, moving upstream to the spawning sites. This information comes from tagging studies recording tagged salmon as they pass upstream.

The seismic survey does not take place in California waters, so it would not expose adult individuals from ESUs originating in California.

We expect individuals from the following juvenile Chinook salmon ESUs to be exposed to seismic activities during their entry into the marine environment in the action area:

- Puget Sound ESU: Summer and fall runs
- Lower Columbia River ESU: Spring and fall runs
- Upper Willamette River ESU
- Upper Columbia River ESU, Spring run
- Snake River ESU: summer and fall runs

Chum

Upstream spawning migration times and marine entry times for chum salmon are shown in Table 40.

Table 40. Spawning Migration and Entry Timing for Chum Salmon ESUs

Chum ESU	Chum Adult Spawning Migration Timing	Chum Juvenile Entry into Marine Environment
Hood Canal Summer-Run ESU	Mid-August to mid-October, peak in September (Johnson et al. 1997b)	February to early April (Tynan 1997)
Columbia River ESU	Early October to mid-November (Johnson et al. 1997b)	March to May Washington Department of Fish and Wildlife, 2019

Adult chum salmon are in coastal staging areas before entering their natal rivers to spawn. Hood Canal is in Puget Sound, and not in the action area, so adults from the Hood Canal Summer-Run ESU will not be exposed at that time, but could be exposed while in the marine environment transiting north into the action area. Due to the timing of the entry into the marine environment, we do not expect any juvenile chum salmon to be exposed during those times. Immature and maturing chum salmon are distributed widely throughout the offshore waters of the Gulf of Alaska, outside the action area (Salo 1991a). After entering the ocean, juvenile chum migrate northward from the Columbia River and Hood Canal along the coast until reaching Alaska

(Johnson et al. 1997b). Juvenile chum could be exposed to the proposed action in July and August while they are traveling north, especially those from the Columbia River.

Sockeye

Spawning migration times and marine entry times for sockeye salmon are shown in Table 41.

Table 41. Spawning Migration and Entry Timing for Sockeye Salmon ESUs

Sockeye ESU	Sockeye Adult Spawning Migration Timing	Sockeye Juvenile Entry into Marine Environment
Ozette Lake ESU	Mid-April to mid-August (Peak: May and June) (NMFS 2009c)	March to June (Peak: April and May) (NMFS 2009c)
Snake River ESU	June to July (NMFS 2015a)	May to mid-June (Tucker et al. 2015)

Due to the timing of their spawning runs, we do not expect the adult sockeye Snake River ESU to be exposed to the proposed seismic activities since they are expected to be in the river at the time of the proposed action. Ozette Lake ESU adult sockeye salmon return from the ocean to Lake Ozette from mid-April to mid-August, and thus could be exposed to the proposed action.

Upon leaving the Ozette River and entering the ocean, juveniles undergo a rapid northward migration along the coast to southeast Alaska, arriving by mid-June to July (Tucker et al. 2015). Juveniles from the Columbia River plume undergo a northward similar migration (the Snake River feeds into the Columbia River), but enter the ocean a little later than Ozette Lake sockeye juveniles. By fall, both ESUs are absent from the continental shelf (Gustafson et al. 1997; Tucker et al. 2015). Because the proposed seismic activities will take place in July and August, and the survey will extend through Southeast Alaska, we expect migrating juvenile sockeye salmon to be exposed to the proposed action.

Steelhead

Spawning migration times and marine entry times for steelhead are shown in Table 42.

Table 42. Spawning Migration and Entry Timing for Steelhead DPSs

Steelhead DPS	Steelhead Adult Spawning Migration Timing	Steelhead Juvenile Entry into Marine Environment
Puget Sound DPS	November to Mid-June: Winter-run April to November: Summer-run	March to June Bell 1990

Steelhead DPS	Steelhead Adult Spawning Migration Timing	Steelhead Juvenile Entry into Marine Environment
	Bell 1990 (Busby et al. 1996b)	
Upper Columbia River DPS	November to May June to Early August: "A-run" Bell 1990 (Busby et al. 1996b)	Mid-April to Early June (Daly et al. 2014)
Middle Columbia River DPS	November to May June to Early August: "A-run" Bell 1990 (Busby et al. 1996b)	Mid-April to Early June (Daly et al. 2014)
Lower Columbia River DPS	Late February to Early June: Spring-run November to May: Winter-run Bell 1990 (Busby et al. 1996b)	Mid-April to Early June (Daly et al. 2014)
Upper Willamette River DPS	February to March: Late winter-run (Busby et al. 1996b)	Mid-April to Early June (Daly et al. 2014)
Snake River Basin DPS	June to Early August: "A-run" August to October: "B-run" Bell 1990 (Busby et al. 1996b)	Mid-April to Early June (Daly et al. 2014)
Northern California Coast DPS	March to August: Summer-run September to November: Winter-run	March to June (Moyle et al. 2017)

Steelhead DPS	Steelhead Adult Spawning Migration Timing	Steelhead Juvenile Entry into Marine Environment
	(Busby et al. 1996b; Moyle et al. 2017)	
California Central Valley DPS	August to October (Busby et al. 1996b; Moyle et al. 2017)	March to May Busby et al. 1996; Moyle et al. 2017 (Moyle et al. 2017)
Central California Coast DPS	October to November (Busby et al. 1996b; Moyle et al. 2017)	January to June Busby et al. 1996; Moyle et al. 2017 (Moyle et al. 2017)
South-Central California DPS	January to May (Moyle et al. 2017)	January to May (Moyle et al. 2017)

For adult steelhead populations originating in California (California Central Valley DPS, Central California Coast DPS, South Central California DPS), we do not expect these individuals to be exposed to the proposed action while in their staging areas, because California rivers are outside the action area. Adult steelhead of other populations could be exposed to the proposed seismic activities while in the marine environment, possibly while transiting to staging areas near their natal rivers.

Due to the timing of the action, we do not expect juvenile steelhead DPSs to be exposed to the proposed action while entering the ocean. All juvenile steelhead could potentially be exposed to the proposed action while in the marine environment.

Salmonid Exposure: Water Depth

The seismic survey tracklines will be in water depths from 50 to 2,800 meters, and will overlap in areas where we expect certain ESA-listed certain Chinook, chum, sockeye, and steelhead life stages from various ESUs and DPSs to be exposed, as described in the previous sections. In order to assess exposure for Pacific salmon in this consultation, we need to establish where the species will be in relation to the seismic survey. This means considering two spatial factors: where the Pacific salmon and steelhead occur in relation to shore (e.g., in what water depths, along what oceanographic feature), and examining where in the water column they occur.

Chinook salmon are commonly found in the California Current, in nearshore environments. Thermal conditions are likely an important factor in their habitat use. In late summer and autumn (late July to November), tagged Chinook occupied cool areas (9 to 12 degrees Celsius; Hinke et al. 2005). It is thought that the cool, upwelled water in the coastal shelf serves as a migratory corridor and feeding ground for Chinook (Bellinger et al. 2015).

Most ESA-listed juvenile Chinook salmon in Southeast Alaska are found in shallow nearshore waters less than 50 meters deep during the month of July (see Figure 40 of Riddell et al. 2018). There is limited information on ocean movement of larger Chinook salmon in Southeast Alaskan waters, but Murphy and Heard (2001) applied 48 data storage tags to Chinook salmon, and depth data retrieved from the study showed that average depths for the tagged salmon were in waters less than 100 meters. Immature and maturing chum salmon are distributed widely throughout the offshore waters of the Gulf of Alaska, outside the action area (Salo 1991a). After entering the ocean, juvenile chum migrate northward from the Columbia River and Hood Canal along the coast until reaching Alaska (Johnson et al. 1997b).

Juvenile sockeye salmon use a narrow band along the coast to rapidly move northward from their natal river, leaving it in mid-May to mid-June, and arriving in the Gulf of Alaska by mid-June to mid-July. Adult sockeye salmon distribute widely in the offshore waters of the Gulf of Alaska (Gustafson et al. 1997; Tucker et al. 2015).

Adult steelhead occur in the north Pacific in the oceanic waters off the continental shelf. When they reach maturity, they migrate east back over the continental shelf to their natal rivers (Quinn 2005). In contrast to other juvenile salmon that use a north-south coastal migration route, juvenile steelhead quickly migrate west after leaving their natal rivers to the oceanic waters past the continental shelf. These movements can take as little as one to three days, with an average of ten days (Daly et al. 2014).

As described earlier, the airgun array will be towed at a depth of 12 meters. In a study conducted in fall (September and October) and winter (January to February) in the eastern Bering Sea, salmon most often occupy the upper level of the water column, with some variation by species and life stage (Walker et al. 2007). Some immature Chinook, sockeye, and chum were captured at depths between 30 and 60 meters, in addition to being caught in waters above 30 meters deep. Chinook and chum have the deepest vertical distributions, with Chinook having an average depth of 42 meters (average daily maxima of 130 meters deep), and chum occupying an average depth of 16 meters (average daily maxima of 58 meters; Walker et al. 2007). Sockeye were found at an average depth of three meters (average daily maxima of 19 meters; Walker et al. 2007) .

Both juvenile and adult steelhead are regarded as being surface-oriented, occupying the upper 10 meters of the water column (Light et al. 1989). Adult sockeye salmon occupy the upper 30 meters of the water column, with most occupying in the upper 10 meters (Quinn et al. 1989; Ogura and Ishida 1995). Juvenile sockeye are mostly found in the upper 15 meters of the column (Beamish et al. 2007).

Because steelhead occupy offshelf waters, we expect juvenile and adult steelhead to be exposed further offshore during the proposed action (in contrast to other Pacific salmon which mostly occupy continental shelf waters). Juvenile steelhead could be exposed to seismic activities during their offshelf movements.

Acoustic Thresholds

Impulsive sound sources such as airguns are known to injure or kill fishes or elicit behavioral responses. For airguns, NMFS analyzed impacts from sound produced by airguns using the recommendations consistent with *ANSI Guidelines* (Popper et al. 2014b). These dual metric criteria—peak pressure and cumulative sound exposure level (SEL_{cum})—are used to estimate zones of effects related to mortality and injury from airgun exposure. NMFS assumes that a specified effect will occur when either metric is met or exceeded.

In the 2014 *ANSI Guidelines*, airgun thresholds are derived from the thresholds developed for impact pile-driving exposures (Halvorsen et al. 2011; Halvorsen et al. 2012b; Halvorsen et al. 2012c). This use of a dual metric criteria is consistent with the current impact hammer criteria NMFS applies for fishes with swim bladders (FHWG 2008; Stadler and Woodbury 2009). The interim criteria developed by the Fisheries Hydroacoustic Working Group include dual metric criteria wherein the onset of physical injury will be expected if either the peak SPL exceeds 206 dB re: 1 μPa, or the SEL_{cum}, exceeds 187 dB re: 1 μPa^2-s for fish two grams or larger, or 183 dB 1 μPa^2-s for fish smaller than two grams. However, at the same time the interim criteria were developed, very little information was available from airgun exposures. As such, it is also often applied to other impulsive sound sources. In addition, the 2008 interim criteria did not specifically separate thresholds according to severity of hearing impairment such as TTS to recoverable injury to mortality, which was done in the 2014 *ANSI Guidelines*. Nor do they differentiate between fish with swim bladders and those without, despite the presence of a swim bladder affecting hearing capabilities and fish sensitivity to sound. The 2008 interim criteria based the lower SEL_{cum} thresholds (187 dB re: 1 μPa^2-s and 183 dB re: 1 μPa^2-s) upon when TTS or minor injuries will be expected to occur. Therefore, these criteria establish the starting point when the whole spectrum of potential physical effects may occur for fishes, from TTS to minor, recoverable injury, up to lethal injury (i.e., either resulting in either instantaneous or delayed mortality). Because some generalized groupings of fish species can be made regarding what is currently known about fish hearing sensitivities (Popper and Hastings 2009; Casper et al. 2012; Popper et al. 2014b) and influence of a swim bladder, and the fact that none of the ESA-listed fish species in the action area have a swim bladder associated with hearing, our analysis of ESA-listed fishes considered in this consultation is focused upon fishes with swim bladders not used in hearing.

Categories and descriptions of hearing sensitivities are further defined in this document (Popper and N. 2014) as the following[15]:

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[15] The 2014 ANSI Guidelines provide distinctions between fish with and without swim bladders and fish with swim bladders involved in hearing. None of the ESA-listed fish species considered in this consultation have swim bladders

- Fishes with a swim bladder that is not involved in hearing, lack hearing specializations and primarily detect particle motion at frequencies below 1 kilohertz include all Pacific salmonid species.

For the National Science Foundation and Lamont-Doherty Earth Observatory's seismic survey activities, airgun thresholds for fishes with swim bladders not involved in hearing are 210 SEL_{cum} and greater than 206 SPL_{peak} for onset of mortality and 203 SEL_{cum} and greater than 206 SPL_{peak} for onset of injury. Criteria and thresholds to estimate TTS in fishes exposed to sound produced by airguns are greater than 186 SEL_{cum}. Exposure to sound produced from airguns at a cumulative sound exposure level of 186 dB (re: 1 μPa^2-s) has resulted in TTS in fishes (Popper et al. 2005a)[16]. For potential behavioral responses of fishes (i.e., sub-injury) from exposure to anthropogenic sounds, there are no formal criteria yet established. This is largely due to the sheer diversity of fishes, their life histories and behaviors, as well as the inherent difficulties conducting studies related to fish behavior in the wild. NMFS applies a conservative threshold of 150 dB re: 1 μPa (rms) to assess potential behavioral responses of fishes from acoustic stimuli, described below.

In a study conducted by McCauley et al. (2003a), fish were exposed to airgun arrays and observed to exhibit alarm responses from sound levels of 158 to 163 dB re: 1 μPa. In addition, when the 2008 criteria were being developed, one of the technical panel experts, Dr. Mardi Hastings, recommended a "safe limit" of fish exposure, meaning where no injury will be expected to occur to fishes from sound exposure, set at 150 dB re: 1 μPa (rms) based upon her research (Hastings 1990). This "safe limit" was also referenced in a document investigating fish effects from underwater sound generated from construction (Sonalysts 1997) where the authors mention two studies conducted by Dr. Mardi Hastings that noted no physical damage to fishes occurred when exposed to sound levels of 150 dB re: 1 μPa (rms) at frequencies between 100 to 2,000 hertz. In that same report, the authors noted they also observed fish behavioral responses during sound exposure of 160 dB re: 1 μPa (rms), albeit at very high frequencies. More recently, exposed Fewtrell and McCauley (2012) exposed fishes to airgun sound between 147 to 151 dB SEL, and observed alarm responses in fishes as well as tightly grouped swimming or fast swimming speeds.

None of the current research available on fish behavioral response to sound make recommendations for a non-injury threshold. The studies mentioned here, as with most data available on behavioral responses to anthropogenic sound for fishes, have been obtained through controlled laboratory studies. In other cases, behavioral studies have been conducted in the field with caged fish. Research on fish behaviors has demonstrated that caged fish do not show normal behavioral responses which makes it difficult to extrapolate caged fish behavior to wild, unconfined fishes (Hawkins et al. 2014; Popper and Hawkins 2014). It is also important to

involved with their hearing abilities, but all do have swim bladders. Thus, we simplified the distinction to fishes with swim bladders.

[16] This is also slightly more conservative than the 2008 interim pile driving criteria of 187 SEL_{cum}.

mention, that some of the information regarding fish behavior while exposed to anthropogenic sounds has been obtained from unpublished documents such as monitoring reports, grey literature, or other non-peer reviewed documents with varying degrees of quality. Therefore, behavioral effects from anthropogenic sound exposure remains poorly understood for fishes, especially in the wild. Nonetheless, potential behavioral responses must be considered as an effect of acoustic stressors on ESA-listed fishes. For the reasons discussed, and until new data indicate otherwise, NMFS believes a 150 dB re: 1 μPa (rms) threshold for behavioral responses of fishes is appropriate. This criterion is used as a guideline to establish a sound level where responses of fishes may occur and could be a concern. For ESA-listed fishes, NMFS applies this criterion when considering the life stage affected, and any adverse effects that could occur from behavioral responses such as attentional disruption, which could lead to reduced foraging success, impaired predatory avoidance, leaving protected cover, release of stress hormones affecting growth rates, poor reproductive success rates and disrupted migration. The thresholds for fishes (injury, TTS, behavioral responses) are summarized in Table 43.

Table 43. Thresholds for fishes exposed to sound produced by airguns.

Onset of Injury	TTS	Behavioral Responses
203 SEL_{cum} and greater than 206 SPL_{peak}	Greater than 187 SEL_{cum}	150 dB re: 1 μPa (rms)

We calculated the distances (isopleths) at which we expect injury to start to occur for fish during the proposed action (Table 44). Currently, NMFS does not have agreed-upon thresholds for the onset of mortality in fish due to sound from airguns.

Table 44. Distances (meters) for onset of injury for fishes.

Onset of TTS and Injury	TTS and Injury Onset Isopleths (meters)
187 SEL_{cum} (TTS)	3,211
206 SPL_{peak} (Injury)	230.1

Salmonid Density and Exposure

Density data for ESA-listed fish species within the action area are not currently available. Therefore, it is not possible to estimate the total number of individual fish that may be affected by seismic airgun activities from the proposed action. In order to estimate the longest range at which a fish may be killed instantaneously, mortally injured, or sustain recoverable injury and

TTS, depends on fish size and location in the water column (i.e. depth), and geometry of exposure.

All ESA-listed fishes that may be present in the action area are capable of detecting sound produced by airguns. We calculated ranges to effects for fish species based upon the criteria discussed in the subsection above (See Table 44). Fishes within these ranges would be predicted to receive the associated effect. Ranges may vary greatly depending on factors such as location, depth, and season of the activity.

Due to the lack of more definitive data on fish density in the open ocean within the action area, it is not feasible to estimate the percentage of ESA-listed salmonids (or number of individuals) that could be located in the proposed isopleths for injury and TTS. Under 50 C.F.R. §402.14(i)(1)(i), a surrogate may be used to express the amount or extent of anticipated take, provided the biological opinion or the incidental take statement: (1) describes the causal link between the surrogate and take of the listed species; (2) describes why it is not practical to express the amount of anticipated take or to monitor take-related impacts in terms of individuals of the listed species; and (3) sets a clear standard for determining when the amount or extent of the taking has been exceeded. Because it is not feasible, and thus not practical, to express the amount of anticipated take in terms of individuals of the ESA-listed salmonid species, we will use a habitat surrogate approach to express the extent of anticipated incidental take of ESA-listed salmonids from the operation of airgun activities used during the proposed action.

10.3.5 Response Analysis

A pulse of sound from the airgun array displaces water around the airgun array and creates a wave of pressure, resulting in physical effects on the marine environment that can then affect marine organisms, such as marine mammals, sea turtles, and fishes considered in this opinion. Possible responses considered in this analysis consist of:

- Hearing threshold shifts;
- Auditory interference (masking);
- Behavioral responses; and
- Non-auditory physical or physiological effects.

The *Response Analysis* also considers information on the potential for stranding and the potential effects on prey of ESA-listed cetaceans, sea turtles, and fishes in the action area.

As discussed in *The Assessment Framework* (Section 2) of this opinion, response analyses determine how ESA-listed resources are likely to respond after exposure to an action's effects on their environment or directly on ESA-listed species themselves. For the purposes of consultation, our assessments try to detect potential lethal, sub-lethal (or physiological), or behavioral responses that might result in reduced fitness of ESA-listed individuals. Ideally, response analyses will consider and weigh evidence of adverse consequences, as well as evidence suggesting the absence of such consequences.

10.3.5.1 Potential Responses of ESA-Listed Marine Mammals to Acoustic Sources

Exposure of marine mammals to very strong impulsive sound sources from the airgun arrays can result in auditory damage, such as changes to sensory hairs in the inner ear, which may temporarily or permanently impair hearing by decreasing the range of sound an animal can detect within its normal hearing ranges. Hearing threshold shifts depend upon the duration, frequency, sound pressure, rise time of the sound, as well as the condition of the animal at the time of exposure. A TTS results in a temporary change to hearing sensitivity (Finneran and Schlundt 2013) and the impairment can last minutes to days, but full recovery of hearing sensitivity is expected. However, a study looking at the effects of sound on mice hearing has shown that, although full hearing can be regained following TTS (i.e., the sensory cells actually receiving sound are normal), damage can still occur to the cochlear nerve leading to delayed but permanent hearing damage resulting in injury or harm (Kujawa and Liberman 2009). At higher received levels, particularly in frequency ranges where animals are more sensitive, PTS can occur, meaning lost auditory sensitivity is unrecoverable. Either TTS or PTS is generally specific to the frequencies over which exposure occurs but can extend to a half-octave above or below the center frequency of the source in tonal exposures, although it is less evident in broadband noise sound sources that are associated with the proposed action (Schlundt et al. 2000; Kastak 2005; Ketten 2012). Both TTS and PTS conditions can result from exposure to a single pulse or from the accumulated effects of multiple pulses, in which case each pulse need not be as loud as a single pulse to have the same accumulated effect. A PTS is expected at levels approximately six dB greater than TTS levels on a peak-pressure basis, or 15 dB greater on an SEL basis than TTS (Southall et al. 2007a). Threshold distances from full operation of the airgun array for this survey that place marine mammals within risk of TTS and PTS can be found in Table 34 and Table 35, respectively.

A few individuals could be exposed to sound levels that may result in TTS, but we expect the probability to be low. There are several other reasons we do not expect long-term hearing effects to any ESA-listed marine mammals. Most individuals are expected to move away from the airgun array as it approaches. Sound intensity received by ESA-listed individuals increases as the seismic survey approaches and the conditions they experience (stress, loss of prey, discomfort, etc.) prompt them to move away from the sound source, thus avoiding more intense exposure that could induce TTS or PTS. Ramp-ups will also reduce the probability of TTS-inducing exposure at the start of seismic survey activities for the same reasons. As acoustic energy accumulates to higher levels, animals would be expected to move away and would therefore be unlikely to be exposed to more injurious sound levels. Furthermore, mitigation measures will be in place to initiate a shut down if individuals enter, or are about to enter the 500-meter (1,640.4 feet) exclusion zone during full airgun array operations, which is beyond the distances believed to have the potential for PTS to result in any of the ESA-listed marine mammals as described above.

As stated previously, potential exposure to 160 dB re: 1 μPa (rms) is not expected to produce a cumulative TTS or other physical injury for several reasons. We expect that individuals will recover from TTS between each potential exposure. Monitoring is expected to produce some degree of mitigation such that exposures will be reduced. When individuals generally move away from the sound source, at least a short distance, the likelihood of consequences from exposure is reduced. In summary, we do not expect animals to be present for a sufficient duration to accumulate sound pressure levels that will lead to the onset of TTS or PTS.

Marine Mammals and Auditory Interference (Masking)

As discussed in other sections of this opinion, interference, or masking, occurs when a sound is a similar frequency and similar to or louder than the sound an animal is trying to hear (Clark et al. 2009; Erbe et al. 2016). Masking can interfere with an individual's ability to gather acoustic information about its environment, such as predators, prey, conspecifics, and other environmental cues (Richardson 1995). This can result in loss of environmental cues of predatory risk, mating opportunity, or foraging options (Francis and Barber 2013).

Although sound pulses from airguns begin as short, discrete sounds, they interact with the marine environment and lengthen through processes such as reverberation. This means that in some cases, such as in shallow water environments, airgun sound can become part of the acoustic background. Studies of how impulsive sound deforms from short bursts to lengthened waveforms in the marine environment are limited, but evidence suggests it can add considerably to the acoustic background (Guerra et al. 2011). Therefore, it has the potential to interfere with an animal's ability to detect sounds in its environment.

There is frequency overlap between airgun array sounds and vocalizations of ESA-listed marine mammals, particularly baleen whales, and to some extent sperm whales.

Overlap of the dominant low frequencies of airgun pulses with low-frequency baleen whale calls could pose a somewhat greater risk of masking. The R/V *Langseth*'s airguns will emit an approximate 0.1 second pulse when fired at intervals of approximately every 22 or every 120 seconds. Therefore, pulses are not expected to "cover up" the vocalizations of ESA-listed baleen whales to a significant extent (Madsen et al. 2002). We address the response of ESA-listed marine mammals stopping vocalizations as a result of airgun sound in the *Marine Mammals and Behavioral Responses* section below.

The proposed seismic surveys could mask whale calls at some of the lower frequencies for these species. This could affect their communication, ability to perceive their environment, and affect echolocation for sperm whales (Evans 1998; NMFS 2006h). Findings by Madsen et al. (2006) suggest airgun array pulses can overlap with frequencies of sperm whale clicks, which are concentrated at two to four kilohertz and 10 to 16 kilohertz, although the strongest airgun spectrum levels are below 200 hertz (two to 188 hertz for the R/V Langseth's airgun array). Given the disparity between sperm whale echolocation and communication-related sound frequencies and the dominant frequencies for the seismic survey, masking is not likely to be significant for sperm whales (NMFS 2006h). Any masking that might occur will likely be temporary because acoustic sources from the seismic surveys are not continuous, and the research vessel continues to transit through the area.

The sound localization abilities of marine mammals suggest that masking will not be as severe as the usual types of masking studies might suggest if signal and sound come from different directions (Richardson 1995). The dominant background noise may be highly directional if it comes from a particular anthropogenic source such as a ship or industrial site. Directional hearing may significantly reduce the masking effects of these sounds by improving the effective signal-to-sound ratio. In the cases of higher frequency hearing by the bottlenose dolphin (*Tursiops truncatus*), beluga whale (*Delphinapterus leucas*), and killer whale (*Orcinus orca*), empirical evidence confirms that masking depends strongly on the relative directions of arrival of sound signals and the masking sound (Bain et al. 1993; Bain and Dahlheim 1994; Dubrovskiy and Giro 2004). Studies have also noted directional hearing at frequencies as low as 0.5 to two kilohertz in several marine mammals, including killer whales (Richardson et al. 1995b). This ability may be useful in reducing masking at these frequencies. Toothed whales and probably other marine mammals as well, have additional capabilities besides directional hearing that can facilitate detection of sounds in the presence of background sound. There is evidence that some toothed whales can shift the dominant frequencies of their echolocation signals from a frequency range with a lot of ambient sound toward frequencies with less noise (Au et al. 1974; Au 1975; Moore and Pawloski 1990; Thomas et al. 1990; Romanenko and Kitain 1992; Lesage et al. 1999). A few marine mammal species increase the source levels or alter the frequency of their calls in the presence of elevated sound levels (Dahlheim 1987; Au 1993; Lesage et al. 1993; Lesage et al. 1999; Terhune 1999; Foote et al. 2004; Holt et al. 2009; Parks 2009b).

In summary, high levels of sound generated by anthropogenic activities may act to mask the detection of weaker biologically important sounds by some marine mammals. This masking is expected to be more prominent for lower frequencies, such as those used by baleen whales for communication. For higher frequencies, such as that used in echolocation by toothed whales, several mechanisms such as directional hearing and shifting dominant frequencies of echolocation signals are available that may allow the animals to be less affected.

Marine Mammals and Behavioral Responses

We expect the greatest response of marine mammals to airgun sounds, in terms of the number of responses and overall impact, to be in the form of behavioral changes, which include increased vigilance, displacement, changes in vocalization, avoidance, altered feeding/migratory behavior, and changes in respiration and diving. ESA-listed individuals may briefly respond to underwater sound by slightly changing their behavior or relocating a short distance from the sound source. Some of these responses could equate to harassment or harm of individuals listed under the ESA but are unlikely to result in meaningful responses at the population level.

Marine mammal responses to anthropogenic sound vary by species, state of maturity, prior exposure, current activity, reproductive state, time of day, and other factors (Ellison et al. 2012;

Harris et al. 2018). This is reflected in a variety of aquatic, aerial, and terrestrial animal responses to anthropogenic noise that may ultimately have fitness consequences (NRC 2005; Francis and Barber 2013; New et al. 2014; Costa et al. 2016; Fleishman et al. 2016). Studies from non-ESA-listed species and from outside the action area can be relevant in determining the responses expected by the species for which adverse effects of the proposed action are likely to occur.

Increased Vigilance and Displacement. Animals generally respond to anthropogenic perturbations as they do to predators, by increasing vigilance and altering habitat selection (Reep et al. 2011). There is increasing support that this prey-like response is true for animals' responses to anthropogenic sound (Harris et al. 2018). Habitat abandonment due to anthropogenic noise exposure has been found in terrestrial species (Francis and Barber 2013). Because of the similarities in hearing anatomy of terrestrial and marine mammals, we expect that it is possible for marine mammals to behave in a similar manner as terrestrial mammals when they detect a sound stimulus. Displacement from important feeding or breeding areas over a prolonged period would likely be more significant for individuals, and could affect the population depending on the extent of the feeding area and duration of displacement. However, given the short duration of the proposed seismic survey, longer-term displacement is not expected to result from implementation of the proposed action.

Changes in Vocalizations. Several other studies have aided in assessing the various levels at which whales may modify or stop their calls in response to airgun sounds. Whales have continued calling while seismic surveys are operating locally (Richardson et al. 1986; McDonald et al. 1993; McDonald et al. 1995; Greene Jr et al. 1999; Madsen et al. 2002; Tyack et al. 2003; Nieukirk et al. 2004; Smultea et al. 2004; Jochens et al. 2006). However, humpback whale males increasingly stopped vocal displays on Angolan breeding grounds as received seismic airgun levels increased (Cerchio et al. 2014). Further, migrating humpback whales showed evidence of a Lombard effect in Australia, increasing vocalization in response to wind-dependent background noise (Dunlop et al. 2014a). Some blue, fin, and sperm whales stopped calling for short and long periods, apparently in response to airguns (Bowles et al. 1994; McDonald et al. 1995; Clark and Gagnon 2006). Fin whales (presumably adult males) engaged in singing in the Mediterranean Sea moved out of the area of a seismic survey while airguns were operational, as well as for at least a week thereafter (Castellote et al. 2012b). Dunn and Hernandez (2009) tracked blue whales during a seismic survey on the R/V *Maurice Ewing* in 2007 and did not observe changes in call rates or evidence of anomalous behavior that they could directly ascribe to the use of airguns at sound levels of less than 145 dB re: 1 μPa (rms; Wilcock et al. 2014). Blue whales may also attempt to compensate for elevated ambient sound by calling more frequently during seismic surveys (Iorio and Clark 2009). Sperm whales may be sensitive to airgun sounds, at least under some conditions, as they have been documented to cease calling in association with airguns being fired hundreds of kilometers away (Bowles et al. 1994). Other studies have found no response by sperm whales to received airgun sound levels up to 146 dB re: 1 μPa (peak-to-peak; McCall Howard 1999; Madsen et al. 2002). For the whale species considered in this consultation, some exposed individuals may cease calling in response to the airgun array, but the effect is expected to be temporary and brief given the constant movement of the vessel when seismic airguns are active and the short duration of the survey. Animals may resume or modify calling at a later time or location once the acoustic stressor has discontinued.

Avoidance and Altered Feeding/Migratory Behavior. There are numerous studies of other behavioral responses other than vocalization changes of some baleen whales to airguns (Richardson et al. 1995a). Although responses to lower-amplitude sounds are known, most studies seem to support a threshold of approximately 160 dB re: 1 μPa (rms); in other words, the level used in this opinion to determine the extent of acoustic effects to marine mammals as the received sound level that causes behavioral responses such as avoidance of the airgun array. Available data indicate that most, if not all, baleen whale species exhibit temporary avoidance of active seismic airguns (Gordon et al. 2003; Stone and Tasker 2006; Potter et al. 2007; Southall et al. 2007a; Southall et al. 2007b; Barkaszi et al. 2012b; Castellote et al. 2012b; Castellote et al. 2012a; NAS 2017; Stone et al. 2017). The activity and attentional focus in which individuals are engaged seems to influence response (Robertson et al. 2013). For example, feeding individuals respond less than mother and calf pairs or migrating individuals to this acoustic stressor (Malme et al. 1984a; Malme and Miles 1985; Richardson et al. 1995b; Miller et al. 1999; Richardson et al. 1999; Miller et al. 2005; Harris et al. 2007).

Gray whales discontinued feeding and/or moved away at received sound levels of 163 dB re: 1 μPa (rms) (Malme et al. 1984b; Malme and Miles 1985; Malme et al. 1986a; Malme et al. 1987; Würsig et al. 1999; Bain and Williams 2006; Gailey et al. 2007; Johnson et al. 2007a; Meier et al. 2007; Yazvenko et al. 2007). Migrating gray whales began to show changes in swimming patterns at approximately 160 dB re: 1 μPa (rms) and slight behavioral changes at 140 to 160 re: 1 μPa (rms; Malme et al. 1984b; Malme et al. 1984a; Malme and Miles 1985). Habitat continues to be used despite frequent seismic survey activity and long-term effects have not been identified (Malme et al. 1984a). Johnson et al. (2007b) reported that gray whales exposed to airgun sounds during seismic surveys off Sakhalin Island, Russia, did not experience any biologically significant or population level effects, based on subsequent research in the area from 2002 through 2005. When strict mitigation measures, such as those proposed by the NMFS Permits and Conservation Division, are taken to avoid conducting seismic surveys during certain times of the year when most gray whales are expected to be present and to closely monitor operations, gray whales may not exhibit any noticeable behavioral responses to seismic survey activities (Gailey et al. 2016).

Humpback whales exhibit lower tolerances when not occupied with feeding. Migrating humpbacks altered their travel path (at least locally) along Western Australia at received levels as low as 140 dB re: 1 μPa (rms) when females with calves were present, or seven to 12 kilometers (3.8 to 6.5 nautical miles) from the acoustic source (McCauley et al. 1998; McCauley et al. 2000b). A startle response occurred as low as 112 dB re: 1 μPa (rms). Closest approaches were generally limited to three to four kilometers (1.6 to 2.2 nautical miles), although some individuals (mainly males) approached to within 100 meters (328.1 feet) on occasion where sound levels were 179 dB re: 1 μPa (rms). Changes in course and speed generally occurred at estimated received levels of 157 to 164 dB re: 1 μPa (rms). Similarly, on the east coast of Australia, migrating humpback whales appear to avoid seismic airguns at distances of three kilometers (1.6 nautical miles) at levels of 140 dB re: 1 μPa^2-second.

Feeding humpback whales have displayed higher levels of tolerance. Humpback whales off the coast of Alaska startled at 150 to 169 dB re: 1 μPa (rms) and no clear evidence of avoidance was apparent at received levels up to 172 dB re: 1 μPa (rms) (Malme et al. 1984b; Malme et al. 1985). Potter et al. (2007) found that humpback whales on feeding grounds in the Atlantic Ocean did exhibit localized avoidance to airgun arrays. Among humpback whales on Angolan breeding grounds, no clear difference was observed in encounter rate or point of closest approach during seismic versus non-seismic periods (Weir 2008).

Multiple factors may contribute to the degree of response exhibited by migrating humpback whales. Researchers found responses by migrating humpback whales to exposure to sound from a 20-cubic inch airgun seemed to be influenced by social effects; “whale groups decreased dive time slightly and decreased speed towards the source, but there were similar responses to the control” (i.e., towed airgun, not in operation) (Dunlop et al. 2014b). Whales in groups may pick up responses by other individuals in the group and react. A recent study examining the response of migrating humpback whales to a full 51,291.5 cubic centimeters (3,130 cubic inches) airgun array found that humpback whales exhibited no abnormal behaviors in response to the active airgun array, and while there were detectible changes in respiration and diving, these were similar to those observed when baseline groups (i.e., not exposed to active sound sources) were joined by another humpback whale (Dunlop et al. 2017). While some humpback whales were also found to reduce their speed and change course along their migratory route, overall these results suggest that the behavioral responses exhibited by humpback whales are unlikely to have significant biological consequences for fitness (Dunlop et al. 2017). Natural sources of sound also influence humpback whale behavior.

Observational data are sparse for specific baleen whale life histories (breeding and feeding grounds) in response to airguns. Available data support a general avoidance response. Some fin and sei whale sighting data indicate similar sighting rates during seismic versus non-seismic periods, but sightings tended to be further away and individuals remained underwater longer (Stone 2003; Stone and Tasker 2006; Stone et al. 2017). Other studies have found at least small differences in sighting rates (lower during seismic activities), as well as whales being more distant during seismic operations (Moulton and Miller 2005; Moulton et al. 2006a; Moulton et al. 2006b). When spotted at the average sighting distance, individuals will have likely been exposed to approximately 169 dB re: 1 μPa (rms) (Moulton and Miller 2005).

Sperm whale response to airguns has thus far included mild behavioral disturbance (temporarily disrupted foraging, avoidance, cessation of vocal behavior), or no reaction. Several studies have found sperm whales in the Atlantic Ocean to show little or no response (Davis et al. 2000; Stone

2003; Moulton and Miller 2005; Madsen et al. 2006; Moulton et al. 2006a; Stone and Tasker 2006; Weir 2008; Miller et al. 2009). Detailed study of sperm whales in the Gulf of Mexico suggests some alteration in foraging from less than 130 to 162 dB re: 1 μPa peak-to-peak, although other behavioral reactions were not noted by several authors (Gordon et al. 2004; Gordon et al. 2006; Jochens et al. 2006; Madsen et al. 2006; Winsor and Mate 2006). This has been contradicted by other studies, which found avoidance reactions by sperm whales in the Gulf of Mexico in response to seismic ensonification (Mate et al. 1994; Jochens and Biggs 2003; Jochens and Biggs 2004). Johnson and Miller (2002) noted possible avoidance at received sound levels of 137 dB re: 1 μPa. Miller et al. (2009) found sperm whales to be generally unresponsive to airgun exposure in the Gulf of Mexico, with possible but inconsistent responses that included delayed foraging and altered vocal behavior. Displacement from the area was not observed. Winsor and Mate (2013) did not find any patterns in the distribution of satellite-tagged sperm whales, at and beyond five kilometers (2.7 nautical miles) from airgun arrays in the Gulf of Mexico, to suggest individuals were displaced or moved away from the airgun noise (Winsor and Mate 2013). No tagged whales occurred within five kilometers (2.7 nautical miles) during the study, but marine mammal observer data from other seismic operations, during the same years and areas used by tagged subjects, recorded 12 occurrences of sperm whales at less than 1.15 kilometers away (Winsor and Mate 2013). In a follow-up study using additional data, Winsor et al. (2017) found no evidence to suggest sperm whales avoid active airguns within distances of 50 kilometers (27 nautical miles).

The lack of response by sperm whales may in part be due to its higher range of hearing sensitivity and the low-frequency (generally less than 188 hertz) pulses produced by seismic airguns (Richardson et al. 1995b). Sperm whales are exposed to considerable energy above 500 hertz during the course of seismic surveys (Goold and Fish 1998), so even though this species generally hears at higher frequencies, this does not mean that it cannot hear airgun sounds. Breitzke et al. (2008) found that source levels were approximately 30 dB re: 1 μPa lower at 1 kilohertz and 60 dB re: 1 μPa lower at 80 kilohertz compared to dominant frequencies during a seismic source calibration. Other anthropogenic sounds, such as pingers and sonars, disrupt behavior and vocal patterns (Watkins and Schevill 1975; Watkins et al. 1985b; Goold 1999).

We expect ESA-listed whales exposed to sound from the airgun array considered in this consultation to exhibit avoidance reactions similar to the behavioral responses described for different species above. Secondary foraging areas are expected to be available, allowing whales to continue feeding. Breeding is not expected to be occurring during the time period of the action, but other essential behaviors such as travel or migration are expected to continue for individuals transiting through the area during the proposed activities.

Behavioral Responses of Pinnipeds. Similar to cetacean species, behavioral responses of pinnipeds can range from a mild orienting response, or a shifting attention, to flight and panic. They may react in a number of ways depending on their experience with the sound source and the activity they are engaged in at the time of the exposure. For example, different responses displayed by captive and wild phocid seals to sound judged to be 'unpleasant' have been reported; where captive seals habituated (did not avoid the sound), and wild seals showed avoidance behavior (Götz and Janik 2011). Captive studies with other pinnipeds have shown a reduction in dive times when presented with qualitatively 'unpleasant' sounds. These studies indicated that the subjective interpretation of the pleasantness of a sound, minus the more commonly studied factors of received sound levels and sounds associated with biological significance, can affect diving behavior (Götz and Janik 2011). More recently, a controlled-exposure study was conducted with U.S. Navy California sea lions at the Navy Marine Mammal Program facility specifically to study behavioral reactions (Houser et al. 2013). Animals were trained to swim across a pen, touch a panel, and return to the starting location. During transit, a simulated mid-frequency sonar signal was played. Behavioral reactions included increased respiration rates, prolonged submergence, and refusal to participate, among others. Younger animals were more likely to respond than older animals, while some sea lions did not respond consistently at any level.

Pinnipeds are not likely to show a strong avoidance reaction to the airgun array sources proposed for use. Visual monitoring from seismic survey vessels has shown only slight (if any) avoidance of airgun arrays by pinnipeds and only slight (if any) changes in behavior. Monitoring work in the Alaskan Beaufort Sea during 1996 through 2001 provided considerable information regarding the behavior of Arctic ice seals exposed to seismic pulses (Harris et al. 2001; Moulton and Lawson 2002). These seismic survey projects usually involved airgun arrays of six to 16 airguns with total volumes of 9,176.8 to 24,580.6 cubic centimeters (560 to 1,500 cubic inches). The combined results suggest that some seals avoid the immediate area around seismic survey vessels. In most survey years, ringed seal (*Phoca hispida*) sightings tended to be farther away from the seismic survey vessel when the airgun arrays were operating than when they were not (Moulton and Lawson 2002). However, these avoidance movements were relatively small, approximately 100 meters (328.1 feet) to a few hundreds of meters, and many seals remained within 100 to 200 meters (328.1 to 656.2 feet) of the trackline as the operating airgun array passed by the animals. Seal sighting rates at the water surface were lower during airgun array operations than during no-airgun periods in each survey year except 1997. Similarly, seals are often very tolerant of pulsed sounds from seal-scaring devices (Mate and Harvey 1987; Jefferson and Curry 1994; Richardson et al. 1995a). However, initial telemetry work suggests that avoidance and other behavioral reactions by two other species of seals to small airgun array sources may at times be stronger than evident to date from visual studies of pinniped reactions to airguns (Thompson et al. 1998).

We have no information to suggest animals eliciting a behavioral response (e.g., temporary disruption of feeding) from exposure to the proposed seismic survey activities will be unable to compensate for this temporary disruption in feeding activity by either immediately feeding at another location, by feeding shortly after cessation of acoustic exposure, or by feeding later.

Research and observations show that pinnipeds in the water are tolerant of anthropogenic noise and activity. If sea lions are exposed to active acoustic sources, they may react in a number of ways depending on their experience with the sound source and what activity they are engaged in at the time of the acoustic exposure. Ranges to some behavioral impacts could take place at distances exceeding 100 kilometers (54 nautical miles), although significant behavioral effects are much more likely at higher received levels within a few kilometers of the sound source. Sea lions may not react at all until the sound source is approaching within a few hundred meters and then may alert, approach, ignore the stimulus, change their behaviors, or avoid the immediate area by swimming away or diving (Finneran et al. 2003; Kvadsheim et al. 2010; Götz and Janik 2011).

In summary, ESA-listed marine mammals are expected to exhibit a wide range of behavioral responses including increased vigilance, displacement, changes in vocalization, avoidance, altered feeding/migratory behavior, and changes in respiration and diving when exposed to sound fields from the airgun array. Baleen whales are expected to mostly exhibit avoidance behavior, and may also alter their vocalizations. Toothed whales (i.e., sperm whales) are expected to exhibit less overt behavioral changes but may alter foraging behavior, including echolocation vocalizations. Behavioral reactions for Steller sea lions would be short-term, likely lasting the duration of the exposure to the sound source as it continuously transits, and behavioral reactions are typically not expected to be significant. In general, long-term consequences for individuals or populations are unlikely.

Marine Mammals and Physical or Physiological Effects

Individual whales exposed to airguns (as well as other sound sources) could experience effects not readily observable, such as stress (Romano et al. 2002), that may have adverse effects. Other possible responses to impulsive sound sources like airgun arrays include neurological effects, bubble formation, resonance effects, and other types of organ or tissue damage (Cox et al. 2006; Southall et al. 2007b; Zimmer and Tyack 2007; Tal et al. 2015), but, similar to stress, these effects are not readily observable. Importantly, these more severe physical and physiological responses have been associated with explosives and/or mid-frequency tactical sonar, not seismic airguns. We do not expect ESA-listed marine mammals to experience any of these more severe physical and physiological responses as a result of exposure to the proposed seismic survey activities.

Stress is an adaptive response and does not normally place an animal at risk. The mammalian stress response involves the hypothalamic-pituitary-adrenal axis being stimulated by a stressor, causing a cascade of physiological responses, such as the release of the stress hormones cortisol, adrenaline (epinephrine), glucocorticosteroids, and others (Thomson and Geraci 1986; St. Aubin and Geraci 1988; St. Aubin et al. 1996; Gulland et al. 1999; Gregory and Schmid 2001; Busch 2009). These hormones subsequently can cause short-term weight loss, the liberation of glucose into the blood stream, impairment of the immune and nervous systems, elevated heart rate, body temperature, blood pressure, and alertness, and other responses (Thomson and Geraci 1986;

Kaufman and Kaufman 1994; Dierauf and Gulland 2001; Cattet et al. 2003; Elftman et al. 2007; Fonfara et al. 2007; Noda et al. 2007; Mancia 2008; Busch 2009; Dickens et al. 2010). In some species, stress can also increase an individual's susceptibility to gastrointestinal parasitism (Greer et al. 2005). In highly stressful circumstances, or in species prone to strong "fight-or-flight" responses, more extreme consequences can result, including muscle damage and death (Cowan and Curry 1998; Cowan and Curry 2002; Herraez et al. 2007; Cowan 2008). The most widely-recognized indicator of vertebrate stress, cortisol, normally takes hours to days to return to baseline levels following a significantly stressful event, but other hormones of the hypothalamic-pituitary-adrenal axis may persist for weeks (Dierauf and Gulland 2001).

Loud sounds generally increase stress indicators in mammals (Kight 2011). And mammalian stress levels can vary by age, sex, season, and health status (St. Aubin et al. 1996; Gardiner and Hall 1997; Hunt et al. 2006; Keay 2006; Romero et al. 2008). For example, studies indicate stress hormones are lower in immature North Atlantic right whales (*Eubalaena glacialis*) than adults, and mammals with poor diets or undergoing dietary change tend to have higher fecal cortisol levels (Hunt et al. 2006; Keay 2006). Romano et al. (2004) found beluga whales and bottlenose dolphins exposed to a seismic watergun (up to 228 dB re: 1 μPa meter peak-to-peak) and single pure tones (up to 201 dB re: 1 μPa) had increases in stress chemicals, including catecholamines, which can affect an individual's ability to fight off disease. During the time following September 11, 2001, shipping traffic and associated ocean noise decreased along the northeastern U.S. This decrease in ocean sound was associated with a significant decline in fecal stress hormones in North Atlantic right whales, providing evidence that chronic exposure to increased noise levels, although not acutely injurious, can produce stress (Rolland et al. 2012a; Rolland et al. 2012b). These levels returned to baseline after 24 hours of vessel traffic returning to pre-9/11 levels.

Because whales use hearing as a primary way to communicate and gather information about their environment, we assume that limiting these abilities will be stressful. Finally, we assume that some individuals exposed at sound levels below those required to induce a TTS, but above the ESA harassment 160 dB re: 1 μPa (rms) threshold, will experience a stress response, which may also be associated with an overt behavioral response. However, because exposure to sounds from airgun arrays operated as part of the proposed action are expected to be temporary, we expect any such stress responses to be temporary and short-term. Given the available data, animals are expected to return to baseline state (e.g., baseline cortisol level pre-airgun array operation) within hours to days, with the duration of the stress response depending on the severity of the exposure. Although we do not have a way to determine the health of the animal at the time of exposure, we assume that the stress responses resulting from these exposures could be more significant or exacerbate other factors if an animal is already in a compromised state.

Data regarding other non-auditory physical and physiological responses to sound specific to cetaceans is generally lacking. In studies of other vertebrates, exposure to loud sound may adversely affect reproductive and metabolic physiology (reviewed in Kight and Swaddle 2011).

Premature birth and indicators of developmental instability (possibly due to disruptions in calcium regulation) have been found in embryonic and neonatal rats exposed to loud sound. Fish eggs and embryos exposed to sound levels only 15 dB greater than background showed increased mortality and surviving fry and slower growth rates, although the opposite trends have also been found in sea bream. However, given the available data and the short duration of exposure to sounds generated by airgun arrays associated with the proposed action, we do not anticipate any effects to the reproductive and metabolic physiology of ESA-listed marine mammals.

It is possible that an animal's prior exposure to sounds from seismic surveys influences its future response. There is little information available to understand what responses an individual may have to future seismic survey exposures as compared to prior experience. If prior exposure produces a learned response, it will likely be similar to or less than prior responses to other novel stimulus stressors with behavioral consequences, such as moving away and reduced time budget for activities otherwise undertaken (Andre 1997; André 1997; Gordon et al. 2006). We do not believe sensitization, more intense, and/or earlier response to subsequent exposures will occur based upon the lack of severe responses previously observed in marine mammals exposed to seismic survey sounds. There is potential for cetaceans to habituate to airgun array sounds, which may lead to additional energetic costs or reductions in foraging success (Nowacek et al. 2015), although, the short-term, transient nature of this survey should minimize the likelihood that sensitization or habituation will occur.

Marine Mammals and Strandings

There is some concern regarding the coincidence of marine mammal strandings and proximal seismic surveys. No conclusive evidence exists to causally link stranding events to seismic surveys. Suggestions that there was a link between seismic surveys and strandings of humpback whales in Brazil (Engel et al. 2004) were not well founded (Iagc 2004; IWC 2007a). In September 2002, two Cuvier's beaked whales (*Ziphius cavirostris*) stranded in the Gulf of California, Mexico during a time that coincided with the R/V *Maurice Ewing* operating a 20 airgun array (139,126.2 cubic centimeters[8,490 cubic inches]) 22 kilometers (11.9 nautical miles) offshore in the general area at the time that stranding occurred. The link between the stranding and the seismic surveys was inconclusive and not based on any physical evidence, as the individuals who happened upon the stranding were ill-equipped to perform an adequate necropsy (Taylor et al. 2004). Furthermore, the small numbers of animals involved and the lack of knowledge regarding the spatial and temporal correlation between the beaked whales and the sound source underlies the uncertainty regarding the linkage between sound sources from seismic surveys and beaked whale strandings (Cox et al. 2006).

Numerous studies suggest that the physiology, behavior, habitat relationships, age, or condition of cetaceans may cause them to strand or might pre-dispose them to strand when exposed to another phenomenon. These suggestions are consistent with the conclusions of numerous other studies that have demonstrated that combinations of dissimilar stressors commonly combine to kill an animal or dramatically reduce its fitness, even though one exposure without the other does not produce the same result (Fair and Becker 2000; Moberg 2000; Kerby et al. 2004; Romano et al. 2004; Creel 2005). At present, the factors of airgun arrays from seismic surveys that may contribute to marine mammal strandings are unknown, and we have no evidence to lead us to believe that aspects of the airgun array proposed for use will cause marine mammal strandings. Therefore, we do not expect ESA-listed marine mammals to strand as a result of the proposed seismic survey.

Responses of Marine Mammal Prey

Seismic surveys may also have adverse effects on ESA-listed marine mammals by affecting their prey (including larval stages) through lethal or sub-lethal damage, stress responses, or alterations in their behavior or distribution. Potential prey that may be affected by exposure to sound from the airgun array include fishes, zooplankton, cephalopods, and other invertebrates such as crustaceans, molluscs, and jellyfish. Carroll et al. (2017) summarized an extensive review of information available on the impact seismic surveys have on fishes and invertebrates. In many cases, species-specific information on the prey of ESA-listed marine mammals is not available. Until more specific information becomes available, we expect that the prey of ESA-listed marine mammals will respond to sound associated with the proposed action in a similar manner to those fishes and invertebrates described below (information derived from Carroll et al. 2017 unless otherwise noted).

Seismic surveys can cause physical and physiological responses in prey fishes and invertebrates, including direct mortality. Responses appear to be highly variable in fishes and depend on the nature of the exposure to seismic survey activities, as well as the species in question. Data indicate that possible responses include hearing threshold shifts, barotraumatic ruptures, stress responses, organ damage, and/or mortality. Research is more limited for invertebrates, but the available data suggest that exposure to seismic survey activities can result in anatomical damage and mortality in some cases. For crustaceans and bivalves (i.e., scallops and oysters), which sea lions feed on, there are mixed results with some studies suggesting that seismic surveys do not result in meaningful physiological and/or physical effects, while others indicate such effects may be possible under certain circumstances. There can be differing results even within studies, depending on what aspect of physiology one examines (e.g., Fitzgibbon et al. 2017). Discrepancies can occur between observational field studies and more controlled experimental studies. A relatively uncontrolled field study did not find significant differences in mortality between oysters that were exposed to a full seismic airgun array and those that were not (Parry et al. 2002). A more controlled study found significant differences in mortality between scallops exposed to a single airgun and a control group that received no exposure (Day et al. 2017), although the increased mortality was not significantly different from expected natural mortality. Another laboratory study observed abnormalities in larval scallops after exposure to low frequency noise in tanks (de Soto et al. 2013). All available data on echinoderms suggests they exhibit no physical or physiological response to exposure to seismic survey activities. Based on the available data, we assume that some fishes and invertebrates may experience physical and physiological effects, including mortality, but in most cases, such effects are only expected at relatively close distances to the sound source.

Cases of fish or invertebrate mortality resulting from exposure to airguns are limited to close-range exposure to high amplitudes (Falk and Lawrence 1973; Kostyuchenko 1973; Holliday et al. 1987; La Bella et al. 1996; D'Amelio 1999; Santulli et al. 1999; McCauley et al. 2000a; McCauley et al. 2000c; Bjarti 2002; Hassel et al. 2003; McCauley et al. 2003a; Popper et al. 2005a). Lethal effects, if any, are expected within a few meters of the airgun array (Dalen and Knutsen 1986; Buchanan et al. 2004).

There are reports showing sub-lethal effects to some fish species. Several species at various life stages have been exposed to high-intensity sound sources (220 to 242 dB re: 1 μPa) at close distances, with some cases of injury (Booman et al. 1996; McCauley et al. 2003a). Effects from TTS were not found in whitefish at received levels of approximately 175 dB re: 1 μPa^2-second, but pike did show 10 to 15 dB of hearing loss with recovery within one day (Popper et al. 2005a). Exposure of monkfish (*Lophius* spp.) and capelin (*Mallotus villosus*) eggs at close range to airguns did not produce differences in mortality compared to control groups (Payne 2009). Salmonid swim bladders were reportedly damaged by received sound levels of approximately 230 dB re: 1 μPa (Falk and Lawrence 1973).

Recently, there has been research suggesting that seismic airgun arrays may lead to a significant reduction in zooplankton, including copepods. McCauley et al. (2017) found that the use of a single airgun (approximately 150 cubic inches) led to a decrease in zooplankton abundance by over 50 percent and a two to three-fold increase in dead adult and larval zooplankton when compared to control scenarios. Effects were found up to 1.2 kilometers (0.6 nautical miles) out, which is the maximum distance the sonar equipment used in the study was able to detect changes in abundance. McCauley et al. (2017) noted that for seismic survey activities to have a significant impact on zooplankton at an ecological scale, the spatial or temporal scale of the seismic activity must be large in comparison to the ecosystem in question, largely due to the fast turnover rate of zooplankton. Three-dimensional seismic surveys that involve multiple overlapping tracklines for intensive surveys are of particular concern (McCauley et al. 2017). However, data from Fields et al. (2019) showed limited effects on the mortality or escape response of *Calanus finmarchicus* within 10 meters (32.8 feet) of seismic blasts from two airguns (260 cubic inches) and no measurable impact at greater distances. Fields et al. (2019) concluded that the impacts to *C. finmarchicus* observed from their series of control experiments were much less than reported by McCauley et al. (2017).

Results of McCauley et al. (2017) excluded analyses of zooplankton at the surface where the majority of copepod prey (available to baleen whales or fishes that are prey of these whales) is expected to be (Witherington et al. 2012). Airguns primarily transmit sound downward and the array in the proposed action will be towed at depths of 12 meters. Sounds from this array should be relatively low at the surface. The proposed seismic survey may temporarily alter copepod or crustacean abundance in the action area, but when considering sound from the airgun array is expected to be relatively low near the surface and the high turnover rate of zooplankton combined with ocean circulation, we expect such effects to be extremely localized. We are not aware of specific studies regarding sound effects on krill (*Euphausiacea* spp.), an important prey of most ESA-listed baleen whales, but we expect the effects would be similar to other zooplankton crustaceans.

The prey of ESA-listed marine mammals may also exhibit behavioral responses if exposed to active seismic airgun arrays. As reviewed by Carroll et al. (2017), considerable variation exists in how fishes behaviorally respond to seismic survey activities, with some studies indicating no response and others noting startle or alarm responses and/or avoidance behavior which could cause greater risk for predation. However, no effects to foraging or reproduction have been documented. Data on the behavioral response of invertebrates similarly suggest that some species may exhibit a startle response, but most studies do not suggest strong behavioral responses. Charifi et al. (2017) found that oysters appear to close their valves in response to low frequency sinusoidal sounds and Day et al. (2017) found that scallops exhibit behavioral responses such as flinching, when exposed to seismic airgun array sounds but none of the observed behavioral responses were considered to be energetically costly. As with marine mammals, behavioral responses by fishes and invertebrates may also be associated with a stress response.

A common response by fishes to airgun sound is a startle or distributional response, where fish react momentarily by changing orientation or swimming speed, or change their vertical distribution in the water column (Fewtrell 2013a; Davidsen et al. 2019). During airgun studies in which the received sound levels were not reported, Fewtrell (2013a) observed caged *Pelates* spp., pink snapper, and trevally (*Caranx ignobilis*) generally exhibited startle, displacement, and/or grouping responses upon exposure to airguns. This effect generally persisted for several minutes, although subsequent exposures to the same individuals did not necessarily elicit a response (Fewtrell 2013a). In addition, Davidsen et al. (2019) performed controlled exposure experiments on Atlantic cod (*Gadus morhua*) and saithe (*Pollachius virens*) to test their response to airgun noise. Davidsen et al. (2019) noted the cod exhibited reduced heart rate (bradycardia) in response to the particle motion component of the sound from the airgun, indicative of an initial flight response; however, no behavioral startle response to the airgun was observed. Both the Atlantic cod and saithe changed both swimming depth and horizontal position more frequently during airgun sound production (Davidsen et al. 2019).

Startle responses were observed in rockfish at received airgun levels of 200 dB re: 1 μPa 0-to-peak and alarm responses at greater than 177 dB re: 1 μPa 0-to-peak (Pearson et al. 1992). Fish also tightened schools and shifted their distribution downward. Normal position and behavior resumed 20 to 60 minutes after firing of the airgun ceased. A downward shift was also noted by Skalski et al. (1992) at received seismic sounds of 186 to 191 dB re: 1 μPa 0-to-peak. Caged European sea bass (*Dichentrarchus labrax*) showed elevated stress levels when exposed to airguns, but levels returned to normal after three days (Skalski 1992). These fish also showed a startle response when the seismic survey vessel was as much as 2.5 kilometers (1.3 nautical miles) away. This response increased in severity as the vessel approached and sound levels increased, but returned to normal after about two hours following cessation of airgun activity.

Whiting (*Merlangius merlangus*) exhibited a downward distributional shift upon exposure to 178 dB re: 1 µPa 0-to-peak sound from airguns, but habituated to the sound after one hour and returned to normal depth (sound environments of 185 to 192 dB re: 1 µPa) despite airgun activity (Chapman and Hawkins 1969). Whiting may also flee from sounds from airguns (Dalen and Knutsen 1986). Hake (*Merluccius* spp.) may re-distribute downward (La Bella et al. 1996). Lesser sand eels (*Ammodytes tobianus*) exhibited initial startle responses and upward vertical movements before fleeing from the seismic survey area upon approach of a vessel with an active source (Hassel et al. 2003; Hassel et al. 2004).

McCauley et al. (2000; 2000a) found small fish show startle responses at lower levels than larger fish in a variety of fish species and generally observed responses at received sound levels of 156 to 161 dB re: 1 µPa (rms), but responses tended to decrease over time suggesting habituation. As with previous studies, caged fish showed increases in swimming speeds and downward vertical shifts. Pollock (*Pollachius* spp.) did not respond to sounds from airguns received at 195 to 218 dB re: 1 µPa 0-to-peak, but did exhibit continual startle responses and fled from the acoustic source when visible (Wardle et al. 2001). Blue whiting (*Micromesistius poutassou*) and mesopelagic fishes were found to re-distribute 20 to 50 meters (65.6 to 164 feet) deeper in response to airgun ensonification and a shift away from the seismic survey area was also found (Slotte et al. 2004). Startle responses were infrequently observed from salmonids receiving 142 to 186 dB re: 1 µPa peak-to-peak sound levels from an airgun (Thomsen 2002). Cod (*Gadus* spp.) and haddock (*Melanogrammus aeglefinus*) likely vacate seismic survey areas in response to airgun activity and estimated catchability decreased starting at received sound levels of 160 to 180 dB re: 1 µPa 0-to-peak (Dalen and Knutsen 1986; Løkkeborg 1991; Engås et al. 1993; Løkkeborg and Soldal 1993b; Turnpenny et al. 1994; Engås et al. 1996b).

Increased swimming activity in response to airgun exposure in fish, as well as reduced foraging activity, is supported by data collected by Lokkeborg et al. (2012). Bass did not appear to vacate the survey area during a shallow-water seismic survey with received sound levels of 163 to 191 dB re: 1 µPa 0-to-peak (Turnpenny and Nedwell 1994). Similarly, European sea bass apparently did not leave their inshore habitat during a four to five-month seismic survey (Pickett et al. 1994). La Bella et al. (1996) found no difference in trawl catch data before and after seismic survey activities, and echosurveys of fish occurrence did not reveal differences in pelagic biomass.

Squid are known to be important prey for sperm whales. Squid responses to operating airguns have also been studied, although to a lesser extent than fishes. In response to airgun exposure, squid exhibited both startle and avoidance responses at received sound levels of 174 dB re: 1 µPa (rms) by first ejecting ink and then moving rapidly away from the area (McCauley et al. 2000a; McCauley et al. 2000c; Fewtrell 2013b). The authors also noted some movement upward. During ramp-up, squid did not discharge ink but alarm responses occurred when received sound levels reached 156 to 161 dB re: 1 µPa (rms). Andre et al. (2011) exposed four cephalopod species (*Loligo vulgaris*, *Sepia officinalis*, *Octopus vulgaris*, and *Ilex coindetii*) to two hours of continuous sound from 50 to 400 hertz at 157 ±5 dB re: 1 µPa. They reported lesions to the sensory hair cells of the statocysts of the exposed animals that increased in severity with time, suggesting that cephalopods are particularly sensitive to low-frequency sound. The received sound pressure level was 157 ±5 dB re: 1 µPa, with peak levels at 175 dB re: 1 µPa. Guerra et al. (2004) suggested that giant squid mortalities were associated with seismic surveys based upon coincidence of carcasses with the seismic surveys in time and space, as well as pathological information from the carcasses, which has implications for loss of prey for sperm whales.

Available data indicate seismic survey activities could result in temporary and minor reduction in the availability of prey for ESA-listed species near the active airgun array. This may be due to changes in prey distributions (i.e., due to avoidance) or abundance (i.e., due to mortality), or both. We expect that if fish or squid detect the sound and perceive it as a threat or some other signal, they are capable of moving away from the sound source (e.g., airgun array) if it causes them discomfort, but are expected to eventually return to the area and be available as prey for marine mammals. For these reasons, we do not expect any temporary movement of prey species out of the action area to have a meaningful impact on ESA-listed marine mammals' ability to forage in the areas affected during seismic survey activities. We do not expect long-term, adverse effects from airgun array operations for ESA-listed marine mammals in the action area. Effects, such as temporary feeding opportunities, are likely to be temporary and, if displaced, both marine mammals and their prey will re-distribute back into the action area once seismic survey activities have concluded.

10.3.5.2 Potential Responses of Leatherback Sea Turtles to Acoustic Sources

As with marine mammals, leatherback sea turtles may exhibit a variety of different responses to sound fields associated with seismic survey activities. Below we review what is known about the following responses that sea turtles may exhibit (reviewed in Nelms et al. 2016):

- Hearing threshold shifts;
- Behavioral responses; and
- Non-auditory physical or physiological effects.

To our knowledge, strandings of sea turtles in association with anthropogenic sound have not been documented, and so no such stranding response is expected. In addition, masking is not expected to affect sea turtles because they are not known to rely heavily on acoustics for life functions (Popper et al. 2014b; Nelms et al. 2016). Therefore these responses are not discussed for leatherback turtles.

Sea Turtles and Hearing Thresholds

Like marine mammals, if exposed to loud sounds, sea turtles may experience TTS and/or PTS. Although all sea turtle species studies exhibit the ability to detect low frequency sound, the potential effects of exposure to loud sounds on sea turtle biology remain largely unknown (Samuel et al. 2005a; Nelms et al. 2016). Few data are available to assess sea turtle hearing, let alone the effects sound sources from seismic surveys may have on their hearing potential. The only study which addressed sea turtle TTS was conducted by Moein et al. (1994), in which a loggerhead turtle experienced TTS upon multiple exposures to an airgun in a shallow water enclosure, but recovered full hearing sensitivity within one day.

As with marine mammals, we assume that sea turtles will not move towards a sound source that causes them stress or discomfort. Some experimental data suggest sea turtles may avoid seismic sound sources (Moein et al. 1994; McCauley et al. 2000a; McCauley et al. 2000c), but monitoring reports from seismic surveys in other regions suggest that some sea turtles do not avoid airguns and were likely exposed to higher levels of pulses from seismic airgun arrays (Smultea and Holst 2003). For this reason, mitigation measures will be implemented to limit leatherback sea turtle exposure at 100 meters (328.1 feet), which, as noted in Section 10.3.3, will fully cover the thresholds for injury. In most cases, we expect most leatherback sea turtles will move away from sounds produced by the airgun array. Although data on the precise sound levels that can result in TTS or PTS are lacking and the effectiveness of mitigation measures is not fully understood, we do not expect the vast majority of leatherback sea turtles present in the action area to be exposed to sound levels that will result in TTS or PTS, but it could occur for a few individuals. Although the probability of this occurrence will be extremely low, for those individuals that will experience TTS, the available data suggest hearing will return to normal within days of the exposure (Moein et al. 1994).

Sea Turtles and Behavioral Responses

As with ESA-listed marine mammals, it is likely that leatherback sea turtles will experience behavioral responses in the form of avoidance. We do not have much information on how sea turtles specifically will respond, but here we discuss the available information. Behavioral responses to human activity have been investigated for only a few species of sea turtles: green and loggerhead (O'Hara and Wilcox 1990; McCauley et al. 2000b); and leatherback, loggerhead, olive ridley, and 160 unidentified hardshell turtles (Weir 2007). The work by O’Hara and Wilcox (1990) and McCauley et al. (2000b) reported behavioral changes of sea turtles in response to seismic airgun arrays. These studies formed the basis for our 175 dB re: 1 μPa (rms) threshold for determining when sea turtles could be harassed due to sound exposure, since at and above this level, loggerhead turtles were observed to exhibit avoidance behavior, increased swimming speed, and erratic behavior. We use this study as a surrogate for leatherbacks since we do not have better acoustic threshold data related to seismic surveys for leatherback sea turtles.

Loggerhead turtles have also been observed to more towards the surface upon exposure to an airgun (Lenhardt et al. 1983; Lenhardt 1994). In contrast, loggerhead turtles resting at the ocean surface were observed to startle and dive as an active seismic source approached them, with the responses decreasing with increasing distance (Deruiter and Larbi Doukara 2012). However, some of these animals may have reacted to the vessel’s presence rather than the sound source specifically (Deruiter and Larbi Doukara 2012). Monitoring reports from seismic surveys show that some sea turtles move away from approaching airgun arrays, although sea turtles may approach active airgun arrays within 10 meters (32.8 feet) with minor behavioral responses (Holst et al. 2005c; Smultea et al. 2005; Holst et al. 2006; NMFS 2006a; NMFS 2006h; Holst and Smultea 2008a).

Observational evidence suggests that sea turtles are not as sensitive to sound as are marine mammals and significant behavioral changes are only expected when sound levels rise above received sound levels of 175 dB re: 1 μPa (rms). If exposed at such sound levels, based on the available data, we anticipate some change in swimming patterns and avoidance behavior. Some leatherback sea turtles may approach the active airgun array to closer proximity, but we expect them to eventually turn away in order to avoid the active airgun array. As such, we expect temporary displacement of exposed individuals from some portions of the action area while the R/V *Langseth* transits through.

Leatherback Sea Turtles and Physical or Physiological Effects

Direct evidence of seismic survey sound causing stress is lacking in sea turtles. However, animals often respond to anthropogenic stressors in a manner that resembles a predator response (Harrington and Veitch 1992; Lima 1998; Gill et al. 2001; Frid and Dill 2002; Frid 2003; Beale and Monaghan 2004; Romero 2004; Harris et al. 2018). As predators generally induce a stress response in their prey (Lopez 2001; Dwyer 2004; Mateo 2007), we assume that leatherback sea turtles experience a stress response if exposed to loud sounds from airgun arrays. We expect breeding adult sea turtles may experience a lower stress response than males, as female loggerhead, hawksbill, and green turtles appear to have a physiological mechanism to reduce or eliminate hormonal response to stress (predator attack, high temperature, and capture) in order to maintain reproductive capacity at least during their breeding season; a mechanism apparently not shared with males (Jessop et al. 2000; Jessop 2001; Jessop et al. 2004). Due to these studies and since leatherback sea turtles have similar biological functions as other sea turtles, we predict that leatherback sea turtles will have an analogous response.

Individuals may experience a stress response at levels lower than approximately 175 dB re: 1 μPa (rms), but data are lacking to evaluate this possibility. Therefore, we follow the best available evidence identifying a behavioral response as the point at which we also expect a significant stress response.

10.3.5.3 Potential Response of ESA-Listed Pacific Salmonids to Acoustic Sources

Airguns are characterized as impulsive sounds. Possible effects for fish from impulsive sounds can be auditory (hearing impairments) or non-auditory (e.g., tissue effects, injury, barotrauma). There have been several documented effects to fish from seismic airguns, including:

- Hearing impairment or physical damage to fish ears,
- Barotrauma,
- Physiological stress responses,

- Masking, and
- Behavioral responses (displacement).

We do not expect mortality to occur for fishes exposed to the seismic airguns. Casper et al. (2012) studied the effects of impulsive noise (e.g., pile driving) on juvenile Chinook salmon and observed no mortalities from the sound exposure. Further, a study examining the effects of a single airgun pulse on pallid sturgeon (*Scaphirhynchus albus*) found no mortality or lethal injury, but the authors pointed out that the effects of multiple exposures were still unknown (Popper et al. 2016). Although these studies did not assess impacts of seismic airguns on ESA-listed salmonids, they provide insight into prospective effects. Furthermore, mortality of fish from airguns have never been recorded under field conditions although inner ear damage has been documented (Streever et al. 2016b).

Hearing Impairment (TTS) or Physical Damage to Ears

ESA-listed fishes may experience TTS as a result of seismic activities in the action area. There have been numerous studies conducted on the effects of seismic airguns on fish hearing. One study focusing on pink snapper (*Pristipomoides filamentosus*) kept in cages while a seismic airgun fired as close as five to 15 meters away showed physical damage to fish ears, with no evidence of recovery after 58 days (McCauley et al. 2003b). Lake chub (*Couesius plumbeus*) and northern pike (*Esox lucius*) exposed to five airgun blasts experienced hearing loss immediately after the exposure, with a return to normal hearing thresholds 18 to 24 hours afterwards (Popper et al. 2005b). A later follow-up study conducted under similar circumstances found no damage to the sensory epithelia in any of the otoloithic end organs in fish subjected to seismic airguns; northern pike and lake chub did exhibit TTS (Song et al. 2008). This is in contrast to other earlier sound exposure studies which did show physical damage to fish ears (Hastings et al. 1996; McCauley et al. 2003b). However, as Song et al. (2008) point out, factors like water depth and the airgun specifications likely make a difference in the degree of effects to fish.

We are unaware of any research demonstrating TTS in the species considered in this opinion (or other fish species with a swim bladder not involved in hearing) from seismic airguns. Coho, Chinook, chum, sockeye salmon, and steelhead all have a swim bladder, but it is not involved in hearing. Although TTS has not been demonstrated in the species groups considered in this opinion, this does not mean it does not occur. Because we know it can occur from other acoustic stressors, we assume it is possible from exposure to a sound stressor caused by seismic airguns. The criteria used for TTS was based upon a conservative value for more sensitive fish species and life stages with swim bladders. If TTS does occur, it would likely co-occur with barotraumas (i.e., non-auditory injury), and therefore would be within the range of other injuries these fishes are likely to experience from airgun blast exposures. None of the ESA-listed fish considered in this opinion (i.e., salmonids) have a hearing specialization or a swim bladder involved in hearing, thus, minimizing the likelihood of each instance of TTS affecting an individual’s fitness. Most fish species are able to rely on alternative mechanisms (e.g., sight, lateral line system) to detect prey, avoid predators, spawn, and to orient in the water column (Popper et al. 2014a). Additionally, hearing is not thought to play a role in salmonid migration (e.g., Putnam et al.

2013). TTS is also short-term with fish being able to replace hair cells when they are damaged (Lombarte et al. 1993; Smith et al. 2006). Depending on the severity of the TTS and underlying degree of hair cell damage, a fish would be expected to recover from the impairment over a period of weeks (for the worst degree of TTS).

In summary, because the ESA-listed fish species considered in this opinion are not known to rely on hearing for essential life functions, and any effects from TTS would be short-term and temporary, instances of TTS would not likely result in measurable long-term effects on any individual's fitness.

Barotrauma

The term "barotrauma" refers to physical damage to tissues or organs, and occurs when there is a rapid change in pressure that directly affects the body gases in the fish (Board et al. 2011). When the seismic airgun discharges, it causes such a change in pressure. These types of sound pressures cause the swim bladder in a fish to rapidly and repeatedly expand and contract, and pound against the internal organs. This pneumatic pounding may result in hemorrhage and rupture of blood vessels and internal organs, including the swim bladder, spleen, liver and kidneys. External damage has also been documented, evident with loss of scales, hematomas in the eyes, base of fins, etc. (e.g., Yelverton et al. 1975; Wiley et al. 1981; Gisiner 1998; Casper et al. 2012; Halvorsen et al. 2012a). Fishes can survive and recover from some injuries, but in other cases, death can be instantaneous, occur within minutes after exposure, or occur several days later.

There was a study demonstrating barotrauma to juvenile Chinook from pile driving (an impulsive sound like airguns, but one that is stationary rather than mobile Halvorsen et al. 2012c). Another study evaluated the ability of juvenile Chinook to recover from barotrauma after exposure to pile driving which provided support that the fish could recover from mild injuries and that exposure would not affect their survival (Casper et al. 2012).

The presence and type of a swim bladder appear to play a role in the susceptibility of fish to impulsive sound. For example, physostomous fishes have an open duct connecting the swim bladder to their esophagus and may be better able to adjust the amount of gas in their body by gulping or releasing air in a more rapid manner than physoclistous fishes. Physoclistous fish do not have this connection and must diffuse or regulate gas pressure in the swim bladder by special tissues or glands. Chinook salmon and other salmonids have a physostomous (open) swim bladder. In a study examining the effects of impulsive pile driving on different fish, Chinook exhibited more mild and moderate injuries when exposed to pile driving than did the Nile tilapia (*Oreochromis niloticus*), which has a physoclistous (closed) swim bladder (Halvorsen et al. 2012b).

Physiological Stress

Physiological effects to fishes from exposure to anthropogenic sound are increases in stress hormones or changes to other biochemical stress indicators (e.g., Sverdrup et al. 1994; D'amelio et al. 1999; Wysocki et al. 2006). Physiological responses of fishes to acoustic stressors have been described in greater detail for other acoustics stressors on fishes. Exposure to seismic airguns could cause spikes in stress hormone levels, or alter a fish's natural behavioral patterns. Physiological effects to fishes from exposure to anthropogenic sound are increases in stress hormones or changes to other biochemical stress indicators (e.g., Sverdrup et al. 1994; D'amelio et al. 1999; Wysocki et al. 2006). Fishes may have physiological stress reactions to sounds that they can detect. For example, a sudden increase in sound pressure level or an increase in overall background noise levels can increase hormone levels and alter other metabolic rates indicative of a stress response. Studies have demonstrated elevated hormones such as cortisol, or increased ventilation and oxygen consumption (Pickering 1981; Smith et al. 2004b; Smith et al. 2004a; Hastings and C. 2009; Simpson et al. 2015; Simpson et al. 2016). Although results from these studies have varied, it has been shown that chronic or long-term (days or weeks) exposures of continuous anthropogenic sounds can lead to a reduction in embryo viability (Sierra-Flores et al. 2015b) and decreased growth rates (Nedelec et al. 2015). Generally, stress responses are more likely to occur in the presence of potentially threatening sound sources such as predator vocalizations or the sudden onset of loud and impulsive sound signals. Stress responses are typically considered to be brief (a few seconds to minutes) if the exposure is short or if fishes habituate or have previous experience with the sound**.** However, exposure to chronic noise sources may lead to more severe effects resulting in fitness consequences such as reduced growth rates, decreased survival rates, reduced foraging success, etc. Although physiological stress responses may not be detectable in fishes during sound exposures, NMFS assumes a stress response occurs when other physiological impacts such as injury or hearing loss occur.

Some studies have been conducted that measure changes in cortisol levels in response to sound sources. Cortisol levels have been measured in fishes exposed to vessel noises, predator vocalizations, or other tones during playback experiments**.** Daily exposure of a short duration upsweep (a tone that sweeps upward across multiple frequencies) across 100 to 1,000 hertz of Atlantic cod (*Gadus morhua*) to artificial sound elicited a minor cortisol response, and when the broodstock was exposed during the spawning period, egg production and fertilization rates were reduced, leading to a more than 50 percent reduction in viable embryos (Sierra-Flores et al. 2015a). The levels returned to normal within one hour post-exposure, which supports the general assumption that spikes in stress hormones generally return to normal once the sound of concern ceases**.** The proposed action will not take place in the streams where salmonids spawn, so we do not expect to see similar effects in exposed fishes. Nichols et al. (2015) exposed giant kelpfish (*Heterostichus rostratus*) to vessel playback sounds, and increased levels of cortisol were found with increased sound levels and intermittency of the playbacks. Gulf toadfish (*Opsanus beta*) were found to have elevated cortisol levels when exposed to low-frequency dolphin vocalization playbacks (Remage-Healey et al. 2006). Interestingly, the researchers observed none of these effects in toadfish exposed to low frequency snapping shrimp "pops," indicating what sound the fish may detect and perceive as threats.

Not all research has indicated stress responses resulting in increased hormone levels. Goldfish exposed to continuous (0.1 to 10 kilohertz) sound at a pressure level of 170 dB re 1 μPa for one month showed no increase in stress hormones (Smith et al. 2004b). Similarly, Wysocki et al. (2007) exposed rainbow trout to continuous band-limited noise with a sound pressure level of about 150 dB re 1 μPa for nine months with no observed stress effects. Additionally, the researchers found no significant changes to growth rates or immune systems compared to control animals held at a sound pressure level of 110 dB re 1 μPa.

Other parameters can be an indicator of stress. A study examining the effects of seismic airguns on Atlantic cod and saithe (also known as pollock [*Pollachius virens*]) found that cod exhibited a reduced heart rate in response to the particle motion component when the airguns were fired; saithe did not exhibit alterations in heart rate (Davidsen et al. 2019). Heart rate can be a sensitive indicator of stress, although other components of cardiac output such as stroke volume play a role and would be necessary to fully consider the effects to fish.

Masking

Masking generally results from a sound impeding an animal's ability to hear other sounds of interest. The frequency of the received level and duration of the sound exposure determine the potential degree of auditory masking. Similar to hearing loss, the greater the degree of masking, the smaller the area becomes within which an animal can detect biologically relevant sounds such as those required to attract mates, avoid predators, or find prey (Slabbekoorn et al. 2010). Because the ability to detect and process sound may be important for fish survival, anything that may significantly prevent or affect the ability of fish to detect, process, or otherwise recognize a biologically or ecologically relevant sound could decrease chances of survival. For example, some studies on anthropogenic sound effects on fishes have shown that the temporal pattern of fish vocalizations (e.g., sciaenids and gobies) may be altered when fish are exposed to sound-masking (Parsons et al. 2009). This may indicate fish are able to react to noisy environments by exploiting "quiet windows" (e.g., Lugli and Fine 2003) or moving from affected areas and congregating in areas less disturbed by nuisance sound sources. In some cases, vocal compensations occur, such as increases in the number of individuals vocalizing in the area, or increases in the pulse/sound rates produced (Picciulin et al. 2012). Fish vocal compensations could have an energetic cost to the individual, which may lead to a fitness consequence such as affecting their reproductive success or increased detection by predators (Bonacito et al. 2001; Amorin et al. 2002).

Behavioral Responses (Displacement)

Behavioral responses could be expected to occur within the ensonified area for other injurious or physiological responses, and perhaps be extended beyond these ranges if a fish could detect the sound at those greater distances. Given that none of the species considered here have any specialized hearing adaptations, and the threshold for TTS is considered conservative for these hearing groups, most behavioral responses would be expected to occur within the ensonified area for injury and TTS.

In general, NMFS assumes that most fish species would respond in a similar manner to air guns as they do to other impulsive sounds like pile driving. These reactions could include startle or alarm responses, quick bursts in swimming speeds, diving, or changes in swimming orientation. In other responses, fish may move from the area or stay and try to hide if they perceive the sound as a potential threat. Other potential changes include reduced predator awareness and reduced feeding effort. The potential for adverse behavioral effects will depend on a number of factors, including the sensitivity to sound, the type and duration of the sound, as well as life stages of fish that are present in the areas affected.

Fish that detect an impulsive sound may respond in “alarm,” as detected by Fewtrell (2003), or other startle responses may also be exhibited. The startle response in fishes is a quick burst of swimming that may be involved in avoidance of predators. A fish that exhibits a startle response may not necessarily be injured, but it is exhibiting behavior that suggests it perceives a stimulus indicating potential danger in its immediate environment. However, fish do not exhibit a startle response every time they experience a strong hydroacoustic stimulus. A study in Puget Sound, Washington, suggests that pile driving operations disrupt juvenile salmon behavior (Feist et al. 1992). Though no underwater sound measurements are available from that study, comparisons between juvenile salmon schooling behavior in areas subjected to pile driving/construction and other areas where there was no pile driving/construction indicate that there were fewer schools of fish in the pile-driving areas than in the non-pile driving areas. The results are not conclusive but there is a suggestion that pile-driving operations may result in a disruption in the normal migratory behavior of the salmon in that study, though the mechanisms salmon may use for avoiding the area are not understood at this time.

Because of the inherent difficulties with conducting fish behavioral studies in the wild, data on behavioral responses for fishes is largely limited to caged or confined fish studies, mostly limited to studies using caged fishes and the use of seismic air guns (Lokkeborg et al. 2012). One way that researchers have been evaluating the effects of seismic airguns on fish is through examining fisheries catch rates before and after seismic surveys. There is evidence of fish displacement due to seismic surveys causing decreased catch rates of cod (Løkkeborg and Soldal 1993a). Another study showed that fishing catch rates decreased for haddock (68 percent) and cod (69 percent) within the seismic activity area, with effects observed up to 18 nautical miles from the seismic sound source, with greater reductions closer to the sound source (Engås et al. 1996a). Catch rates did not return to normal in the five days after seismic activity ended. The authors also found that the effects of seismic activity were more pronounced on large cod (>60 centimeters) than smaller cod, with smaller cod still caught in the trawls and longlines. The authors hypothesized that this may be due to a size-dependent swimming capability of the larger fish to get away from the seismic sound source, or that the smaller fish are more able to take the bait on the longlines when the larger fish are not present (Engås et al. 1996a). A single airgun that created peak pressures above 186 dB caused a decline of 52.4 percent in rockfish (*Sebastes spp.*) catch per unit effort compared to control conditions (Skalski et al. 1992). It is important to point out that there has been a wide range of responses of fish catch rates to seismic surveys. In another study in Prudhoe Bay, Alaska, seismic activity changed fish catch rates, increasing catches of some species, and decreasing catches of others (Streever et al. 2016a). A study examining reef fish behavior with video cameras during a seismic survey that approached within 0.7 and 6.5 kilometers found that reef fish abundance declined by 78 percent in the evening hours, when fish abundance had been highest. One fish was observed to exhibit a behavioral response by swimming away from a ledge (Paxton et al. 2017). However, another study looking at the response of reef fish to a three-dimensional seismic study found no measurable effect on species richness or abundance (Miller and Cripps 2013). In light of other studies described here, it still remains possible that ESA-listed fishes in the action area could experience displacement or other behavioral responses.

Percentage of ESA-Listed Fishes Exposed to TTS/Injury

For ESA-listed fishes that will potentially be exposed to the National Science Foundation and Lamont-Doherty Earth Observatory's airgun activities, the habitat surrogate used for the extent of take in this opinion is the area of the water column exposed to sound pressure levels that would potentially result in TTS and injury of ESA-listed fishes (the only forms of take authorized for fish in this opinion). As discussed above, this is the area where the effects of the proposed action would potentially cause take of the ESA-listed salmonid species. This area begins at the airgun array and extends to 230.1 meters for injury and extends from 230.1 meters to 3,211 meters from the airgun array for TTS.

Based on the habitat surrogate described above, approximately 32.4 km^2 and 0.17km^2 of ESA-listed fish habitat could be impacted by TTS and injury levels from the seismic airgun array, respectively. In all, the extent of take for ESA-listed fishes that could be exposed to seismic airguns (TTS and injury) from the proposed action is shown in Table 45 below. As indicated in Table 45, the area in which TTS or injury could occur at any one time during the use of seismic airguns during the proposed action, relative to the potential habitat available to the animal during the same time period, is extremely small. At most, only 0.02 percent and 0.0001 percent of ESA-listed Chinook habitat (from the Lower Columbia River and Puget Sound ESUs) could be impacted by TTS and injury levels from the airgun array, respectively.

Table 45 Estimated Area of ESA-Listed Salmonid Habitat Affected by ESA Harassment (TTS) and Injury During NSF's Proposed Seismic Airgun Activities.

DPS/ESU	Total Habitat Affected (TTS)	Total Habitat Affected (injury)	Marine Habitat Area	Percentage of Habitat Affected (TTS/Injury)	Northern/Southern Extent	Western Boundary
Snake River fall Chinook salmon (Adult)	32.4 km^2	0.17 km^2	639,642 km^2	.005%/.00002%	Yakutat Coast/ Central Oregon Coast Weitkamp (2010) and Shelton et al. (2019)	South of action area: Maximum of 120 nautical miles from shore); Inside US EEZ adjacent to Alaska: 145°W(See

						Figure 5 of Sharma and Quinn (2012))
Snake River fall Chinook salmon (Juvenile)	32.4 km^2	0.17 km^2	225,386 km^2	.014%/.00007%	Yakutat Coast/ Central Oregon Coast Weitkamp (2010) and Shelton et al. (2019)	Continental Shelf (200 meter depth contour)
Snake River spring/summer Chinook salmon (Adult)	32.4 km^2	0.17 km^2	639,642 km^2	.005%/.00002%	Yakutat Coast/ Central Oregon Coast Weitkamp (2010) and Shelton et al. (2019)	South of action area: Maximum of 120 nautical miles from shore); Inside US EEZ adjacent to Alaska: 145°W(See Figure 5 of Sharma and Quinn (2012)))
Snake River spring/summer Chinook salmon (Juvenile)	32.4 km^2	0.17 km^2	225,386 km^2	.014%/.00007%	Yakutat Coast/ Central Oregon Coast Weitkamp (2010) and Shelton et al. (2019)	Continental Shelf (200 meter depth contour)
Lower Columbia River Chinook salmon (Adult)	32.4 km^2	0.17 km^2	467,536 km^2	.007%/.00004%	Northern Southeast Alaska/Central Oregon Coast Weitkamp (2010) and Shelton et al. (2019)	South of action area: Continental Shelf (200 meter depth contour); Inside US EEZ adjacent to Alaska: 145°W (See Figure 4 of Sharma and Quinn (2012))
Lower Columbia River Chinook salmon (Juvenile)	32.4 km^2	0.17 km^2	198,450 km^2	.02%/.00008%	Northern Southeast Alaska/Central Oregon Coast Weitkamp (2010) and Shelton et al. (2019)	Continental Shelf (200 meter depth contour)
Upper Willamette River Chinook salmon (Adult)	32.4 km^2	0.17 km^2	639,642 km^2	.005%/.00002%	Yakutat Coast/ Columbia River Weitkamp (2010) and Shelton et al. (2019)	South of action area: Maximum of 120 nautical

						miles from shore); Inside US EEZ adjacent to Alaska: 145°W(See Figure 5 of Sharma and Quinn (2012))
Upper Willamette River Chinook salmon (Juvenile)	32.4 km^2	0.17 km^2	225,386 km^2	.0014%/.00007%	Yakutat Coast/ Columbia River Weitkamp (2010) and Shelton et al. (2019)	Continental Shelf (200 meter depth contour)
Upper Columbia River spring Chinook salmon (Adult)	32.4 km^2	0.17 km^2	639,642 km^2	.005%/.00002%	Yakutat Coast/ Central Oregon Coast Weitkamp (2010) and Shelton et al. (2019)	South of action area: Maximum of 120 nautical miles from shore); Inside US EEZ adjacent to Alaska: 145°W(See Figure 5 of Sharma and Quinn (2012))
Upper Columbia River spring Chinook salmon (Juvenile)	32.4 km^2	0.17 km^2	225,386 km^2	.0014%/.00007%	Yakutat Coast/ Central Oregon Coast Weitkamp (2010) and Shelton et al. (2019)	Continental Shelf (200 meter depth contour)
Puget Sound Chinook salmon (Adult)	32.4 km^2	0.17 km^2	450,526 km^2	0.0072%/.00004 %	Northern Southeast Alaska/Washington Coast Weitkamp (2010) and Shelton et al. (2019)	Inside action area: Continental Shelf (200 meter depth contour); North of action area: 145°W(See Figure 6 of Sharma and Quinn (2012))
Puget Sound Chinook salmon (Juvenile)	32.4 km^2	0.17 km^2	176,591 km^2	.02%/.0001%	Northern Southeast Alaska/Washington Coast Weitkamp (2010) and Shelton et al. (2019)	100-meter depth contour

Chum salmon (all ESUs)	32.4 km^2	0.17 km^2	4,376,644 km^2	.0007%/.000004 %	North and westward migration; primarily occur north of 48 °N Myers et al. (2007)	171°E (See Figure 2 of Myers et al. (2007))
Sockeye salmon (all ESUs)	32.4 km^2	0.17 km^2	5,434,790 km^2	.0006%/.000003 %	North and westward migration; primarily occur north of 48°N Myers et al. (2007)	167°E (See Figure 2 of Myers et al. (2007))
Steelhead (all DPSs)	32.4 km^2	0.17 km^2	6,083,400 km^2	.0005%/.000003 %	Southern California/Northern Alaska Light et al. (1989)	161°E (See Figure 16 of Light et al. (1989))

10.4 Risk Analysis

In this section, we assess the consequences of the responses to the individuals that have been exposed to sounds from the use of airgun arrays, the populations those individuals represent, and the species those populations comprise. When we do not expect individual ESA-listed blue, fin, Western North Pacific gray, North Pacific right, Mexico DPS humpback, sei, and sperm whales, Western DPS Steller sea lions, leatherback sea turtles, Chinook salmon (Snake River fall-run, Snake River spring/summer-run, Lower Columbia River, Upper Willamette River, Upper Columbia River spring-run, and Puget Sound ESUs), sockeye salmon (Snake River and Ozette River ESUs), chum salmon (Hood Canal summer-run and Columbia River ESUs), and steelhead (South-Central California Coast, Central California Coast, California Central Valley, Northern California, Upper Columbia River, Snake River Basin, Lower Columbia River, Upper Willamette River, Middle Columbia River, and Puget Sound DPSs) exposed to an action's effects to experience reductions in fitness, we will not expect the action to affect the viability of the populations to which those individuals belong, or the species those populations comprise. If we conclude that individual animals are likely to experience reductions in fitness, we will assess the consequences of those fitness reductions on the population(s) to which those individuals belong.

We expect up to 36 blue, 987 fin, three Western North Pacific gray, two North Pacific right, 21 Mexico DPS humpback, 42 sei, and 153 sperm whales, as well as 104 Western DPS Steller sea lions to be exposed to the airgun array within 160 dB re: 1 μPa (rms) ensonified areas during the seismic survey activities resulting in behavioral harassment. We expect up to one blue, 45 fin, and one sei whale to be exposed to the airgun array within PTS ensonified areas during the seismic survey activities resulting in injury. We expect up to three leatherback turtles to be exposed to the airgun array within 175 dB re: 1 μPa (rms) ensonified areas during the seismic survey activities resulting in behavioral harassment. Expected exposures to TTS and injury for ESA-listed Pacific salmon are in Table 45.

As described above, the proposed action will result in temporary harassment and potential harm to the exposed marine mammals, leatherback sea turtles, and fishes. Harassment is not expected to have more than short-term effects on individuals of any ESA-listed species (blue, fin, Western North Pacific gray, Mexico DPS humpback, sei, and sperm whales, Western DPS Steller sea lions, leatherback turtles, or specific ESUs and DPSs of ESA-listed Chinook, chum, sockeye, and steelhead). Harm under the ESA is not expected to occur with high probability given the mitigation measures (e.g., shut down procedures) in place for the proposed seismic survey activities to protect ESA-listed marine mammals and leatherback sea turtles. We believe these measures (e.g., lookout procedures) will also benefit specific ESUs and DPSs of ESA-listed Chinook, chum, sockeye, and steelhead. As such we do not expect ESA-listed marine mammals, leatherback sea turtles, or fishes exposed to the action's effects to experience permanent reductions in fitness, nor do we expect the action to have adverse consequences on the viability of the populations those individuals represent or the species those populations comprise.

11 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 C.F.R. §402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

During the writing of this opinion, we searched for information on future state, tribal, local, or private (non-Federal) actions that were reasonably certain to occur in the action area. Based on our search of electronic media, including state agency information, we did not find information regarding additional state or private activities that are likely to occur in the action area during the foreseeable future that were not considered in the *Environmental Baseline* of this opinion. Similarly, we are not aware of any proposed or anticipated changes in these activities that would substantially change their impacts on ESA-listed blue, fin, Western North Pacific gray, Mexico DPS humpback, sei, and sperm whales, Western DPS Steller sea lions, leatherback sea turtles, or the ESUs and DPSs of ESA-listed Chinook, chum, sockeye, and steelhead considered in this opinion.

12 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 10) to the *Environmental Baseline* (Section 9) and the *Cumulative Effects* (Section 11) to formulate the agency's biological opinion as to whether the proposed action is likely to reduce appreciably the likelihood of both the survival and recovery of a ESA-listed species in the wild by reducing its numbers, reproduction, or distribution. The assessment is made in full consideration of the *Species and Critical Habitat Not Likely to be*

Adversely Affected (Section 7), and *Status of the Species Likely to be Adversely Affected* (Section 8).

The following discussions separately summarize the probable risks the proposed actions pose to ESA-listed marine mammals, leatherback sea turtles, and salmonids that are likely to be exposed to the stressors associated with the seismic survey activities. These summaries integrate the exposure profiles presented previously with the results of our response analyses for the proposed actions considered in this opinion.

12.1 Blue Whale

Adult and juvenile blue whales are present in the action area and are expected to be exposed to noise from the seismic survey activities. The severity of an animal's response to noise associated with the seismic survey will depend on the duration and severity of exposure.

The minimum population size for Eastern North Pacific Ocean blue whales is 1,050; the more recent abundance estimate is 1,496 whales (Carretta et al. 2020b). Current estimates indicate a growth rate of just under three percent per year (Calambokidis et al. 2009).

We expect that adults and juveniles may be affected by take in the form of PTS, TTS, or behavioral changes from sound sources associated with the seismic survey. Take may have short- or long-term consequences, depending on the level of noise from airguns to which animals are exposed. No reduction in the distribution of blue whales from the Pacific Ocean or changes to the geographic range of the species are expected because of the National Science Foundation's seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization. Further, no reduction in numbers is anticipated due to the proposed actions.

There are expected to be one individual harmed and 35 individuals harassed because of the proposed seismic survey activities. These individuals can comprise of both adults and juveniles. We anticipate temporary behavioral responses and/or short-term effects to reproduction, with individuals returning to normal shortly after the exposure has ended. Therefore, no permanent reduction in reproduction is expected because of the proposed actions. Because we do not anticipate a reduction in numbers or reproduction of blue whales as a result of the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

The Final Recovery Plan for the blue whale lists recovery objectives for the species. The following recovery objectives are relevant to the impacts of the proposed actions:

- Reduce or eliminate human-caused injury and mortality of blue whales.
- Minimize detrimental effects of directed vessel interactions with blue whales.
- Coordinate state, federal, and international efforts to implement recovery actions for blue whales.

Because no mortalities or measurable effects on the abundance, distribution, and reproduction of blue whale populations are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization will impede the recovery objectives for blue whales. In conclusion, we believe the non-lethal effects of take associated with the proposed actions will not jeopardize the continued existence of blue whales.

12.2 Fin Whale

Adult and juvenile fin whales are present in the action area and are expected to be exposed to noise from the seismic survey activities. The severity of the individual's response to noise associated with the seismic survey will depend on the duration and severity of the exposure.

Current estimates indicate approximately 10,000 fin whales in U.S. Pacific Ocean waters, with an annual growth rate of 4.8 percent in the Northeast Pacific (Nadeem et al. 2016).

We expect that adults and juveniles may be affected by take in the form of PTS, TTS, or behavioral changes from sound sources associated with the seismic survey. Take may have short- or long-term consequences, depending on the level of noise from airguns to which animals are exposed. No reduction in the distribution of fin whales from the Pacific Ocean is expected because of the National Science Foundation's seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization. Further, no reduction in numbers is anticipated due to the proposed actions.

There are expected to be 45 individuals harmed and 942 individuals harassed because of the proposed seismic survey activities. These individuals can comprise of both adults and juveniles. We anticipate temporary behavioral responses and/or short-term effects to reproduction, with individuals returning to normal shortly after the exposure has ended. Therefore, no permanent reduction in reproduction is expected because of the proposed actions. Because we do not anticipate a reduction in numbers or reproduction of fin whales as a result of the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

The 2010 Final Recovery Plan for the fin whale lists recovery objectives for the species. The following recovery objectives are relevant to the impacts of the proposed actions:

- Achieve sufficient and viable population in all ocean basins.
- Ensure significant threats are addressed.

Because no mortalities or measurable effects on the abundance, distribution, and reproduction of fin whale populations are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization will impede the recovery objectives for fin whales. In conclusion, we believe the non-lethal effects of take associated with the proposed actions will not jeopardize the continued existence of fin whales.

12.3 Gray Whale – Western North Pacific DPS

Adult and juvenile Western North Pacific DPS gray whales are present in the action area and are expected to be exposed to noise from the seismic survey activities. The severity of the individual's response to noise associated with the seismic survey will depend on the duration and severity of the exposure.

The global, pre-exploitation estimate for abundance of the Western North Pacific DPS of gray whales is unknown. By 1910, after some commercial exploitation had already occurred, it is estimated that only 1,000 to 1,500 gray whales remained in the Western North Pacific population (Berzin and Vladimirov 1981). By the 1930s it was speculated that gray whales in the Western North Pacific could be extinct (Bowen 1974; Mizue 1951). Estimated population size from photo-ID data in 2016 was estimated at 290 whales (Nmin=271) (Cooke et al. 2017).

We expect that adults and juveniles may be affected by take in the form of TTS or behavioral changes from sound sources associated with the seismic survey. Take may have short- or long-term consequences, depending on the level of noise from airguns to which animals are exposed. No reduction in the distribution of Western North Pacific DPS of gray whales from the Pacific Ocean is expected because of the National Science Foundation's seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization. Further, no reduction in numbers is anticipated due to the proposed actions.

There are expected to be zero individuals harmed and three individuals harassed because of the proposed seismic survey activities. These individuals can comprise of both adults and juveniles. We anticipate temporary behavioral responses with individuals returning to normal shortly after the exposure has ended. Therefore, no reduction in reproduction is expected because of the proposed actions. Because we do not anticipate a reduction in numbers or reproduction of Western North Pacific DPS of gray whales as a result of the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

There is no Recovery Plan for the Western North Pacific DPS gray whale because listed species that reside mostly outside of U.S. jurisdiction are considered not likely to benefit from recovery planning efforts.

Because no mortalities or measurable effects on the abundance, distribution, and reproduction of Western North Pacific DPS gray whale populations are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization will impede the recovery objectives for Western North Pacific DPS gray whales. In conclusion, we believe the non-lethal effects of take associated with the proposed actions will not jeopardize the continued existence of Western North Pacific DPS gray whales.

12.4 North Pacific Right Whale

Only adult North Pacific right whales have been present in the action area since 1950 (Kloster 2021) and are expected to be exposed to noise from the seismic survey activities. The severity of the individual's response to noise associated with the seismic survey will depend on the duration and severity of the exposure.

The North Pacific right whale remains one of the most endangered whale species in the world. Their abundance likely numbers fewer than 1,000 individuals.

We expect that adults may be affected by take in the form of TTS or behavioral changes from sound sources associated with the seismic survey. Take may have short- or long-term consequences, depending on the level of noise from airguns to which animals are exposed. No reduction in the distribution of North Pacific right whales from the Pacific Ocean is expected because of the National Science Foundation's seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization. Further, no reduction in numbers is anticipated due to the proposed actions.

There are expected to be zero individuals harmed and two adults harassed because of the proposed seismic survey activities. We anticipate temporary behavioral responses with individuals returning to normal shortly after the exposure has ended. Therefore, no reduction in reproduction is expected because of the proposed actions. Because we do not anticipate a reduction in numbers or reproduction of North Pacific right whales as a result of the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

The 2013 Final Recovery Plan for the North Pacific right whale lists recovery objectives for the species. The following recovery objectives are relevant to the impacts of the proposed actions:

- Achieve sufficient and viable populations in all ocean basins.
- Ensure significant threats are addressed.

Because no mortalities or measurable effects on the abundance, distribution, and reproduction of North Pacific right whale populations are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization will impede the recovery objectives for the North Pacific right whale. In conclusion, we believe the non-lethal effects of take associated with the proposed actions will not jeopardize the continued existence of the North Pacific right whale.

12.5 Humpback Whale – Mexico DPS

Adult and juvenile Mexico DPS humpback whales are present in the action area and are expected to be exposed to noise from the seismic survey activities. The severity of the individual's response to noise associated with the seismic survey will depend on the duration and severity of the exposure.

The global, pre-exploitation estimate for humpback whales is 1,000,000 (Roman and Palumbi 2003). The current abundance estimate for the Mexico DPS of humpback whales is 3,264 individuals (81 FR 62259). A population growth rate is currently unavailable for the Mexico DPS of humpback whales.

We expect that adults and juveniles may be affected by take in the form of TTS or behavioral changes from sound sources associated with the seismic survey. Take may have short- or long-term consequences, depending on the level of noise from airguns to which animals are exposed. No reduction in the distribution of Mexico DPS humpback whales from the Pacific Ocean is expected because of the National Science Foundation's seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization. Further, no reduction in numbers is anticipated due to the proposed actions.

There are expected to be zero individuals harmed and 21 individuals harassed because of the proposed seismic survey activities. These individuals can comprise of both adults and juveniles. We anticipate temporary behavioral responses with individuals returning to normal shortly after the exposure has ended. Therefore, no reduction in reproduction is expected because of the proposed actions. Because we do not anticipate a reduction in numbers or reproduction of Mexico DPS humpback whales as a result of the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

The 1991 Final Recovery Plan for the humpback whale lists recovery objectives for the species. The following recovery objectives are relevant to the impacts of the proposed actions:

- Maintain and enhance habitats used by humpback whales currently or historically.
- Identify and reduce direct human-related injury and morality.
- Measure and monitor key population parameters.
- Improve administration and coordination of recovery program for humpback whales.

Because no mortalities or measurable effects on the abundance, distribution, and reproduction of Mexico DPS humpback whales populations are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization will impede the recovery objectives for the Mexico DPS humpback whales. In conclusion, we believe the non-lethal effects of take associated with the proposed actions will not jeopardize the continued existence of the Mexico DPS humpback whale.

12.6 Sei Whale

Adult and juvenile sei whales are present in the action area and are expected to be exposed to noise from the seismic survey activities. The severity of the individual's response to noise associated with the seismic survey will depend on the duration and severity of the exposure.

Models indicate that total abundance of sei whales declined from 42,000 to 8,600 individuals between 1963 and 1974 in the North Pacific Ocean. More recently, the North Pacific Ocean population was estimated to be 29,632 (95 percent confidence intervals 18,576 to 47,267) between 2010 and 2012 (IWC 2016; Thomas et al. 2016).

We expect that adults and juveniles may be affected by take in the form of PTS, TTS, or behavioral changes from sound sources associated with the seismic survey. Take may have short- or long-term consequences, depending on the level of noise from airguns to which animals are exposed. No reduction in the distribution of sei whales from the Pacific Ocean is expected because of the National Science Foundation's seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization. Further, no reduction in numbers is anticipated due to the proposed actions.

There are expected to be one individual harmed and 41 individuals harassed because of the proposed seismic survey activities. These individuals can comprise of both adults and juveniles. We anticipate temporary behavioral responses and/or short-term effects to reproduction, with individuals returning to normal shortly after the exposure has ended. Therefore, no permanent reduction in reproduction is expected because of the proposed actions. Because we do not anticipate a reduction in numbers or reproduction of sei whales as a result of the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

The 2001 Final Recovery Plan for the sei whale lists recovery objectives for the species. The following recovery objectives are relevant to the impacts of the proposed actions:

- Achieve sufficient and viable populations in all ocean basins.
- Ensure significant threats are addressed.

Because no mortalities or measurable effects on the abundance, distribution, and reproduction of sei whales populations are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization will impede the recovery objectives for the sei whale. In conclusion, we believe the non-lethal effects of take associated with the proposed actions will not jeopardize the continued existence of the sei whale.

12.7 Sperm Whale

Adult and juvenile sperm whales are present in the action area and are expected to be exposed to noise from the seismic survey activities. The severity of the individual's response to noise associated with the seismic survey will depend on the duration and severity of the exposure.

The sperm whale is the most abundant of the large whale species, with total abundance estimates between 200,000 and 1,500,000. The most recent estimate indicated a global population of between 300,000 and 450,000 individuals (Whitehead 2009). The higher estimates may be approaching population sizes prior to commercial whaling. There are no reliable estimates for sperm whale abundance across the entire Pacific Ocean. However, estimates are available in the northeast Pacific Ocean, where abundance was estimated to be between 26,300 and 32,100 animals in 1997. In the eastern tropical Pacific Ocean, the abundance of sperm whales was estimated to be 22,700 (95 percent confidence intervals 14,800 to 34,600) in 1993.

We expect that adults and juveniles may be affected by take in the form of TTS or behavioral changes from sound sources associated with the seismic survey. Take may have short- or long-term consequences, depending on the level of noise from airguns to which animals are exposed. No reduction in the distribution of sperm whales from the Pacific Ocean is expected because of the National Science Foundation's seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization. Further, no reduction in numbers is anticipated due to the proposed actions.

There are expected to be zero individuals harmed and 153 individuals harassed because of the proposed seismic survey activities. These individuals can comprise of both adults and juveniles. We anticipate temporary behavioral responses with individuals returning to normal shortly after the exposure has ended. Therefore, no reduction in reproduction is expected because of the proposed actions. Because we do not anticipate a reduction in numbers or reproduction of sperm whales as a result of the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

The 2010 Final Recovery Plan for the sperm whale lists recovery objectives for the species. The following recovery objectives are relevant to the impacts of the proposed actions:

- Achieve sufficient and viable populations in all ocean basins.
- Ensure significant threats are addressed.

Because no mortalities or measurable effects on the abundance, distribution, and reproduction of sperm whale populations are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization will impede the recovery objectives for sperm whales. In conclusion, we believe the non-lethal effects of take associated with the proposed actions will not jeopardize the continued existence of the sperm whale.

12.8 Steller Sea Lion – Western DPS

Adult and juvenile Western DPS of Steller sea lions are present in the action area and are expected to be exposed to noise from the seismic survey activities. The severity of the individual's response to noise associated with the seismic survey will depend on the duration and severity of the exposure.

Estimated population size for the Western DPS of Steller sea lion in Alaska was 12,581 pups and 40,351 for non-pups in 2019 (total N_{min}= 52,932) (Muto et al. 2020). This is less than half of the historical counts in the 1950s (N=140,000) and 1970s (N=110,000). Using data collected from 1978 through 2017, there is strong evidence that pup and non-pup counts of western stock Steller sea lions in Alaska were at their lowest levels in 2002 and 2003, respectively, and have increased at 1.78 percent and 2.14 percent, respectively, between 2002 and 2017 (Sweeney et al. 2016).

We expect that adults and juveniles may be affected by take in the form of TTS or behavioral changes from sound sources associated with the seismic survey. Take may have short- or long-term consequences, depending on the level of noise from airguns to which animals are exposed. No reduction in the distribution of Steller sea lions from the Pacific Ocean is expected because of the National Science Foundation's seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization. Further, no reduction in numbers is anticipated due to the proposed actions.

There are expected to be zero individuals harmed and 104 individuals harassed because of the proposed seismic survey activities. These individuals can comprise of both adults and juveniles. We anticipate temporary behavioral responses with individuals returning to normal shortly after the exposure has ended. Therefore, no reduction in reproduction is expected because of the proposed actions. Because we do not anticipate a reduction in numbers or reproduction of Western DPS of Steller sea lions as a result of the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

The 2008 Final Recovery Plan for the Steller sea lion lists recovery objectives for the species. The following recovery objectives are relevant to the impacts of the proposed actions:

- Insure adequate habitat and range for recovery
- Protect from over-utilization for commercial, recreational, scientific, or educational purposes.
- Protect from other natural or anthropogenic actions and administer the recovery program.

Because no mortalities or measurable effects on the abundance, distribution, and reproduction of Western DPS of Steller sea lion populations are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization will impede the recovery objectives for Western DPS of Steller sea lions. In conclusion, we believe the non-lethal effects of take associated with the proposed actions will not jeopardize the continued existence of the Western DPS of Steller sea lions.

12.9 Leatherback Sea Turtle

Only adult leatherback sea turtles are present in the action area and are expected to be exposed to noise from the seismic survey activities. The severity of the individual's response to noise associated with the seismic survey will depend on the duration and severity of the exposure.

Leatherback turtle populations in the Pacific Ocean are low. Overall populations in the Pacific Ocean have declined from an estimated 81,000 individuals to less than 3,000 total adults and subadults (Spotila et al. 2000). Counts of leatherback turtles at nesting beaches in the western Pacific Ocean indicate that the subpopulation has been declining at a rate of almost six percent per year since 1984 (Tapilatu et al. 2013).

We expect that adults may be affected by take in the form of TTS or behavioral changes from sound sources associated with the seismic survey. Take may have short- or long-term consequences, depending on the level of noise from airguns to which animals are exposed. No reduction in the distribution of leatherback sea turtles from the Pacific Ocean is expected because of the National Science Foundation's seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization. Further, no reduction in numbers is anticipated due to the proposed actions.

There are expected to be zero individuals harmed and three adults harassed because of the proposed seismic survey activities. We anticipate temporary behavioral responses with individuals returning to normal shortly after the exposure has ended. Therefore, no reduction in reproduction is expected because of the proposed actions. Because we do not anticipate a reduction in numbers or reproduction of leatherback sea turtles as a result of the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

The Pacific Recovery Plan for the population of leatherback turtles lists recovery objectives for the species. The following recovery objective is relevant to the impacts of the proposed action:

- Monitoring and research.

Because no mortalities or measurable effects on the abundance, distribution, and reproduction of leatherback sea turtle populations are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization will impede the recovery objectives for leatherback sea turtles. In conclusion, we believe the non-lethal effects of take associated with the proposed actions will not jeopardize the continued existence of leatherback sea turtles.

12.10 Salmonids

Adults and juveniles from ESA-listed Chinook, chum, sockeye, and steelhead ESUs and DPSs are present in the action area and are expected to be exposed to noise from the seismic survey activities. The severity of the individual's response to noise associated with the seismic survey will depend on the duration and severity of the exposure.

A summary of abundance numbers for ESA-listed Chinook, chum, sockeye, and steelhead present in the action area in displayed in Table 46.

We expect that adults and juveniles may be affected by take in the form of PTS, TTS, or behavioral changes from sound sources associated with the seismic survey. Take may have short- or long-term consequences, depending on the level of noise from airguns to which animals are exposed. No reduction in the distribution of ESA-listed Chinook, chum, sockeye, and steelhead from the Pacific Ocean is expected because of the National Science Foundation's seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization. Further, no reduction in numbers is anticipated due to the proposed actions.

Due to the lack of more definitive density data for ESA-listed salmonids in the action area we were not able to estimate the percentage of ESA-listed Chinook, chum, sockeye, and steelhead ESUs and DPSs (or the number of individuals) that could be exposed to airgun sounds from the proposed action. Instead, we relied on a surrogate to determine the estimated percentage of ESA-listed salmonid habitat to be impacted during airgun operations. As shown in Table 45, only a small percentage of habitat would be impacted by the proposed airgun activities, which we predict will not change the current level of ESA-listed salmonid population numbers shown in Table 46.

We anticipate temporary behavioral responses and/or short-term effects to reproduction, with individuals returning to normal shortly after the exposure has ended. Therefore, no permanent reduction in reproduction is expected because of the proposed actions. Because we do not anticipate a reduction in numbers or reproduction of ESA-listed salmonids as a result of the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

Table 46. Summary of estimated annual abundance of ESA-listed salmonids. Abundance estimates for each ESU and DPS are divided into natural, listed hatchery intact adipose, and listed hatchery adipose clip (NMFS 2020a)[17].

Species	Life Stage	Natural	Listed Hatchery Intact Adipose	Listed Hatchery Adipose Clip
	Adult	210	-	2232

[17] Adult abundance numbers represent the total number of spawners. These do not factor in adults in the ocean environment.

Species	Life Stage	Natural	Listed Hatchery Intact Adipose	Listed Hatchery Adipose Clip
Sacramento River winter-run Chinook	Smolt	195,354	-	200,000
Central Valley spring-run Chinook	Adult	3,727	-	2,273
	Smolt	775,474	-	2,169,329
California Coastal Chinook	Adult	7,034	-	-
	Smolt	1,278,078	-	-
Snake River fall Chinook	Adult	10,337	13,551	15,508
	Smolt	692,819	2862418	2483713
Snake River spring/summer Chinook	Adult	12,798	421	2,387
	Smolt	1,007,526	775,305	4,453,663
Lower Columbia River Chinook	Adult	29,469	38,594[1]	-
	Smolt	11,745,027	962,458	31,353,395
Upper Willamette River Chinook	Adult	10,203	31,476[1]	-
	Smolt	1,211,863	157	4,709,045
Upper Columbia River spring Chinook	Adult	2,872	3364	6,226
	Smolt	468,820	368,642	621,759
Puget Sound Chinook	Adult	22,398	15,543[1]	-
	Smolt	3,035,288	7,271,130	36,297,500
Hood Canal summer run chum	Adult	25,146	1,452	-
	Smolt	3,889,955	150,000	-
Columbia River chum	Adult	10,644	426	-
	Smolt	662,6218	601,503	200,000
Central California Coast coho	Adult	1,932	327	559
	Smolt	158,130	165,880	60,000
Southern Oregon/Northern California Coast coho	Adult	9,065	10,934	-
	Parr	2,013,593	575,000	7,287,647
Oregon Coast coho	Adult	94,320	0	-
	Parr	6,641,564	0	-
Lower Columbia River coho	Adult	29,866	8,791	-
	Smolt	661,468	249,784	-
Ozette Lake sockeye	Adult	5,036[2]	0	0
	Smolt	1,037,787	259,250	45,750
Snake River sockeye	Adult	546	-	4,004
	Smolt	19,181	-	242,610
	Adult	695	-	0

Species	Life Stage	Natural	Listed Hatchery Intact Adipose	Listed Hatchery Adipose Clip
South-Central California steelhead	Smolt	79,057	-	0
Central California Coast steelhead	Adult	2,187	-	3,866
	Smolt	248,771	-	648,891
California Central Valley steelhead	Adult	1,686	-	3,856
	Smolt	630,403	-	1,600,653
Northern California steelhead	Adult	7,221	-	-
	Smolt	821,389	-	-
Upper Columbia River steelhead	Adult	1,931	1,163	5,309
	Smolt	199,380	138,601	687,567
Snake River Basin steelhead	Adult	10,547	16,137	79,510
	Smolt	798,341	705,490	3,300,152
Lower Columbia River steelhead	Adult	12,920	22297[1]	-
	Smolt	352,146	9138	1,197,156
Upper Willamette River steelhead	Adult	2,912	-	-
	Smolt	140,396	-	-
Middle Columbia River steelhead	Adult	5,052	112	448
	Smolt	407,697	110,469	444,973
Puget Sound steelhead	Adult	19,313[2]	-	-
	Smolt	2,196,901	112,500	110,000

[1] We do not have separate estimates for fin-clipped and intact adipose fin hatchery fish for the life stage of this DPS/ESU.

[2] Includes estimates for natural and hatchery fish (intact and clipped numbers)

No reduction in the distribution of ESA-listed Chinook, chum, sockeye, and steelhead ESUs and DPSs in Pacific Ocean is expected because of the National Science Foundation's seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization. Further, no reduction in numbers is anticipated due to the proposed actions.

Recovery plans for the ESA-listed Chinook, chum, sockeye, and steelhead ESUs and DPSs present in the action area are presented in Section 8. Because no mortalities or measurable effects on the abundance, distribution, and reproduction of the ESA-listed Chinook, chum, sockeye, and steelhead ESUs and DPSs present in the action area are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization will impede the recovery objectives for these salmonids. In conclusion, we believe the non-lethal effects of take associated with the proposed actions will not jeopardize the continued existence of ESA-listed Chinook, chum, sockeye, and steelhead ESUs and DPSs present in the action area.

Conclusion

After reviewing the current status of the ESA-listed species and the effects of the proposed actions, added to the environmental baseline and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of blue whales, fin whales, Western North Pacific DPS of gray whales, North Pacific right whales, Mexico DPS of humpback whales, sei whales, sperm whales, Western DPS of Steller sea lions, leatherback sea turtles, Chinook salmon (Snake River fall-run, Snake River spring/summer-run, Lower Columbia River, Upper Willamette River, Upper Columbia River spring-run, and Puget Sound ESUs), sockeye salmon (Snake River and Ozette River ESUs) chum salmon (Hood Canal summer-run and Columbia River ESUs), and steelhead (South-Central California Coast, Central California Coast, California Central Valley, Northern California, Upper Columbia River, Snake River Basin, Lower Columbia River, Upper Willamette River, Middle Columbia River, and Puget Sound DPSs).

NMFS also concluded that the action is not likely to adversely affect the following ESA-listed species and designated critical habitat: Southern Resident killer whale (*Orcinus orca*); Guadalupe fur seal (*Arctocephalus townsendi*); East Pacific DPS of green turtle (*Chelonia mydas*); North Pacific Ocean DPS of loggerhead turtle (*Caretta caretta*); Mexico's Pacific coast breeding colonies of olive ridley turtle (*Lepidochelys olivacea*); Central California Coast ESU, Lower Columbia River ESU, Oregon Coast ESU, and Southern Oregon and Northern California Coast ESU of coho salmon (*Oncorhynchus kisutch*); California Coastal ESU, Central Valley Spring-Run ESU, and Sacramento River Winter-Run ESU of Chinook salmon; Southern DPS of Eulachon (*Thaleichthys pacificus*); Southern DPS of green sturgeon (*Acipenser medirostris*); and Steller sea lion Western DPS critical habitat.

13 Incidental Take Statement

Section 7(b)(4) of the ESA requires that when a proposed agency action is found to be consistent with section 7(a)(2) of the ESA, either as proposed by the action agency or modified by a RPA, and the proposed action may incidentally take individuals of ESA-listed species, NMFS will issue a statement that specifies the impact of any incidental taking of endangered or threatened species (incidental take statement). To minimize such impacts, NMFS provides RPMs, and terms and conditions that must be complied with by the Federal agency or any applicant in order to be exempt from the prohibitions against "take" of listed species. Only incidental take resulting from the agency actions and any specified RPMs, and terms and conditions identified in the incidental take statement are exempt from the taking prohibition of section 9(a), pursuant to section 7(o) of the ESA. NMFS believes the RPMs described below are necessary and appropriate to minimize the impacts of incidental take on threatened and endangered species. The measures described below must be undertaken by the National Science Foundation, NMFS Permits and Conservation

Division, and applicants so that they become binding conditions for the exemption in section 7(o)(2) to apply.

Section 9(a)(1) of the ESA prohibits the taking of endangered species without a specific permit or exemption. Protective regulations adopted pursuant to section 4(d) of the ESA extend the prohibition to all threatened species. 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 (50 CFR 222.102). We interpret "harass" as meaning 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 (Wieting 2016). Harm is defined by NMFS as an act which actually kills or injures fish or wildlife, and may also include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 CFR 222.102). Incidental take is defined 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(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this incidental take statement.

13.1 Amount or Extent of Take

Section 7 regulations require NMFS to specify the impact of any incidental take of endangered or threatened species; that is, the amount or extent, of such incidental taking on the species (50 C.F.R. §402.14(i)(1)(i)). The amount of take represents the number of individuals that are expected to be taken by actions while the extent of take specifies the impact, i.e., the amount or extent, of such incidental taking on the species and may be used if we cannot assign numerical limits of animals that could be incidentally taken during the course of an action (see 80 FR 26832).

If the amount or location of tracklines during the seismic survey changes, or the number of seismic survey days is increased, then incidental take exempted in this opinion for marine mammals, sea turtles, and fishes may be exceeded. As such, if more tracklines are conducted during the seismic survey, an increase in the number of days beyond the 25 percent contingency, greater estimates of sound propagation, and/or increases in airgun array source levels occur, reinitiation of consultation may be necessary (see Reinitiation of Consultation section 15).

As discussed previously, we have jurisdiction to authorize incidental take of ESA-listed species in areas outside the territorial seas of Canada (i.e., greater than 12 nautical miles). Earlier, we examined the probable exposure of ESA-listed species in the full extent of the action area (Section 10) to make our jeopardy determination. Here, we describe the amount of incidental take authorized for the action area outside the territorial seas of Canada.

13.1.1 Marine Mammals

NMFS ESA Interagency Cooperation Division and NMFS Permits and Conservation Division anticipate the proposed seismic survey in the Northeast Pacific Ocean is likely to result in the incidental take of ESA-listed marine mammals by harassment and harm (Table 47). Behavioral harassment is expected to occur at received levels at or above 160 dB re: 1 μPa (rms) for ESA-listed marine mammals. For all species of ESA-listed marine mammals expected to experience adverse effects, this incidental take will result from exposure to acoustic energy during airgun array operations and is not expected to result in the death or injury of any individuals that will be exposed. It is believed that any harm or PTS incurred in these marine mammals as a result of the proposed seismic survey activities will be in the form of only a small degree of PTS, not total deafness, and will be unlikely to affect the fitness of any individuals, other than temporarily, because of the constant movement of both the R/V *Langseth* and of the marine mammals in the action area (i.e., the duration of exposure to loud sounds will be relatively short). Also, we expect that marine mammals will likely move away from a sound source that represents an aversive stimulus, especially at levels that will be expected to result in PTS, and because the relatively low speed of the R/V *Langseth*'s approach will allow enough time for marine mammals to detect the ship's approach and move away during an active seismic survey.

Table 47. Estimated amount of incidental take of Endangered Species Act-listed marine mammals exempted in the Northeast Pacific Ocean by the incidental take statement.[18]

Species	Incidental Take by Harassment (Potential Temporary Threshold Shift and Behavioral)	Authorized Incidental Take by Harm (Permanent Threshold Shift)
Blue Whale	31	1
Fin Whale	873	44
Gray Whale – Western North Pacific DPS	2	0
North Pacific Right Whale	1	0
Humpback Whale – Mexico DPS	15	0
Sei Whale	34	1
Sperm Whale	131	0

[18] This table does not include estimated exposures in Canadian territorial seas, as NMFS does not have jurisdiction to authorize take under the ESA in another nation's territorial seas. See Section 4.

Steller Sea Lion – Western DPS	54	0

DPS=Distinct Population Segment

13.1.2 Sea Turtles

We also expect leatherback turtles will be exposed to sounds from the airgun arrays during the course of the proposed seismic survey that will elicit a behavioral response constituting harassment. A behavioral response that will constitute ESA harassment is expected to occur at received levels at or above 175 dB re: 1 µPa (rms) for three leatherback sea turtles. No death or injury is expected for any individual sea turtle exposed to seismic survey activities.

13.1.3 Salmonids

We expect individual ESA-listed fishes will be exposed to sounds from the airgun array during the course of the proposed seismic survey that will elicit injury or TTS constituting harm and harassment under the ESA. No death is expected for any individual ESA-listed fish exposed to seismic survey activities.

Because we were not able to numerically estimate the amount of salmonid exposure, we are relying on the extent of the zones where sound levels surpass the thresholds for TTS and injury of ESA-listed salmonids (Table 44) as a surrogate for salmonid take. Injury for ESA-listed salmonids is expected at received levels of 187 SEL_{cum}, which includes a 32.4 square kilometer area in the eastern Pacific based upon the propagation and trackline estimates provided by the National Science Foundation. Injury for ESA-listed salmonids is expected at received levels of 206 SPL_{peak}, which includes a 0.17 square kilometer area in the eastern Pacific based upon the propagation and trackline estimates provided by the National Science Foundation. Although we cannot estimate the amount of take of individual fishes, we can estimate the extent of habitat affected by the airgun array, which is used as a proxy for the take of ESA-listed salmonids. The percentage of habitat surpassing the thresholds for TTS and injury of ESA-listed salmonids are presented in Table 45.

13.2 Reasonable and Prudent Measures

RPMs are measures to minimize the amount or extent of incidental take (50 C.F.R. §402.02). Only incidental take resulting from the agency actions and any specified RPMs, and terms and conditions identified in the incidental take statement are exempt from the taking prohibition of section 9(a), pursuant to section 7(o) of the ESA.

NMFS believes the RPMs described below are necessary and appropriate to minimize the impacts of incidental take on threatened and endangered species:

- The NMFS Permits and Conservation Division must ensure that the National Science Foundation and Lamont-Doherty Earth Observatory implement a program to mitigate and report the potential effects of seismic survey activities as well as the effectiveness of mitigation measures incorporated as part of the proposed IHA for the incidental taking of blue, fin, gray (Western North Pacific DPS), humpback (Mexico DPS), North Pacific right, sei, and sperm whales, and Steller sea lions (Western DPS) pursuant to section 101(a)(5)(D) of the MMPA and as specified below for leatherback turtles and fishes (i.e., the monitoring requirements). In addition, the NMFS Permits and Conservation Division must ensure that the provisions of the IHA are carried out, and inform the NMFS ESA Interagency Cooperation Division if take is exceeded.

- The NMFS Permits and Conservation Division must ensure that the National Science Foundation and Lamont-Doherty Earth Observatory implement a program to monitor and report any potential interactions between seismic survey activities and threatened and endangered species of marine mammals.
- The National Science Foundation must implement a program to mitigate and report the potential effects of seismic survey activities as well as the effectiveness of mitigation measures for endangered and threatened leatherback sea turtles and fishes.

13.3 Terms and Conditions

In order for any incidental take to be exempt from the prohibitions of section 9 of the ESA, the National Science foundation and NMFS Permits and Conservation Division must comply with the following terms and conditions, which implement the RPMs described above. These include the take minimization, monitoring and reporting measures required by the section 7 regulations (50 C.F.R. §402.14(i)). If the National Science Foundation and NMFS Permits and Conservation Division fail to ensure compliance with the applicable terms and conditions to implement the RPMs, the protective coverage of section 7(o)(2) may lapse.

To implement each of the RPMs noted above, the National Science Foundation, and the NMFS Permits and Conservation Division shall implement the following terms and conditions.

1. A copy of the draft comprehensive report on all seismic survey activities and monitoring results of ESA-listed marine mammals, sea turtles, and fishes must be provided to the ESA Interagency Cooperation Division within 90 days of the completion of the seismic survey, or expiration of the IHA, whichever comes sooner.
2. Any reports of injured or dead ESA-listed species must be provided to the ESA Interagency Cooperation Division within 24 hours to Cathy Tortorici, Chief, ESA Interagency Cooperation Division by email at cathy.tortorici@noaa.gov.

14 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. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on ESA-listed species or critical habitat, to help implement recovery plans or develop information (50 C.F.R. §402.02).

We recommend the following conservation recommendations, which will provide information for future consultations involving seismic surveys and the issuance of IHAs that may affect ESA-listed species, and which are consistent with the National Science Foundation and NMFS Permits and Conservation Division's ESA section 7(a)(1) obligation:

1. We recommend that the National Science Foundation promote and fund research examining the potential effects of seismic surveys on ESA-listed sea turtle and fish.
2. We recommend that the National Science Foundation develop a more robust propagation model that incorporates environmental variables into estimates of how far sound levels reach from airgun arrays.
3. We recommend that the National Science Foundation seek information and high quality data to refine current models, and/or use other relevant models, of potential impacts to ESA-listed species from seismic surveys and validate assumptions used in effects analyses.
4. We recommend that the National Science Foundation conduct sound source verification in study areas (and future locations) to validate predicted and modeled isopleth distances to ESA harm and harassment thresholds. These results can be used to improve estimates of received sound levels and guide subsequent needs for mitigation for future seismic survey activities.
5. We recommend that the NMFS Permits and Conservation Division develop a flow chart with decision points for mitigation and monitoring measures to be included in future IHAs for seismic surveys.
6. We recommend the National Science Foundation use (and NMFS Permits and Conservation require in MMPA incidental take authorizations and IHAs) thermal imaging cameras, in addition to binoculars and the naked eye, for use during daytime and nighttime visual observations and test their effectiveness at detecting threatened and endangered species versus the binocular and naked eye methods.
7. We recommend the National Science Foundation use the Marine Mammal Commission's recommended method for estimating the number of cetaceans in the vicinity of seismic surveys based on the number of groups detected for post-seismic survey activities take analysis and use in monitoring reports.
8. We recommend the National Science Foundation and NMFS Permits and Conservation Division collaborate to make the data collected as part of the required monitoring and reporting available to the public and scientific community in an easily accessible online database that can be queried to aggregate data across PSO reports. Access to such data, which may include sightings as well as responses to seismic survey activities, will not only aid in understanding the biology of ESA-listed species (e.g., their range), it will inform future consultations and incidental take authorizations/permits by providing information on the effectiveness of the conservation measures and the impact of seismic survey activities on ESA-listed species.

9. We recommend the National Science Foundation utilize real-time cetacean sighting services such as the WhaleAlert application (http://www.whalealert.org/). We recognize that the research vessel may not have reliable internet access during operations far offshore and in remote locations, but access may be better in some nearshore locations where many of the cetaceans considered in this opinion are likely found in greater numbers. Monitoring such systems will help plan seismic survey activities and transits to avoid locations with recent ESA-listed cetacean sightings, and may also be valuable for alerting others of ESA-listed cetaceans in the area to aid avoidance.
10. We recommend the National Science Foundation submit their monitoring data (i.e., visual sightings) from PSOs to the Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations online database (http://seamap.env.duke.edu/) so that it can be added to the aggregate global marine mammal, seabird, sea turtle, and fish observation data.
11. We recommend the National Science Foundation notify NMFS Permits and Conservation Division of any sightings of North Pacific right whales and provide sighting information within 48 hours.
12. We recommend the vessel operator and other relevant vessel personnel (e.g., crew members) on the *Langseth* take the U.S. Navy's marine species awareness training available online at: https://www.youtube.com/watch?v=KKo3r1yVBBA in order to detect ESA-listed species to aid avoidance and relay information to PSOs.

In order for NMFS Endangered Species Act Interagency Cooperation Division to be kept informed of actions minimizing or avoiding adverse effects on, or benefiting, ESA-listed species or their critical habitat, the National Science Foundation and the NMFS Permits and Conservation Division should notify the NMFS Endangered Species Act Interagency Cooperation Division of any conservation recommendations they implement in their final action.

15 Reinitiation of Consultation

This concludes formal consultation for the National Science Foundation's proposed high-energy marine seismic survey by the R/V *Marcus G. Langseth* of the Queen Charlotte Fault in the Northeast Pacific and NMFS Permits and Conservation Division's issuance of an IHA for the proposed high-energy marine seismic survey pursuant to section 101(a)(5)(D) of the MMPA. Consistent with 50 C.F.R. §402.16, reinitiation of formal 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:

1. The amount or extent of taking specified in the incidental take statement is exceeded.
2. New information reveals effects of the agency action that may affect ESA-listed species or critical habitat in a manner or to an extent not previously considered.
3. The identified action is subsequently modified in a manner that causes an effect to ESA-listed species or designated critical habitat that was not considered in this opinion.

4. A new species is listed or critical habitat designated under the ESA that may be affected by the action.

If the amount of tracklines, location of tracklines, acoustic characteristics of the airgun arrays, timing of the survey, or any other aspect of the proposed action changes in such a way that the incidental take of ESA-listed species can be greater than estimated in the incidental take statement of this opinion, then one or more of the reinitiation triggers above may be met and reinitiation of consultation may be necessary.

16 References

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17 APPENDICES

17.1 Appendix A- Proposed Incidental Harassment Authorization

INCIDENTAL HARASSMENT AUTHORIZATION

The Lamont-Doherty Earth Observatory of Columbia University (L-DEO) is hereby authorized under section 101(a)(5)(D) of the Marine Mammal Protection Act (MMPA; 16 U.S.C. 1371(a)(5)(D)) to incidentally harass marine mammals, under the following conditions.

1. This Incidental Harassment Authorization (IHA) is valid for one year from the date of issuance.

2. This IHA authorizes take incidental to geophysical survey activity in the northeast Pacific Ocean, as specified in L-DEO's IHA application.

3. General Conditions

    (a) A copy of this IHA must be in the possession of L-DEO, the vessel operator, the lead protected species observer (PSO) and any other relevant designees of L-DEO operating under the authority of this IHA.

    (b) The species authorized for taking are listed in Table 1. The taking, by Level A and Level B harassment only, is limited to the species and numbers listed in Table 1.

    (c) The taking by serious injury or death of any of the species listed in Table 1 or any taking of any other species of marine mammal is prohibited and may result in the modification, suspension, or revocation of this IHA. Any taking exceeding the authorized amounts listed in Table 1 is prohibited and may result in the modification, suspension, or revocation of this IHA.

    (d) During use of the acoustic source, if any marine mammal species that are not listed in Table 1, or a species for which authorization has been granted but the takes have been met, appears within or enters the Level B harassment zone (Table 3) the acoustic source must be shut down.

    (e) L-DEO must ensure that relevant vessel personnel and PSO team participate in a joint onboard briefing led by the vessel operator and lead PSO to ensure that responsibilities, communication procedures, protected species monitoring protocols, operational procedures, and IHA requirements are clearly understood.

4. Mitigation Requirements

    (a) L-DEO must use independent, dedicated, trained visual and acoustic PSOs, meaning that the PSOs must be employed by a third-party observer provider, must not have tasks other than to conduct observational effort, collect data, and communicate with and instruct relevant vessel crew with regard to the presence of protected species and mitigation requirements (including brief alerts regarding maritime hazards), and must have successfully completed an approved PSO training course appropriate for their designated task (visual or acoustic). Individual PSOs may perform acoustic and visual PSO duties (though not at the same time).

(b) At least one visual and two acoustic PSOs must have a minimum of 90 days at-sea experience working in those roles, respectively, during a deep penetration seismic survey, with no more than 18 months elapsed since the conclusion of the at-sea experience

(c) Visual Observation

(i) During survey operations (e.g., any day on which use of the acoustic source is planned to occur, and whenever the acoustic source is in the water, whether activated or not), a minimum of two PSOs must be on duty and conducting visual observations at all times during daylight hours (i.e., from 30 minutes prior to sunrise through 30 minutes following sunset) and 30 minutes prior to and during ramp-up of the airgun array. Visual monitoring of the exclusion and buffer zones must begin no less than 30 minutes prior to ramp-up and must continue until one hour after use of the acoustic source ceases or until 30 minutes past sunset.

(ii) Visual PSOs must coordinate to ensure 360° visual coverage around the vessel from the most appropriate observation posts, and must conduct visual observations using binoculars and the naked eye while free from distractions and in a consistent, systematic, and diligent manner. Estimated harassment zones are provided in Tables 2-3 for reference.

(iii) Visual PSOs must immediately communicate all observations to the acoustic PSO(s) on duty, including any determination by the PSO regarding species identification, distance, and bearing and the degree of confidence in the determination.

(iv) During good conditions (e.g., daylight hours; Beaufort sea state (BSS) 3 or less), visual PSOs must conduct observations when the acoustic source is not operating for comparison of sighting rates and behavior with and without use of the acoustic source and between acquisition periods, to the maximum extent practicable.

(v) Visual PSOs may be on watch for a maximum of four consecutive hours followed by a break of at least one hour between watches and may conduct a maximum of 12 hours of observation per 24-hour period.

Combined observational duties (visual and acoustic but not at same time) may not exceed 12 hours per 24-hour period for any individual PSO.

(d) Acoustic Monitoring

(i) The source vessel must use a towed passive acoustic monitoring system (PAM) which must be monitored by, at a minimum, one on-duty acoustic PSO beginning at least 30 minutes prior to ramp-up and at all times during use of the acoustic source.

(ii) When both visual and acoustic PSOs are on duty, all detections must be immediately communicated to the remainder of the on-duty PSO team for potential verification of visual observations by the acoustic PSO or of acoustic detections by visual PSOs.

(iii) Acoustic PSOs may be on watch for a maximum of four consecutive hours followed by a break of at least one hour between watches and may conduct a maximum of 12 hours of observation per 24-hour period. Combined observational duties may not exceed 12 hours per 24-hour period for any individual PSO.

(iv) Survey activity may continue for 30 minutes when the PAM system malfunctions or is damaged, while the PAM operator diagnoses the issue. If the diagnosis indicates that the PAM system must be repaired to solve the problem, operations may continue for an additional five hours without acoustic monitoring during daylight hours only under the following conditions:

a. Sea state is less than or equal to BSS 4;

b. With the exception of delphinids, no marine mammals detected solely by PAM in the applicable exclusion zone in the previous two hours;

c. NMFS is notified via email as soon as practicable with the time and location in which operations began occurring without an active PAM system; and

d. Operations with an active acoustic source, but without an operating PAM system, do not exceed a cumulative total of five hours in any 24-hour period.

(e) Exclusion zone and buffer zone

(i) Except as provided below in 4(e)(ii), the PSOs must establish and monitor a 500-m exclusion zone and additional 500-m buffer zone (total 1,000 m). The 1,000-m zone shall serve to focus observational effort but not limit such effort; observations of marine mammals beyond this distance shall also be recorded as described in 5(d) below and/or trigger shut down as described in 4(g)(iv) below, as appropriate. The exclusion zone encompasses the area at and below the sea surface out to a radius of 500 m from the edges of the airgun array (rather than being based on the center of the array or around the vessel itself) (0–500 m). The buffer zone encompasses the area at and below the sea surface from the edge of the exclusion zone, out to a radius of 1,000 meters from the edges of the airgun array (500–1,000 m). During use of the acoustic source, occurrence of marine mammals within the buffer zone (but outside the exclusion zone) must be communicated to the operator to prepare for the potential shut down of the acoustic source. PSOs must monitor the exclusion zone and buffer zone for a minimum of 30 minutes prior to ramp-up (i.e., pre-start clearance).

(ii) An extended 1,500-m exclusion zone must be established for all beaked whales. No buffer zone is required.

(f) Pre-start clearance and Ramp-up

(i) A ramp-up procedure must be followed at all times as part of the activation of the acoustic source, except as described under 4(f)(vi).

(ii) Ramp-up must not be initiated if any marine mammal is within the exclusion or buffer zone. If a marine mammal is observed within the exclusion zone or the buffer zone during the 30 minute pre-start clearance period, ramp-up may not begin until the animal(s) has been observed exiting the zone or until an additional time period has elapsed with no further sightings (15 minutes for small odontocetes and pinnipeds, and 30 minutes for mysticetes and all other odontocetes, including sperm whales, beaked whales, killer whales, and Risso's dolphins).

(iii) Ramp-up must begin by activating a single airgun of the smallest volume in the array and must continue in stages by doubling the number of active elements at the commencement of each stage, with each stage of approximately the same duration. Duration must not be less than 20 minutes.

(iv) PSOs must monitor the exclusion and buffer zones during ramp-up, and ramp-up must cease and the source must be shut down upon visual observation or acoustic detection of a marine mammal within the exclusion zone. Once ramp-up has begun, observations of marine mammals within the buffer zone do not require shut down, but such observation must be communicated to the operator to prepare for the potential shut down.

(v) Ramp-up may occur at times of poor visibility, including nighttime, if appropriate acoustic monitoring has occurred with no detections in the 30 minutes prior to beginning ramp-up.

(vi) If the acoustic source is shut down for brief periods (i.e., less than 30 minutes) for reasons other than that described for shut down (e.g., mechanical difficulty), it may be activated again without ramp-up if PSOs have maintained constant visual and/or acoustic observation and no visual or acoustic detections of marine mammals have occurred within the applicable exclusion zone. For any longer shut down, pre-start clearance observation and ramp-up are required. For any shut down at night or in periods of poor visibility (e.g., BSS 4 or greater), ramp-up is required, but if the shut down period was brief and constant observation was maintained, pre-start clearance watch is not required.

(vii) Testing of the acoustic source involving all elements requires ramp-up. Testing limited to individual source elements or strings does not require ramp-up but does require pre-start clearance watch.

(g) Shut down

(i) Any PSO on duty has the authority to delay the start of survey operations or to call for shut down of the acoustic source.

(ii) The operator must establish and maintain clear lines of communication directly between PSOs on duty and crew controlling the acoustic source to ensure that shut down commands are conveyed swiftly while allowing PSOs to maintain watch.

(iii) When the airgun array is active (i.e., anytime one or more airguns is active, including during ramp-up) and (1) a marine mammal (excluding delphinids of the species described in 4(g)(v)) appears within or enters the exclusion zone and/or (2) a marine mammal is detected acoustically and localized within the exclusion zone, the acoustic source must be shut down. When shut down is called for by a PSO, the airgun array must be immediately deactivated. Any dispute regarding a PSO shut down must be resolved after deactivation.

(iv) The airgun array must be shut down if any of the following are detected at any distance:

1. North Pacific right whale.

2. Large whale (defined as a sperm whale or any mysticete species) with a calf (defined as an animal less than two-thirds the body size of an adult observed to be in close association with an adult).

3. Aggregation of six or more large whales.

(v) The shut down requirement shall be waived for Pacific white-sided dolphins and northern right whale dolphins.

a. If a Pacific white-sided dolphin or northern right whale dolphin is visually and/or acoustically detected and localized within the exclusion zone, no shut down is required unless the acoustic PSO or a visual PSO confirms the individual to be of a species other than those listed above, in which case a shut down is required.

b. If there is uncertainty regarding identification, visual PSOs may use best professional judgment in making the decision to call for a shut down.

(vi) Upon implementation of shut down, the source may be reactivated after the marine mammal(s) has been observed exiting the applicable exclusion zone (i.e., animal is not required to fully exit the buffer zone where applicable) or following a clearance period (15 minutes for small odontocetes and pinnipeds, and 30 minutes for mysticetes and all other odontocetes, including sperm whales, beaked whales, killer whales, and Risso's dolphins) with no further observation of the marine mammal(s).

(h) Vessel strike avoidance:

(i) Vessel operator and crew must maintain a vigilant watch for all marine mammals and slow down, stop their vessel, or alter course, as appropriate and regardless of vessel size, to avoid striking any marine mammals. A visual observer aboard the vessel must monitor a vessel strike avoidance zone around the vessel (distances stated below). Visual observers monitoring the vessel strike avoidance zone may be third-party observers (i.e., PSOs) or crew members, but crew members responsible for these duties must be provided sufficient training to 1) distinguish marine mammals from other phenomena and 2) broadly to identify a marine mammal as a right whale, other whale (defined in this context as sperm whales or baleen whales other than right whales), or other marine mammal.

(ii) Vessel speeds must be reduced to 10 knots or less when mother/calf pairs, pods, or large assemblages of cetaceans are observed near a vessel.

(iii) The vessel must maintain a minimum separation distance of 500 m from right whales. If a whale is observed but cannot be confirmed as a species other than a right whale, the vessel operator must assume that it is a right whale and take appropriate action.

(iv) The vessel must maintain a minimum separation distance of 100 m from sperm whales and all other baleen whales.

(v) The vessel must, to the maximum extent practicable, attempt to maintain a minimum separation distance of 50 m from all other marine mammals, with an understanding that at times this may not be possible (e.g., for animals that approach the vessel).

(vi) When marine mammals are sighted while a vessel is underway, the vessel shall take action as necessary to avoid violating the relevant separation distance (e.g., attempt to remain parallel to the animal's course, avoid excessive speed or abrupt changes in direction until the animal has left the area). If marine mammals are sighted within the relevant separation distance, the vessel must reduce speed and shift the engine to neutral, not engaging the engines until animals are clear of the area. This does not apply to any vessel towing gear or any vessel that is navigationally constrained.

(vii) These requirements do not apply in any case where compliance would create an imminent and serious threat to a person or vessel or to the extent that a vessel is restricted in its ability to maneuver and, because of the restriction, cannot comply.

5. Monitoring Requirements

(a) The operator must provide PSOs with bigeye binoculars (e.g., 25 x 150; 2.7 view angle; individual ocular focus; height control) of appropriate quality solely for PSO use. These must be pedestal-mounted on the deck at the most appropriate vantage point that provides for optimal sea surface observation, PSO safety, and safe operation of the vessel.

(b) The operator must work with the selected third-party observer provider to ensure PSOs have all equipment (including backup equipment) needed to adequately perform necessary tasks, including accurate determination of distance and bearing to observed marine mammals. Such equipment, at a minimum, must include:

(i) PAM must include a system that has been verified and tested by an experienced acoustic PSO that will be using it during the trip for which monitoring is required.

(ii) Reticle binoculars (e.g., 7 x 50) of appropriate quality (at least one per PSO, plus backups).

(iii) Global Positioning Unit (GPS) (plus backup).

(iv) Digital single-lens reflex cameras of appropriate quality that capture photographs and video (plus backup).

(v) Compass (plus backup).

(vi) Radios for communication among vessel crew and PSOs (at least one per PSO, plus backups).

(vii) Any other tools necessary to adequately perform necessary PSO tasks.

(c) Protected Species Observers (PSOs, Visual and Acoustic) Qualifications

(i) PSOs must have successfully completed an acceptable PSO training course appropriate for their designated task (visual or acoustic). Acoustic PSOs are required to complete specialized training for operating PAM systems and are encouraged to have familiarity with the vessel with which they will be working.

(ii) NMFS must review and approve PSO resumes.

(iii) NMFS shall have one week to approve PSOs from the time that the necessary information is submitted, after which PSOs meeting the minimum requirements shall automatically be considered approved.

(iv) One visual PSO with experience as shown in 4(b) shall be designated as the lead for the entire protected species observation team. The lead must coordinate duty schedules and roles for the PSO team and serve as primary point of contact for the vessel operator. (Note that the responsibility of coordinating duty schedules and roles may instead be assigned to a shore-based, third-party monitoring coordinator.) To the maximum extent practicable, the lead PSO must devise the duty schedule such that experienced PSOs are on duty with those PSOs with appropriate training but who have not yet gained relevant experience.

(v) PSOs must successfully complete relevant training, including completion of all required coursework and passing (80 percent or greater) a written and/or oral examination developed for the training program.

(vi) PSOs must have successfully attained a bachelor's degree from an accredited college or university with a major in one of the natural sciences, a minimum of 30 semester hours or equivalent in the biological sciences, and at least one undergraduate course in math or statistics.

(vii) The educational requirements may be waived if the PSO has acquired the relevant skills through alternate experience. Requests for such a waiver must be submitted to NMFS and must include written justification. Requests must be granted or denied (with justification) by NMFS within one week of receipt of submitted information. Alternate experience that may be considered includes, but is not limited to (1) secondary education and/or experience comparable to PSO duties; (2) previous work experience conducting academic, commercial, or government-sponsored protected species surveys; or (3) previous work experience as a PSO; the PSO should demonstrate good standing and consistently good performance of PSO duties.

(d) Data Collection

(i) PSOs must use standardized data collection forms, whether hard copy or electronic. PSOs must record detailed information about any implementation of mitigation requirements, including the distance of animals to the acoustic source and description of specific actions that ensued, the behavior of the animal(s), any observed changes in behavior before and after implementation of mitigation, and if shut down was implemented, the length of time before any subsequent ramp-up of the acoustic source. If required mitigation was not implemented, PSOs should record a description of the circumstances.

(ii) At a minimum, the following information must be recorded:

a. Vessel name and call sign;

b. PSO names and affiliations;

c. Date and participants of PSO briefings (as discussed in General Requirement);

d. Dates of departures and returns to port with port name;

e. Dates and times (Greenwich Mean Time) of survey effort and times corresponding with PSO effort;

f. Vessel location (latitude/longitude) when survey effort began and ended and vessel location at beginning and end of visual PSO duty shifts;

g. Vessel heading and speed at beginning and end of visual PSO duty shifts and upon any line change;

h. Environmental conditions while on visual survey (at beginning and end of PSO shift and whenever conditions changed significantly), including BSS and any other relevant weather conditions including cloud cover, fog, sun glare, and overall visibility to the horizon;

i. Factors that may have contributed to impaired observations during each PSO shift change or as needed as environmental conditions changed (e.g., vessel traffic, equipment malfunctions); and

j. Survey activity information, such as acoustic source power output while in operation, number and volume of airguns operating in the array, tow depth of the array, and any other notes of significance (i.e., pre-start clearance, ramp-up, shut down, testing, shooting, ramp-up completion, end of operations, streamers, etc.).

(iii) Upon visual observation of any marine mammal, the following information must be recorded:

a. Watch status (sighting made by PSO on/off effort, opportunistic, crew, alternate vessel/platform);

b. PSO who sighted the animal;

c. Time of sighting;

d. Vessel location at time of sighting;

e. Water depth;

f. Direction of vessel's travel (compass direction);

g. Direction of animal's travel relative to the vessel;

h. Pace of the animal;

i. Estimated distance to the animal and its heading relative to vessel at initial sighting;

j. Identification of the animal (e.g., genus/species, lowest possible taxonomic level, or unidentified) and the composition of the group if there is a mix of species;

k. Estimated number of animals (high/low/best);

l. Estimated number of animals by cohort (adults, yearlings, juveniles, calves, group composition, etc.);

m. Description (as many distinguishing features as possible of each individual seen, including length, shape, color, pattern, scars or markings, shape and size of dorsal fin, shape of head, and blow characteristics);

n. Detailed behavior observations (e.g., number of blows/breaths, number of surfaces, breaching, spyhopping, diving, feeding, traveling; as explicit and detailed as possible; note any observed changes in behavior);

o. Animal's closest point of approach (CPA) and/or closest distance from any element of the acoustic source;

p. Platform activity at time of sighting (e.g., deploying, recovering, testing, shooting, data acquisition, other); and

q. Description of any actions implemented in response to the sighting (e.g., delays, shut down, ramp-up) and time and location of the action.

(iv) If a marine mammal is detected while using the PAM system, the following information must be recorded:

a. An acoustic encounter identification number, and whether the detection was linked with a visual sighting;

b. Date and time when first and last heard;

c. Types and nature of sounds heard (e.g., clicks, whistles, creaks, burst pulses, continuous, sporadic, strength of signal);

d. Any additional information recorded such as water depth of the hydrophone array, bearing of the animal to the vessel (if determinable), species or taxonomic group (if determinable), spectrogram screenshot, and any other notable information.

6. Reporting

(a) L-DEO must submit a draft comprehensive report to NMFS on all activities and monitoring results within 90 days of the completion of the survey or expiration of the IHA, whichever comes sooner. A final report must be submitted within 30 days following resolution of any comments on the draft report. The draft report must include the following:

(i) Summary of all activities conducted and sightings of marine mammals near the activities;

(ii) Summary of all data required to be collected (see 5(d));

(iii) Full documentation of methods, results, and interpretation pertaining to all monitoring;

(iii) Summary of dates and locations of survey operations (including (1) the number of days on which the airgun array was active and (2) the percentage of time and total time the array was active during daylight vs. nighttime hours (including dawn and dusk)) and all marine mammal sightings (dates, times, locations, activities, associated survey activities);

(iv) Geo-referenced time-stamped vessel tracklines for all time periods during which airguns were operating. Tracklines should include points recording any change in airgun status (e.g., when the airguns began operating, when they were turned off, or when they changed from full array to single gun or vice versa);

(v) GIS files in ESRI shapefile format and UTC date and time, latitude in decimal degrees, and longitude in decimal degrees. All coordinates must be referenced to the WGS84 geographic coordinate system; and

(vi) Raw observational data.

(b) Reporting Injured or Dead Marine Mammals

(i) Discovery of Injured or Dead Marine Mammal – In the event that personnel involved in the survey activities covered by the authorization discover an injured or dead marine mammal, L-DEO must report the incident to the Office of Protected Resources (OPR), NMFS and the NMFS Alaska Regional Stranding Coordinator as soon as feasible. The report must include the following information:

a. Time, date, and location (latitude/longitude) of the first discovery (and updated location information if known and applicable);

b. Species identification (if known) or description of the animal(s) involved;

c. Condition of the animal(s) (including carcass condition if the animal is dead);

d. Observed behaviors of the animal(s), if alive;

e. If available, photographs or video footage of the animal(s); and

f. General circumstances under which the animal was discovered.

(ii) Vessel Strike – In the event of a ship strike of a marine mammal by any vessel involved in the activities covered by the authorization, L-DEO must report the incident to OPR, NMFS and to the Alaska Regional Stranding Coordinator as soon as feasible. The report must include the following information:

a. Time, date, and location (latitude/longitude) of the incident;

b. Species identification (if known) or description of the animal(s) involved;

c. Vessel's speed during and leading up to the incident;

d. Vessel's course/heading and what operations were being conducted (if applicable);

e. Status of all sound sources in use;

f. Description of avoidance measures/requirements that were in place at the time of the strike and what additional measures were taken, if any, to avoid strike;

g. Environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover, visibility) immediately preceding the strike;

h. Estimated size and length of animal that was struck;

i. Description of the behavior of the marine mammal immediately preceding and following the strike;

j. If available, description of the presence and behavior of any other marine mammals immediately preceding the strike;

k. Estimated fate of the animal (e.g., dead, injured but alive, injured and moving, blood or tissue observed in the water, status unknown, disappeared); and

l. To the extent practicable, photographs or video footage of the animal(s).

7. Actions to minimize additional harm to live-stranded (or milling) marine mammals – In the event of a live stranding (or near-shore atypical milling) event within 50 km of the survey operations, where the NMFS stranding network is engaged in herding or other interventions to return animals to the water, the Director of OPR, NMFS (or designee) will advise L-DEO of the need to implement shut down procedures for all active acoustic sources operating within 50 km of the stranding. Shut down procedures for live stranding or milling marine mammals include the following:

(a) If at any time, the marine mammal(s) die or are euthanized, or if herding/intervention efforts are stopped, the Director of OPR, NMFS (or designee) will advise L-DEO that the shut down around the animals' location is no longer needed.

(b) Otherwise, shut down procedures will remain in effect until the Director of OPR, NMFS (or designee) determines and advises L-DEO that all live animals involved have left the area (either of their own volition or following an intervention).

(c) If further observations of the marine mammals indicate the potential for re-stranding, additional coordination with L-DEO will be required to determine what measures are necessary to minimize that likelihood (*e.g.*, extending the shut down or moving operations farther away) and to implement those measures as appropriate.

(d) Additional information requests – If NMFS determines that the circumstances of any marine mammal stranding found in the vicinity of the activity suggest investigation of the association with survey activities is warranted, and an investigation into the stranding is being pursued, NMFS will submit a written request to L-DEO indicating that the following initial available information must be provided as soon as possible, but no later than 7 business days after the request for information.

(i) Status of all sound source use in the 48 hours preceding the estimated time of stranding and within 50 km of the discovery/notification of the stranding by NMFS; and

(ii) If available, description of the behavior of any marine mammal(s) observed preceding (*i.e.*, within 48 hours and 50 km) and immediately after the discovery of the stranding.

In the event that the investigation is still inconclusive, the investigation of the association of the survey activities is still warranted, and the investigation is still being pursued, NMFS may provide additional information requests, in writing, regarding the nature and location of survey operations prior to the time period above.

8. This Authorization may be modified, suspended or revoked if the holder fails to abide by the conditions prescribed herein (including, but not limited to, failure to comply with monitoring or reporting requirements), or if NMFS determines: (1) the authorized taking is likely to have or is having more than a negligible impact on the species or stocks of affected marine mammals, (2) the authorized taking is likely to have or is having an unmitigable adverse impact on the availability of the affected species or stocks for subsistence uses, or (3) the prescribed measures are likely not or are not effecting the least practicable adverse impact on the affected species or stocks and their habitat.

9. Renewals – On a case-by-case basis, NMFS may issue a one-time, one-year Renewal IHA following notice to the public providing an additional 15 days for public comments when (1) up to another year of identical, or nearly identical, activities as described in the Specified Activities section of this notice is planned or (2) the activities as described in the Specified Activities section of this notice would not be completed by the time the IHA expires and a Renewal would allow for completion of the activities beyond that described in the Dates and Duration section of this notice, provided all of the following conditions are met:

(a) A request for renewal is received no later than 60 days prior to the needed Renewal IHA effective date (recognizing that the Renewal IHA expiration date cannot extend beyond one year from expiration of the initial IHA).

(b) The request for renewal must include the following:

(i) An explanation that the activities to be conducted under the requested Renewal IHA are identical to the activities analyzed under the initial IHA, are a subset of the activities, or include changes so minor (e.g., reduction in pile size) that the changes do not affect the previous analyses, mitigation and monitoring requirements, or take estimates (with the exception of reducing the type or amount of take).

(ii) A preliminary monitoring report showing the results of the required monitoring to date and an explanation showing that the monitoring results do not indicate impacts of a scale or nature not previously analyzed or authorized.

(c) Upon review of the request for Renewal, the status of the affected species or stocks, and any other pertinent information, NMFS determines that there are no more than minor changes in the activities, the mitigation and monitoring measures will remain the same and appropriate, and the findings in the initial IHA remain valid.

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Catherine Marzin,

Acting Director, Office of Protected Resources,

National Marine Fisheries Service.

Table 1. Numbers of Incidental Take of Marine Mammals Authorized.

Species	Authorized Take	
	Level B	Level A
Humpback whale	403	14
Blue whale	31	1
Fin whale	873	44
Sei whale	34	1
Minke whale	57	2
Gray whale (ENP)	1,448	45
Gray whale (WNP)	2	0
Sperm whale	131	0
Baird's beaked whale	29	0
Cuvier’s beaked whale	114	0
Stejneger’s beaked whale	120	0
Pacific white-sided dolphin	1,374	0
Northern right-whale dolphin	927	0
Risso’s dolphin	22	0
Killer whale	290	0
Dall's porpoise	5,661	178
Harbor porpoise	990	26
Northern fur seal	5,812	0
California sea lion	1,258	0
Steller sea lion (eDPS)	2,381	0
Steller sea lion (wDPS)	54	0
Northern elephant seal	6,850	0
Harbor seal	6,012	0

Table 2. Modeled Radial Distances (m) to Isopleths Corresponding to Level A Harassment Thresholds.

Airgun Configuration	Threshold	Level A harassment zone (m)				
		LF cetaceans	MF cetaceans	HF cetaceans	Phocids	Otariids
36-airgun array (6,600 cubic inches)	SEL_{cum}	320	0	1	10	0
	Peak	39	14	268	44	11

Table 3. Modeled Radial Distances (m) to Isopleths Corresponding to Level B Harassment Threshold.

Airgun Configuration	Water Depth (m)	Level B harassment zone (m)
36-airgun array (6,600 cubic inches)	>1,000	6,733
	100-1,000	9,468
	<100	12,650