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Geosciences Directorate
Division of Ocean Sciences
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FINDING OF NO SIGNIFICANT IMPACT (FONSI) PURSUANT TO THE NATIONAL ENVIRONMENTAL POLICY ACT (NEPA) AND EXECUTIVE ORDER 12114 AND DECISION DOCUMENT (DD)

Marine Geophysical Survey by R/V *Marcus G. Langseth* of the Queen Charlotte Fault in the Northeast Pacific Ocean, Summer 2021

Award: OCE 1824927
Principal Investigator/Institution: Lindsay Worthington, University of New Mexico
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Award: OCE 1824165
Principal Investigators/Institution: Emily Roland, Western Washington University

Project Title: Relationship between plate boundary obliquity, strain accommodation, and fault zone geometry at oceanic-continental transforms: The Queen Charlotte Fault

A Final Environmental Assessment (Final EA) was prepared for the above noted proposed research project funded by the National Science Foundation (NSF) (Proposed Action). The Proposed Action would involve marine geophysical surveys (or "seismic surveys") to be conducted on board Research Vessel *Marcus G. Langseth* (R/V *Langseth*) along Queen Charlotte Fault (QCF) during summer 2021. R/V *Langseth* is owned and operated by Columbia University's Lamont-Doherty Earth Observatory (LDEO). The Proposed Action would involve the Principal Investigators (PI) noted above and referred to herein as the "Proposing Institutions". The Proposed Action was originally proposed for summer 2020 but was deferred due to logistical issues associated with COVID-19 and unfinalized federal regulatory processes.

The Final EA entitled, "Environmental Assessment/Analysis of a Marine Geophysical Survey by R/V *Marcus G. Langseth* of the Queen Charlotte Fault in the Northeast Pacific Ocean, Summer 2021" (Report # FA0186-00A) (Attachment 1), was prepared by LGL Limited environmental research associates (LGL) on behalf of NSF and analyzed the potential impacts on the human and natural environment associated with the Proposed Action pursuant to the National Environmental Policy Act (NEPA) and Executive Order 12114, "Environmental Effects Abroad of Major Federal Actions". The Final EA tiers to the *Programmatic Environmental Impact Statement/Overseas Environmental Impact Statement for Marine Seismic Research Funded by the National Science Foundation or Conducted by the U.S. Geological Survey* (June 2011) and the *Record of Decision* (June 2012) (jointly referred to herein as the PEIS). This Finding of No Significant Impact/Decision Document (FONSI/DD) also incorporates by reference the analyses and conclusions set forth in the Incidental Harassment Authorizations (IHAs), the Biological Opinion (BiOp)/Incidental Take Statement (ITS), and Letter of Concurrence issued by the U.S. National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) and the U.S. Fish & Wildlife Service (FWS) for this Proposed Action. The conclusions from the Final EA, and other federal regulatory processes, were consistent with the conclusions of the PEIS and were used to inform the Division of Ocean Sciences (OCE) management of potential environmental impacts of the survey. OCE has reviewed and concurs with the Final EA findings. The Final EA is incorporated into this FONSI/DD by reference as if fully set forth herein.

Project Objectives and Context
The primary goals of the seismic surveys are to use two-dimensional (2-D) seismic surveying and Ocean Bottom Seismometers (OBS) to characterize crustal and uppermost mantle velocity structure, fault zone architecture and rheology, and seismicity of the QCF. To achieve the project goals, the researchers propose to conduct 2-D reflection and refraction surveys using R/V *Langseth*. The surveys are proposed to occur within Exclusive Economic Zones (EEZ) and Territorial Waters of the U.S. and Canada, ranging in water depths of 50 to 2800 m. The proposed surveys are illustrated with representative tracklines in the Final EA (Attachment 1, Figure 1).

Summary of Proposed Action and Alternatives
The procedures of the Proposed Action would be similar to those used during previous 2-D seismic surveys and would use conventional seismic methodology. The survey would involve one source vessel, R/V *Langseth*, which would tow a 36-airgun array with a discharge volume maximum of 6600 cubic inches (in^3) at a depth of 12 meters (m). The receiving system would consist of a 15-kilometer (km) long multichannel hydrophone streamer. OBSs would be deployed from R/V *Langseth*, CCGS *Tully*, or similar vessel. As the airgun array is towed along the survey lines, a hydrophone streamer or the OBSs would receive the returning acoustic signals; OBSs would store the data internally for later analysis. In addition to the operations of the airgun array, a multibeam echosounder (MBES) and sub-bottom profiler (SBP) would be operated from R/V *Langseth* continuously throughout the cruise, but not during transit to or from the site. Approximately 4250 km of transect lines would be surveyed. Most of the survey, approximately 63%, would occur in deep water, about 30% would occur in intermediate water, and only approximately 1% would take place in shallow water. Approximately 13% of the transect lines (548 km) would be undertaken in Canadian Territorial Waters.

The proposed surveys would be expected to last for approximately 36 days, including 27 days of seismic operations, 2 days of transit to and from the survey area, 3 days for equipment deployment/recovery, and 4 days of contingency. R/V *Langseth* would likely leave out of and return to port in Ketchikan, AK, during summer (July/August) 2021. Some deviation in the length of the survey and ports of call may be required, depending on logistics, weather, and restrictions due to COVID-19; however, seismic operations would only occur in the area noted and timeframe allowable under the IHA and other relevant documentation.

Another alternative to conducting the Proposed Action would be the "No Action" alternative (i.e., the proposed research operations would not be conducted). The "No Action" alternative would result in no disturbance to marine species attributable to the Proposed Action, but geological data of considerable scientific value and relevance to increasing our understanding of the seismogenic zone along Queen Charlotte Fault would not be collected. The purpose and need for the proposed activity would not be met through the "No Action" alternative.

Summary of environmental consequences
The Final EA includes analysis on the affected environment (Chapter III) and the potential effects of the Proposed Action on the environment (Chapter IV). Potential impacts of the Proposed Action on the environment would be primarily a result of the operation of the airgun array. The potential effects of sounds from airguns on marine species, including mammals and sea turtles of particular concern, are described in detail in Attachment 1 (Chapter IV and PEIS Chapters 3 & 4) and might include one or more of the following: tolerance, masking of natural sounds, behavioral disturbance, and at least in theory, temporary or permanent hearing impairment, or non-auditory physical or physiological effects. It is unlikely that the Proposed Action would result in any cases of temporary or especially permanent hearing impairment, or any significant non-auditory physical or physiological effects. Some behavioral disturbance is expected if animals are in the general area during seismic operations, but this would be localized, short-term, and involve limited numbers of animals. The potential effects from the other proposed acoustic sources were

also considered; however, they would not be likely to have a significant effect on the environment (Attachment 1, Chapter IV; and PEIS Chapter 3).

The Proposed Action includes an extensive monitoring and mitigation program to further minimize potential impacts on the environment. Mitigation efforts include pre-cruise planning activities and operational activities (Attachment 1, Chapters II and IV; and PEIS Section 2.4.1.1). Pre-cruise planning mitigation activities included consideration of energy source optimization/minimization; survey timing (i.e., environmental conditions: seasonal presence of animals and weather); and calculation of mitigation zones.

The operational mitigation program would further minimize potential impacts to marine species that may be present during the conduct of the proposed research to a level of insignificance. As detailed in Attachment 1 (Chapters II and IV), the IHAs, BiOp/ITS, and Letter of Concurrence issued by NMFS and USFWS, the Proposed Action would include operational monitoring and mitigation measures, such as, but not limited to: visual observations; acoustic monitoring; enforcement of exclusion and buffer zones; pre-clearance and ramp ups, shutdowns and power downs of the airguns; monitoring and reporting. The fact that the airgun array, as a result of its design, directs the majority of the energy downward, and less energy laterally, would also be an inherent mitigation measure. The acoustic source would be shut down for North Pacific right whales, any large whale with a calf, and aggregation of large whales (defined as 6 or more) observed at any distance from the vessel during operations. The shutdown requirement would be waived for Pacific white-sided dolphin and northern right whale dolphin. The acoustic source would also be powered down (or, if necessary, shut down) in the event a sea turtle or the short tailed albatross were observed diving or foraging within the designated exclusion zone (EZ); to further reduce potential impacts on short tailed albatross, mitigation measures would also include use of streamer lines, downward-pointing deck lighting, and curtains/shades to be used in cabins at night. Observers (and vessel crew) would monitor for short-tailed albatross and any impacts the acoustic sources may have on fish. LDEO and its contractors are committed to applying these measures in order to minimize any effects on marine mammals, sea turtles, seabirds, and fish, and other potential environmental impacts.

NMFS included vessel strike avoidance measures in the IHA; however, as noted in the Final EA, R/V *Langseth* (and other vessels in the U.S. Academic Research Fleet) have no history of marine mammal strikes. Although NSF calculated predicted distances to the Level A thresholds based on current NMFS Technical Acoustic Guidance[1], per the IHA, NMFS established a fixed operational 500 m exclusion zone and 1,000 m buffer zone for the survey; the IHA also requires a 1,500 m EZ for all beaked whales. The predicted distances for the Level B zones are based on the 160 dB re 1 µPa SPL isopleth, per current NMFS policy for Level B harassment. Additional mitigation, monitoring and reporting requirements were identified through compliance with other regulatory processes, such as the Canadian Fisheries Act. In Canadian waters, the designated EZ for shut downs for sperm and beaked whales (any species) would be 1500 m and for other marine mammal species and sea turtles would be 1000 m. In addition, Canada recommended refraining from conducting operations in waters <100 m and limiting seismic survey operations to daylight only and incorporating use of a support vessel with additional PSOs in water depths of 100-200 m. Ultimately, proposed survey tracklines within Canadian waters will likely be adjusted to avoid operations in <200m water depth to obviate the need for compliance with some additional mitigation measures (e.g., support vessel, daylight operations). Mitigation, monitoring and reporting requirements were incorporated into the Final EA, the FONSI/DD, and/or the LDEO Science Support Plan; PSOs would take the lead in ensuring compliance with all monitoring and mitigation measures.

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[1] 2018 Revision to: Technical guidance for assessing the effects of anthropogenic sound on marine mammal hearing (version 2.0). Underwater thresholds for onset of permanent and temporary threshold shifts. Office of Protected Resources, NMFS, Silver Spring, MD.

With the planned monitoring and mitigation measures, unavoidable impacts to marine species that could be encountered would be expected to be minimal, and limited to short-term, localized changes in behavior and distribution near the seismic vessel. At most, effects on marine mammals may be interpreted as falling within the U.S. Marine Mammal Protection Act (MMPA) definition of Level B Harassment for those species managed by NMFS, however, NMFS also issued small numbers of Level A take for some marine mammal species for the remote possibility of low-level physiological effects from the Proposed Action. Although considered unlikely, any Level A harassment potentially incurred would be expected to be in the form of some smaller degree of permanent hearing loss due in part to the required monitoring measures for detecting marine mammals and required mitigation measures for power downs or shut downs of the airgun array if any animal is likely to enter the exclusion zones. Neither mortality nor complete deafness of marine mammals is expected to result from the surveys. No long-term or significant effects would be expected on individual marine mammals, sea turtles, seabirds, fish or the populations to which they belong or on their habitats. When operating within the Canadian EEZ, LDEO will also follow the guidance provided by Canadian Department of Fisheries and Oceans (DFO) (Attachment 2), including the appropriate additional monitoring and mitigation measures, to avoid causing any harmful alteration, disruption, or destruction of fish (including marine mammal) habitat, or causing prohibited effects to aquatic species at risk.

The results of the cumulative impacts analysis in the PEIS indicated that there would not be any significant cumulative effects to marine resources from the proposed NSF-funded marine seismic research, including the combined use of airguns, MBES, SBP, and acoustic pingers. However, the PEIS also stated that cruise-specific cumulative effects analysis would be conducted, "allowing for the identification of other potential activities in the area of the proposed seismic survey that may result in cumulative impacts to environmental resources." The potential cumulative effects of the Proposed Action were evaluated in Section 4.1.6 of the Final EA. Due to the location of the Proposed Action, human activities in the area around the survey vessel would be anticipated to include other research activities, possible Naval activities, vessel traffic, fisheries activities, tourism, whaling and sealing. Because the proposed survey would occur mainly in water deeper than 50 m, any recreational SCUBA diving is unlikely to be impacted. Fisheries activities within the region and potential impacts are described in further detail in the Final EA, Chapters III and IV. Fisheries activities would not be precluded in the survey area; however, a safe distance would need to be kept to avoid possible entanglement with the towed airgun array and OBS deployments. Conflicts would be avoided through Notice to Mariners and direct radio communications with fishers during the surveys. Considering the limited time that the planned seismic survey would take place close to shore, where most subsistence activities would occur, and brief period of operations, the proposed project is not expected to have any significant impacts to the availability of subsistence resources, including fish, Steller sea lions, harbor seals, and sea otters. No fish kills or injuries were observed during any previous NSF-funded seismic survey activities. Given the brief duration of the proposed survey and the temporary nature of potential environmental impacts, no cumulative effects, or economic impacts to fisheries, would be anticipated. After review, the combined effects of the project and other potential human activities in the area are not anticipated to result in significant impacts on the environment.

The "No Action" alternative would remove the potential of the limited direct and indirect environmental consequences as described. However, it would preclude important scientific research from going forward that would contribute to our understanding of Queen Charlotte Fault. The proposed research would contribute to the characterization of the crustal and uppermost mantle velocity structure, fault zone architecture and rheology, and seismicity of the QCF, and the comprehensive assessment of geohazards for the Pacific Northwest, such as earthquake, tsunami, and submarine landslide hazards. The "No Action" alternative would result in a lost opportunity to obtain important scientific data and knowledge relevant to the geosciences and to society in general. The collaboration, involving PIs and students, would be lost along with the collection of new data, future interpretation of these data and introduction of new results into the greater scientific community. Loss of NSF support often represents a significant negative impact to the academic infrastructure, including the professional and academic careers of the researchers, students, ship technicians and crew who are part of the U.S. Academic Research Fleet. The "No Action" alternative would not meet the purpose and need of the Proposed Action.

Public Engagement and Coordination with Other Agencies and Processes

NSF posted a Draft Environmental Assessment (Draft EA) on the NSF website for a 30-day public comment period from 15 January 2021 thru 16 February 2021 and sent notices to potential interested parties. NSF also sent letters to Alaskan tribal contacts to provide notification of the Proposed Action and related environmental compliance review, including the availability of the Draft EA, and also to provide an opportunity to consult. No comments or responses were received in response to the NSF outreach efforts.

NSF coordinated with NMFS and USFWS to complete the Final EA prior to issuance of the IHAs and BiOp/ITS in order to facilitate adoption of the NSF Final EA as part of the NMFS and USFWS NEPA processes. NSF had enhanced coordination with NMFS and USFWS throughout the IHA and ESA consultation processes to facilitate this streamlined approach. As already highlighted, based on discussions with federal regulators during MMPA and ESA processes, and DFO, refinements to the information in the Draft EA and planned operations were made. The new information included in the Final EA, however, did not alter the overall conclusions of the Draft EA and remained consistent with the PEIS.

Compliance with other federal statutes and regulatory processes are summarized below and in further detail in the Final EA, Section 4.1.7. In addition to these processes, efforts were made to coordinate in advance of operations with the U.S. Navy to address security matters. Due to their involvement with the Proposed Action, the U.S. Geological Survey agreed to be a Cooperating Agency.

(a) Endangered Species Act (ESA)

On 4 December 2019, NSF submitted a Letter of Concurrence request to USFWS that the proposed activity may affect but was not likely to adversely affect the ***endangered*** short-tailed albatross and Hawaiian petrel. Per USFWS request, and after further review and consideration, NSF modified the request to reflect the proposed activity would have no effect on the Hawaiian petrel. On 8 April 2021, USFWS provided a Letter of Concurrence (Attachment 1, Appendix E) that the proposed activity "may affect" but was not likely to "adversely affect" the short-tailed albatross.

On 3 December 2019, NSF submitted a formal ESA Section 7 consultation request, including the Draft EA, to NMFS for the proposed activity. On 7 July 2021, NMFS issued a BiOp and ITS (Attachment 3).

(b) Marine Mammal Protection Act (MMPA)

An IHA application was submitted to NMFS on 3 December 2019 by LDEO on behalf of itself, NSF, and the researchers, to NMFS, under the U.S. MMPA, for "taking by harassment" (disturbance) of small numbers of marine mammals during the proposed seismic survey. On 4 June 2021, NMFS issued in the Federal Register a notice of intent to issue an IHA for the survey and a 30-day public comment period. NMFS issued an IHA for the proposed activity on 9 July 2021 (Attachment 4).

An IHA application was submitted on 19 December 2019 by LDEO on behalf of itself, NSF, and the researchers, to USFWS, under the U.S. MMPA, for "taking by harassment" (disturbance) of small numbers of marine mammals during the proposed seismic survey. On 9 June 2021, USFWS issued in the Federal Register a notice of intent to issue an IHA for the survey and a 30-day public comment period (Attachment 1, Appendix F). USFWS issued an IHA for the proposed activity on 15 July 2021 (Attachment 5).

(e) Essential Fish Habitat (EFH)
EFH and Habit Areas of Particular Concern (HAPCs) were identified to occur within or near the proposed survey area. Although NSF anticipated no significant impacts to EFH and HAPC, as the Proposed Action may affect EFH, in accordance with the Magnuson-Stevens Fishery Conservation and Management Act, NSF requested consultation with NMFS on 4 December 2019 and again on 29 March 2021 (resubmitted due to deferring the survey). On 17 January 2020, and again on 2 June 2021, NMFS concurred with NSF's determination that proposed activities may affect but no adverse effects to EFH or HAPC would be anticipated from the Proposed Action (Attachment 1, Appendix G).

(f) Canadian Department of Fisheries and Oceans (DFO)
An application for a Species at Risk permit application per the Species at Risk Act (SARA) was submitted on 22 December 2019. After discussion with DFO staff, the Species at Risk application was revised and resubmitted along with a Canadian Fisheries Act Request for Review on 18 December 2020. After consultation with DFO, some adjustments to transect lines were made. On 8 July 2021, DFO issued a Letter of Advice with measures to follow to avoid causing the death of fish (including marine mammals) and/or harmful alteration, disruption, or destruction of fish habitat, or causing prohibited effects to SARA species, any part of their critical habitat or the residences of their individuals (Attachment 2).

Conclusion and Decision
NSF has reviewed and concurs with the conclusions of the Final EA (Attachment 1) that implementation of the Proposed Action will not have a significant impact on the environment. Consequently, implementation of the Proposed Action will not have a significant direct, indirect or cumulative impact on the environment within the meaning of NEPA or EO 12114. Because no significant environmental impacts will result from implementing the Proposed Action, an environmental impact statement is not required and will not be prepared. Therefore, no further study under NEPA or EO 12114 is required.

As described above, NSF's compliance with the ESA, MMPA, EFH, and the Canadian Fisheries Act is completed.

In sum, NSF concludes that implementation of the Proposed Action will not result in significant impacts after full consideration of the Final EA; the PEIS; the IHAs, BiOp/ITS, and Letter of Concurrence EFH determination issued by NMFS and/or USFWS; DFO Letter of Advice; and the entire environmental compliance record. Accordingly, on behalf of NSF, I authorize the issuance of a Finding of No Significant Impact for the Proposed Action, the marine seismic survey proposed to be conducted on board Research Vessel *Marcus G. Langseth* along the Queen Charlotte Fault during the effective time period of the IHAs, and hereby approve the Proposed Action to commence.

Bauke Houtman 16 July 2021

Bauke (Bob) Houtman Date
Integrative Programs Section Head
Division of Ocean Sciences

Attachment 1: Environmental Assessment/Analysis of a Marine Geophysical Survey by R/V *Marcus G. Langseth* of the Queen Charlotte Fault in the Northeast Pacific Ocean, Summer 2021
Attachment 2: Letter of Advice, Canadian Department of Fisheries and Oceans
Attachment 3: NMSF Biological Opinion/Incidental Take Statement
Attachment 4: NMFS Incidental Harassment Authorization

Attachment 5: USFWS Incidental Harassment Authorization

Attachment 1

Final Environmental Assessment/Analysis of a Marine Geophysical Survey by R/V *Marcus G. Langseth* of the Queen Charlotte Fault in the Northeast Pacific Ocean, Summer 2021

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LGL Report FA0186-00C

TABLE OF CONTENTS

Page

LIST OF FIGURES

Page

LIST OF TABLES

ABSTRACT

Researchers from the University of New Mexico and Western Washington University, with funding from the U.S. National Science Foundation (NSF), and in collaboration with researchers from the United States Geological Survey (USGS), Dalhousie University, and the Geological Survey of Canada, propose to conduct high-energy seismic surveys from the Research Vessel (R/V) *Marcus G. Langseth* (*Langseth*) at the Queen Charlotte Fault (QCF) in the Northeast Pacific Ocean during summer 2021. R/V *Langseth* is owned by Columbia University and operated by Lamont-Doherty Earth Observatory (L-DEO) of Columbia University. The proposed two-dimensional (2-D) seismic surveys would occur within Exclusive Economic Zones (EEZ) of Canada and the U.S., including Canadian Territorial Waters. The surveys would use a 36-airgun towed array with a total discharge volume of ~6600 in^3 and would occur in water depths ranging from 50 to 2800 m. NSF, as the research funding and action agency, has a mission to "promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense…". The proposed seismic surveys would collect data in support of a research proposal that has been reviewed under the NSF merit review process and identified as an NSF program priority. They would provide data necessary to characterize crustal and uppermost mantle velocity structure, fault zone architecture and rheology, and seismicity of the QCF.

This Final Environmental Assessment/Analysis (EA) addresses NSF's requirements under the National Environmental Policy Act (NEPA) for the proposed NSF federal action within the U.S. EEZ and Executive Order 12114, "Environmental Effects Abroad of Major Federal Actions", for the proposed NSF federal action within the Canadian EEZ. Due to their involvement with the Proposed Action, the USGS requested to be a Cooperating Agency. As operator of R/V *Langseth*, L-DEO, on behalf of itself, NSF, the University of New Mexico, and Western Washington University, have requested an Incidental Harassment Authorization (IHA) from the U.S. National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS) to authorize the incidental (i.e., not intentional) harassment of small numbers of marine mammals should this occur during the seismic surveys. The analysis in this document supports the IHA application process and provides additional information on marine species that are not addressed by the IHA application, including sea turtles, seabirds, fish, and invertebrates that are listed under the U.S. Endangered Species Act (ESA), including candidate species. As analysis on endangered and threatened species was included, the Draft EA was used to support ESA Section 7 consultations with NMFS and USFWS. Alternatives addressed in this EA consist of the Proposed Action with issuance of an associated IHA and the No Action alternative, with no IHA and no seismic surveys. This document tiers to the Programmatic Environmental Impact Statement/Overseas Environmental Impact Statement for Marine Seismic Research Funded by the National Science Foundation or Conducted by the U.S. Geological Survey (June 2011) and Record of Decision (June 2012), referred to herein as PEIS.

Numerous species of marine mammals inhabit the proposed project area in the northeastern Pacific Ocean. Under the U.S. ESA, several of these species are listed as ***endangered***, including the North Pacific right, sei, fin, blue, and sperm whales; the Western North Pacific Distinct Population Segment (DPS) of gray whales and the Western DPS of Steller sea lions may also occur there. The ***threatened*** Mexico DPS of the humpback whale could also occur in the proposed project area, but it is unlikely that humpback whales from the ***endangered*** Central America or Western North Pacific DPSs or killer whales from the ***endangered*** Southern Resident DPS would occur in the project area at the time of the surveys. The North Pacific right whale, Pacific populations of the sei and blue whales, and Southern Resident killer whales are also listed as *endangered* under Canada's *Species at Risk Act* (SARA); the Pacific population of fin whale, and all other populations of killer whales in the Pacific Ocean are listed as *threatened*. The northern sea

otter is the one marine mammal species mentioned in this document that, in the U.S., is managed by the USFWS; all others are managed by NMFS.

ESA-listed sea turtle species that could occur in the project area include the ***endangered*** leatherback turtle and ***threatened*** green turtle; the leatherback turtle is also listed as *endangered* under SARA, but the green turtle is not listed. The ***endangered*** short-tailed albatross (also *endangered* under SARA) is the only ESA-listed seabird that could be encountered in the area. Although Alaskan fish populations are not listed under the ESA, there are several ESA-listed fish species that spawn on the west coast of the Lower 48 U.S. and may occur in Alaskan and B.C. waters during the marine phases of their life cycles, including the ***threatened*** green sturgeon (Southern DPS) and several DPSs of steelhead trout; and various ***endangered*** and ***threatened*** evolutionary significant units (ESUs) of chinook, chum, coho, and sockeye salmon. None of these species are listed under SARA, but the basking shark and northern abalone are listed as *endangered*.

Potential impacts of the proposed seismic surveys on the environment would be primarily a result of the operation of the airgun array. A multibeam echosounder and sub-bottom profiler would also be operated during the surveys. Impacts from the Proposed Action would be associated with increased underwater anthropogenic sounds, which could result in avoidance behavior by marine mammals, sea turtles, seabirds, and fish, and other forms of disturbance. An integral part of the planned surveys is a monitoring and mitigation program designed to minimize potential impacts of the proposed activities on marine animals present during the proposed surveys, and to document, as much as possible, the nature and extent of any effects. Injurious impacts to marine mammals, sea turtles, and seabirds have not been proven to occur near airgun arrays or the other types of sound sources to be used. However, a precautionary approach would be taken, and the planned monitoring and mitigation measures would reduce the possibility of any effects.

Protection measures designed to mitigate the potential environmental impacts to marine mammals, sea turtles, and seabirds would include the following: ramp ups; typically two (but a minimum of one) dedicated observers maintaining a visual watch during all daytime airgun operations; two observers before and during ramp ups during the day; start-ups during poor visibility or at night if the exclusion zone (EZ) has been acoustically monitored (e.g., passive acoustic monitoring (PAM)) for 30 minutes with no detections; PAM via towed hydrophones during both day and night to complement visual monitoring; and shutdowns when marine mammals are detected in or about to enter designated EZ. The acoustic source would also be powered down (or if necessary, shut down) in the event a sea turtle or an ESA-listed seabird would be observed diving or foraging within the designated EZ. Observers would also watch for impacts the acoustic sources may have on fish. L-DEO and its contractors are committed to applying these measures in order to minimize effects on marine mammals, sea turtles, seabirds, and fish, and other potential environmental impacts. Survey operations would be conducted in accordance with all applicable international, U.S. federal, and state regulations, including IHA and Incidental Take Statement (ITS) requirements.

With the planned monitoring and mitigation measures, unavoidable impacts to each species of marine mammal and sea turtle that could be encountered would be expected to be limited to short-term, localized changes in behavior and distribution near the seismic vessel. At most, effects on marine mammals would be anticipated as falling within the Marine Mammal Protection Act (MMPA) definition of "Level B Harassment" for those species managed by NMFS. No long-term or significant effects would be expected on individual marine mammals, sea turtles, seabirds, fish, the populations to which they belong, or their habitats. Although Level A takes are very unlikely, NSF followed the *Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing* (NMFS 2016a, 2018a), resulting in the estimation of Level A takes for some marine mammal species. No significant impacts would be expected on the populations of those species for which a Level A take is permitted.

LIST OF ACRONYMS

~	approximately
2-D	two-dimensional
ACC	Alaska Coastal Current
ADCP	Acoustic Doppler Current Profiler
AEP	Auditory Evoked Potential
AMVER	Automated Mutual-Assistance Vessel Rescue
B.C.	British Columbia, Canada
BIA	Biologically Important Area
CBD	Convention on Biological Diversity
CCGS	Canadian Coast Guard Ship
CITES	Convention on International Trade in Endangered Species
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
DAA	Detailed Analysis Area
dB	decibel
DFO	Canadian Department of Fisheries and Oceans
DoN	Department of the Navy
DPS	Distinct Population Segment
EA	Environmental Assessment/Analysis
EBSA	Ecologically or Biologically Significant Marine Areas
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
EO	Executive Order
ESA	(U.S.) Endangered Species Act
EZ	Exclusion Zone
FM	Frequency Modulated
FONSI	Finding of no significant impact
GIS	Geographic Information System
GOA	Gulf of Alaska
GOM	Gulf of Mexico
h	hour
HAPC	Habitat Area of Particular Concern
hp	horsepower
Hz	Hertz
IHA	Incidental Harassment Authorization (under MMPA)
in	inch
ITS	Incidental Take Statement
IUCN	International Union for the Conservation of Nature
IWC	International Whaling Commission
kHz	kilohertz
km	kilometer
kt	knot
L-DEO	Lamont-Doherty Earth Observatory
LFA	Low-frequency Active (sonar)
LME	Large Marine Ecosystem
m	meter
MBES	Multibeam Echosounder
MCS	Multi-Channel Seismic
MFA	Mid-frequency Active (sonar)
min	minute

MMPA	(U.S.) Marine Mammal Protection Act
MPA	Marine Protected Area
ms	millisecond
NMFS	(U.S.) National Marine Fisheries Service
nmi	nautical mile
NOAA	National Oceanic and Atmospheric Administration
NPC	North Pacific Current
NRC	(U.S.) National Research Council
NSF	National Science Foundation
OBS	Ocean Bottom Seismometer
OEIS	Overseas Environmental Impact Statement
OOI	Ocean Observatories Initiative
p or pk	peak
PBR	Potential Biological Removal
PDO	Pacific Decadal Oscillation
PEIS	Programmatic Environmental Impact Statement
PI	Principal Investigator
PTS	Permanent Threshold Shift
PSO	Protected Species Observer
QAA	Qualitative Analysis Area
QCF	Queen Charlotte Fault
rms	root-mean-square
R/V	research vessel
s	second
SARA	(Canada) Species at Risk Act
SBP	Sub-bottom Profiler
SEAFAC	Southeast Alaska Acoustic Measurement Facility
SEL	Sound Exposure Level (a measure of acoustic energy)
SPL	Sound Pressure Level
SOSUS	(U.S. Navy) Sound Surveillance System
t	tonnes
TTS	Temporary Threshold Shift
U.K.	United Kingdom
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
U.S.	United States of America
USCG	U.S. Coast Guard
USGS	U.S. Geological Survey
USFWS	U.S. Fish and Wildlife Service
μPa	microPascal
vs.	versus
WCMC	World Conservation Monitoring Centre
y	year

I Purpose and Need

This Final Environmental Assessment/Analysis (EA) addresses NSF's requirements under the National Environmental Policy Act (NEPA) and Executive Order 12114, "Environmental Effects Abroad of Major Federal Actions". The Final EA tiers to the Final Programmatic Environmental Impact Statement (PEIS)/Overseas Environmental Impact Statement (OEIS) for Marine Seismic Research funded by the National Science Foundation or Conducted by the U.S. Geological Survey (NSF and USGS 2011) and Record of Decision (NSF 2012), referred to herein as the PEIS. The purpose of this Final EA is to provide the information needed to assess the potential environmental impacts associated with the Proposed Action, including the use of an airgun array during the proposed seismic surveys. Due to their involvement with the Proposed Action, the U.S. Geological Survey (USGS) requested to be a Cooperating Agency.

The Final EA provides details of the Proposed Action at the site-specific level and addresses potential impacts of the proposed seismic surveys on marine mammals, sea turtles, seabirds, fish, and invertebrates. The Draft EA was used in support of other regulatory processes, including an application for an Incidental Harassment Authorization (IHA) and Section 7 consultations under the Endangered Species Act (ESA) with the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS). The IHA would allow the non-intentional, non-injurious "take by harassment" of small numbers of marine mammals[1] during the proposed seismic surveys. Following the *Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing* (NMFS 2016a, 2018a), small numbers of Level A takes have been requested for the remote possibility of low-level physiological effects; however, because of the characteristics of the Proposed Action and proposed monitoring and mitigation measures, in addition to the general avoidance by marine mammals of loud sounds, Level A takes are considered highly unlikely.

The Final EA addresses: (1) comments received during federal regulatory consultations and public comment period on the NSF Draft EA; (2) a schedule change from summer 2020 to summer 2021 due to COVID-19 impacts, and (3) a change in the mitigation zones, based on both modeling for the Level A and Level B thresholds and using empirical measurements from Crone et al. (2014) from the Cascadia Margin, that were then used to revise the take estimates.

1.1 Mission of NSF

The National Science Foundation (NSF) 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. Further details on the mission of NSF are described in § 1.2 of the PEIS.

1.2 Purpose of and Need for the Proposed Action

As noted in the PEIS, § 1.3, NSF 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 purpose of the proposed study is to use two-dimensional (2-D) seismic surveying in order to characterize crustal

[1] To be eligible for an IHA under the MMPA, the proposed "taking" (with mitigation measures in place) must not cause serious physical injury or death of marine mammals, must have negligible impacts on the species and stocks, must "take" no more than small numbers of those species or stocks, and must not have an unmitigable adverse impact on the availability of the species or stocks for legitimate subsistence uses.

and uppermost mantle velocity structure, fault zone architecture and rheology, and seismicity of the Queen Charlotte Fault (QCF). The proposed activities would collect data in support of a research proposal that has been reviewed through the NSF merit review process and have been identified as NSF program priorities to meet the agency's critical need to foster an understanding of Earth processes.

1.3 Background of NSF-funded Marine Seismic Research

The background of NSF-funded marine seismic research is described in § 1.5 of the PEIS.

1.4 Regulatory Setting

The regulatory setting of this EA is described in § 1.8 of the PEIS, including the

- Executive Order 12114--Environmental effects abroad of major Federal actions;
- National Environmental Protection Act (NEPA) of 1969 (42 United States Code [USC] §§ 4321, *et seq.*); the Council on Environmental Quality (CEQ) Regulations for Implementing the Procedural Provisions of NEPA (Title 40 Code of Federal Regulations [CFR] §§ 1500-1508 (1978, as amended in 1986 and 2005))[2]; NSF Compliance with the National Environmental Policy Act (45 CFR Part 640);
- Marine Mammal Protection Act (MMPA) of 1972 (16 USC §§ 1631, *et seq*.);
- Endangered Species Act (ESA) of 1973 (16 USC 35 §§ 1531, *et seq.*);
- National Historic Preservation Act (NHPA) of 1966 (54 USC §§ 300101, *et seq.*); and
- Magnuson-Stevens Fishery Conservation and Management Act - Essential Fish Habitat (EFH) (16 USC §§ 1801, *et seq*.).

II ALTERNATIVES INCLUDING PROPOSED ACTION

In this Final EA, two alternatives are evaluated: (1) the proposed seismic surveys and associated issuance of an associated IHA and (2) No Action alternative. Two additional alternatives were considered but were eliminated from further analysis. A summary of the Proposed Action, the alternative, and alternatives eliminated from further analysis is provided at the end of this section.

2.1 Proposed Action

The Proposed Action, including project objectives and context, activities, and monitoring/mitigation measures for the proposed seismic surveys, is described in the following subsections.

[2] This EA is being prepared using the 1978 CEQ NEPA Regulations. NEPA reviews initiated prior to the effective date of the 2020 CEQ NEPA regulations may be conducted using the 1978 version of the regulations. The effective date of the 2020 CEQ NEPA Regulations was September 14, 2020. This NEPA review began prior to this date (e.g., the Draft EA was submitted in support of compliance with federal regulatory processes in December 2019) and the agency has decided to proceed under the 1978 regulations.

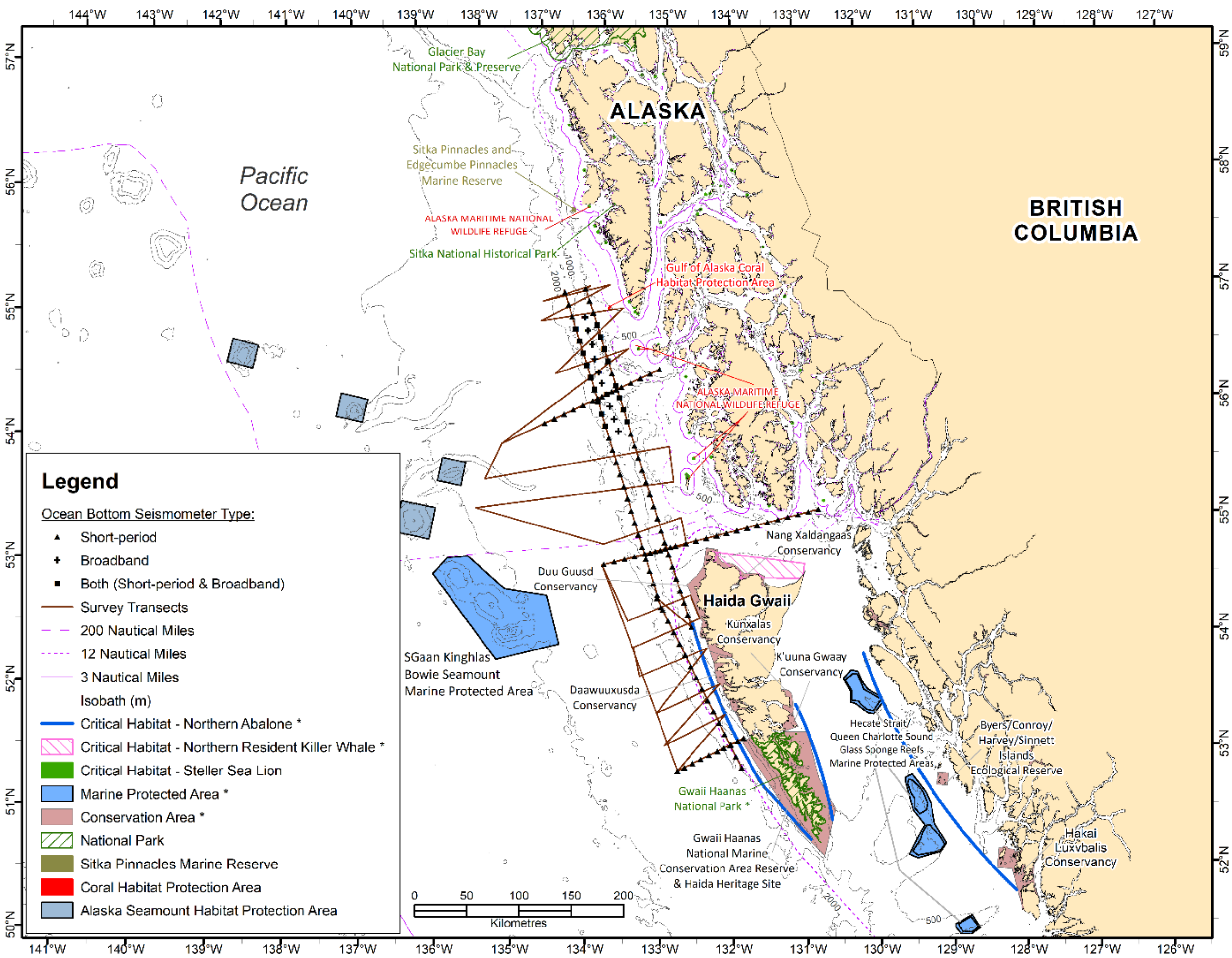

FIGURE 1. Location of the proposed seismic surveys and OBS deployments in the Northeast Pacific Ocean off the coasts of Southeast Alaska and northern British Columbia. Canadian conservation areas and critical habitat are denoted by *.

2.1.1 Project Objectives and Context

Researchers from the University of New Mexico and Western Washington University have proposed to conduct seismic surveys using R/V *Langseth* in the Northeast Pacific Ocean (Fig. 1). Although not funded through NSF, collaborators Dr. M. Nedimovic (Dalhousie University) and the Geological Survey of Canada, as well as the USGS (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 or OBSs; land seismometers), partial funding for a support vessel, and data acquisition, processing, and exchange. The land-based seismometer research effort would capitalize on proposed R/V *Langseth* marine-based activities and would vastly expand the geophysical dataset available for analysis for the region. The following information provides an overview of the project objectives associated with the marine surveys.

The QCF system is a ~1200-km-long onshore-offshore transform system connecting the Cascadia and Alaska-Aleutian subduction zones. The QCF is the ~900 km-long offshore component of the transform system, and the fault accommodates >50 mm/yr of dextral strike-slip motion between the Pacific and North American tectonic plates. This project would characterize ~450-km segment of the fault that encompasses systematic variations in key parameters in space and time: 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 ~12-6 Ma 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 main goal of the seismic program proposed by University of New Mexico and Western Washington University is to characterize crustal and uppermost mantle velocity structure, fault zone architecture and rheology, and seismicity of the QCF. To achieve the project goals, the Principal Investigators (PI) Drs. L. Worthington (University of New Mexico) and E. Roland (Western Washington University) propose to utilize long-offset 2-D seismic reflection and wide-angle reflection-refraction capabilities of R/V *Langseth* and a combined U.S.-Canadian broadband OBS array.

2.1.2 Proposed Activities

2.1.2.1 Location of the Survey Activities

The proposed survey would occur within ~52–57°N, ~131–137°W. Representative survey tracklines are shown in Figure 1. As described further in this document, however, 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. Thus, for the surveys, the tracklines could occur anywhere within the coordinates noted above. The surveys are proposed to occur within Exclusive Economic Zones (EEZ) of the U.S. and Canada, including within Canadian Territorial Waters ranging in depth from 50 to 2800 m.

2.1.2.2 Description of Activities

The procedures to be used for the proposed marine geophysical surveys would be similar to those used during previous surveys by L-DEO and would use conventional seismic methodology. The survey would involve one source vessel, R/V *Langseth*, which would tow a 36-airgun array with a discharge volume of ~6600 in^3 at a depth of 12 m. The receiving system would consist of a 15-km long hydrophone streamer and up to 60 short-period OBSs, which would be deployed at a total of 123 sites in multiple phases from a second vessel, the Canadian Coast Guard ship (CCGS) *John P. Tully* (*Tully*). In the event the *Tully* is unavailable to assist with OBS deployments (e.g., scheduling and/or COVID issues), another vessel with similar capabilities would be retained to deploy the OBSs. Twenty-eight broadband OBS instruments would also collect data during the survey and may be deployed prior to the active-source seismic survey, depending on logistical constraints. The airguns would fire at a shot interval of 50 m (~23 s) during multi-channel seismic (MCS) surveys with the hydrophone streamer (~42% of survey), at a 150-m (~69 s) interval during refraction surveys to OBSs (~29% of survey), and at a shot interval of ~1 min (~130 m) during turns (~29% of survey).

Short-period OBSs would be deployed along five OBS refraction lines by CCGS *Tully*. 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 (Fig. 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 Dixon Entrance (Fig. 1). The coast-parallel OBS refraction transect nearest to shore (Fig. 1) would only be surveyed once at OBS shot spacing. The other coast-parallel OBS refraction transect (on the ocean side; Fig. 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. As previously noted, the location of the survey lines could shift from what is currently depicted in Figure 1 depending on factors such as science drivers, poor data quality, weather, etc.

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 onboard processing system. Approximately ~4250 km of transect lines would be surveyed. This is a slight decrease in the original proposed line km of 4260 km as indicated in the Draft EA. Although the location of some tracklines changed from what was originally proposed, the original trackline locations were used to generate take estimates, as they are still adequately representative of the proposed survey plan. For the current plan, 63% of the survey would occur in deep water, instead of 69% as originally proposed; about 1/3 (30%) would occur in intermediate water, instead of 35%; and only 1% would take place in shallow water (instead of 3%). Slightly less effort (548 km vs. 680 km) would occur in Canadian Territorial Waters water. There could be additional seismic operations associated with turns, airgun testing, and repeat coverage of any areas where initial data quality is sub-standard. In the take calculations (see § 4.1.1.5), 25% has been added in the form of operational days which is equivalent to adding 25% to the proposed line km to be surveyed.

In addition to the operations of the airgun array, a multibeam echosounder (MBES), sub-bottom profiler (SBP), and Acoustic Doppler Current Profiler (ADCP) would be operated from R/V *Langseth* continuously during the seismic surveys, but not during transit to and from the survey area. All planned geophysical data acquisition activities would be conducted by L-DEO 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.

2.1.2.3 Schedule

The proposed surveys would be expected to last for 36 days, including ~27 days of seismic operations, ~2 days of transit to and from the survey area, 3 days for equipment deployment/recovery, and 4 days of contingency. R/V *Langseth* would likely leave out of and return to port in Ketchikan, AK, during summer (July/August) 2021. As R/V *Langseth* is a national asset, NSF and L-DEO strive to schedule its operations in the most efficient manner possible; schedule efficiencies are achieved when regionally occurring research projects are scheduled consecutively and non-operational transits are minimized. Because of the nature of the NSF merit review process and the long timeline associated with the ESA Section 7 consultation and IHA processes, not all research projects or vessel logistics are identified at the time the consultation documents are submitted to federal regulators; typically, however, these types of details, such as port arrival/departure locations, are not a substantive component of the consultations. The ensuing analysis (including take estimates) focuses on the time of the survey (summer); the best available species densities for that time of the year have been used.

2.1.2.4 Vessel Specifications

R/V *Langseth* is described in § 2.2.2.1 of the PEIS. The vessel speed during seismic operations would be ~4.2 kt (~7.8 km/h) during the 2-D survey.

CCGS *Tully* would be used to deploy OBSs. The vessel has a length of 69 m, a beam of 14.5 m, and a draft of 4.5 m. The ship is powered by two Deutz 628 diesel engines, producing 3697 hp, which drives the controllable-pitch propeller. The vessel also has stern and bow thrusters. The cruising speed is 10 kts, and the range is ~22,224 n.mi. with an endurance of 50 days. In the event the *Tully* is unavailable to assist with OBS deployments (e.g., scheduling and/or COVID issues), another vessel with similar capabilities would be retained to deploy the OBSs.

Other details of CCGS *Tully* include the following:

Owner:	Canadian Coast Guard
Operator:	Canadian Coast Guard
Flag:	Canada
Date Built:	1985
Gross Tonnage:	2021
Accommodation Capacity:	41 including ~20 scientists

2.1.2.5 Airgun Description

During the surveys, R/V *Langseth* would tow four strings with 36 airguns (plus 4 spares). During the surveys, all four strings, totaling 36 active airguns with a total discharge volume of 6600 in^3, would be used. The airgun array is described in § 2.2.3.1 of the PEIS, and the airgun configuration is illustrated in Figure 2-11 of the PEIS. The array would be towed at a depth of 12 m, and the shot interval would be 50 m (~23 s) during MCS surveys, 150 m (69 s) during refraction surveys, and at times ~1 min (~130 m).

2.1.2.6 OBS Description

The seismometers would consist of up to 60 short-period OBSs and 28 broadband instruments that would be deployed prior to or during the survey. Along OBS refraction lines, short-period OBSs would be deployed by CCGS *Tully* at ~10 km intervals, with a spacing of ~5 km over the central ~40 km 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 ~1 m and an anchor weighing ~80 kg. OBS sample rates would be set at 100 Hz and 200 Hz 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 of time. All OBSs would be recovered upon conclusion of the survey; however, the broadband OBSs would be deployed for ~12 months before recovery.

2.1.2.7 Additional Acoustical Data Acquisition Systems

Along with the airgun operations, two additional acoustical data acquisition systems (an MBES and SBP) would be operated from R/V *Langseth* during the proposed surveys, but not during transits to/from the survey site and port. The ocean floor would be mapped with the Kongsberg EM 122 MBES and a Knudsen Chirp 3260 SBP. These sources are described in § 2.2.3.1 of the PEIS. The OBSs would be recovered by CCGS *Tully* (or similar vessel), which is also equipped with a Knudsen Chirp system. To retrieve OBSs, an acoustic release transponder (pinger) is used to interrogate the instrument at a frequency of 8–11 kHz, and a response is received at a frequency of 11.5–13 kHz. The burn-wire release assembly is then activated, and the instrument is released to float to the surface from the anchor which is not retrieved.

2.1.3 Monitoring and Mitigation Measures

Standard monitoring and mitigation measures for seismic surveys are described in § 2.4.1.1 and 2.4.2 of the PEIS and would occur in two phases: pre-cruise planning and operations. The following sections describe the efforts during both stages for the proposed activities. Numerous papers have been published with recommendations on how to reduce anthropogenic sound in the ocean (e.g., Simmonds et al. 2014; Wright 2014; Dolman and Jasny 2015), some of which have been taken into account here.

2.1.3.1 Planning Phase

As discussed in § 2.4.1.1 of the PEIS, mitigation of potential impacts from the proposed activities begins during the planning phase. Several factors were considered during the planning phase of the proposed activities, including:

***Energy Source*.—**Part of the considerations for the proposed marine seismic surveys was to evaluate whether the research objectives could be met with a smaller energy source. However, the scientific objectives for the proposed surveys could not be met using a smaller source. The proposed airgun source and long-offset, crustal-scale seismic acquisition is required to penetrate to crustal depths that would address the project goals (crustal structure, basement formation).

***Survey Location and Timing*.—**The PIs worked with NSF to consider potential times to carry out the proposed surveys, key factors taken into consideration included environmental conditions (i.e., the seasonal presence of marine mammals, sea turtles, and seabirds), weather conditions, equipment, and optimal timing for other proposed seismic surveys using R/V *Langseth*, as well as coordination with the Canadian Coast Guard and Geological Survey of Canada. Although marine mammals, including baleen whales, are expected to occur in the proposed survey area during summer, summer is the most practical season for the proposed surveys based on weather conditions and other operational requirements. Some minor adjustments to the location of proposed seismic transect were also made during consultations with regulators.

***Mitigation Zones*.—**During the planning phase, mitigation zones for the proposed marine seismic surveys using the 36-airgun array were not derived from the farfield signature but based on modeling by L-DEO for the exclusion zones (EZ) for Level A takes, and a combination of empirical data and modeling for the Level B (160 dB re 1µPa$_{rms}$) threshold. The background information and methodology for this are provided in Appendix A. The proposed surveys would acquire data with the 36-airgun array at a maximum tow depth of 12 m. L-DEO model results are used to determine the 160-dB$_{rms}$ radius for the 36-airgun array and 40-in^3 airgun (mitigation airgun) at a 12-m tow depth in deep water (>1000 m) down to a maximum depth of 2000 m, as animals are generally not anticipated to dive below 2000 m (Costa and Williams 1999). For the 36-airgun array, radii for intermediate-water depths (100–1000 m) and shallow water (<100 m) are derived from empirical data from Crone et al. (2014) with a scaling factor applied to account for differences in tow depth (see Appendix A). As Crone et al. (2014) did not collect empirical data for the 40-in^3 airgun, the radii for intermediate water depths (100–1000 m) are derived from the deep-water ones by applying a correction factor of 1.5.

For shallow water (<100 m), radii are based on empirically derived measurements in the Gulf of Mexico (GOM) with scaling applied to account for differences in tow depth (see Appendix A). Table 1 shows the distances at which the 160-dB re 1µPa$_{rms}$ sound levels are expected to be received for the

36-airgun array and the single (mitigation) airgun. The 160-dB level is the behavioral disturbance criterion (Level B) that is used by NMFS to estimate anticipated takes for marine mammals. Table 1 also shows the distances at which the 175-dB re 1µPa_{rms} sound level is expected to be received for the 36-airgun array and a single airgun; this level is used by NMFS, as well as the US DoN (2017), to determine behavioral disturbance for turtles.

The thresholds for permanent threshold shift (PTS) onset or Level A Harassment (injury) for marine mammals and sea turtles for impulsive sounds use dual metrics of cumulative sound exposure level (SEL_{cum} over 24 hours) and peak sound pressure levels (SPL_{flat}). Different thresholds are provided for the various hearing groups, including low-frequency (LF) cetaceans (e.g., baleen whales), mid-frequency (MF) cetaceans (e.g., most delphinids), high-frequency (HF) cetaceans (e.g., harbor porpoise and *Kogia* spp.), phocids underwater (PW), and otariids underwater (OW) (NMFS 2016a, 2018a), and sea turtles (DoN 2017). Per the *Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing* (NMFS 2016a, 2018a), the largest distance of the dual criteria (SEL_{cum} or Peak SPL_{flat}) was used to calculate Level A takes and threshold distances for marine mammals. Here, SEL_{cum} is used for turtles and LF cetaceans, and Peak SPL is used for all other marine mammal hearing groups (Table 2).

This document has been prepared in accordance with the current National Oceanic and Atmospheric Administration (NOAA) acoustic practices, and the monitoring and mitigation procedures are based on best practices noted by Pierson et al. (1998), Weir and Dolman (2007), Nowacek et al. (2013a), Wright (2014), Wright and Cosentino (2015), and Acosta et al. (2017). For other recent high-energy seismic surveys conducted by L-DEO, NMFS required protected species observers (PSOs) to establish and monitor a 500-m EZ for shut downs and to monitor an additional 500-m buffer zone beyond the EZ for most marine mammals. A 1500-m EZ was established for beaked whales. Shut downs, rather than power downs, were required for marine mammals observed within or entering the designated EZ. NMFS and USFWS have required power downs for sea turtles or diving ESA-listed seabirds in U.S. waters. A power down required the reduction of the full array to a single 40-in^3 airgun; a 100-m EZ was established and monitored for shut downs of the single airgun for sea turtles and seabirds. Based on consultation discussions, it is anticipated these same measures would be required by regulators in authorizations for the Proposed Action. Enforcement of mitigation zones via power and shutdowns would be implemented as described below.

2.1.3.2 Operational Phase

Marine mammals and sea turtles are known to occur in the proposed survey area. However, the number of individual animals expected to be approached closely during the proposed activities are expected to be relatively small in relation to regional population sizes. To minimize the likelihood that potential impacts could occur to the species and stocks, monitoring and mitigation measures proposed during the operational phase of the proposed activities, which are consistent with the PEIS and past IHA and incidental take statement (ITS) requirements, include: (1) monitoring by PSOs for marine mammals, sea turtles, and ESA-listed seabirds diving near the vessel, and observing for potential impacts of acoustic sources on fish; (2) passive acoustic monitoring (PAM); (3) PSO data and documentation; and (4) mitigation during operations (speed or course alteration; power-down, shut-down, and ramp-up procedures; and special mitigation measures for rare species, species concentrations, and sensitive habitats).

TABLE 1. Level B. Predicted distances to which sound levels ≥160-dB and ≥175-dB re 1 μPa$_{rms}$ could be received during the proposed surveys in the Northeast Pacific Ocean. The 160-dB criterion applies to all hearing groups of marine mammals and the 175-dB criterion applies to sea turtles.

Source and Volume	Tow Depth (m)	Water Depth (m)	Predicted distances (in m) to the 160-dB Received Sound Level	Predicted distances (in m) to the 175-dB Received Sound Level
Single Bolt airgun, 40 in^3	12	>1000 m	431[1]	77[1]*
		100–1000 m	647[2]	116[2]
		<100 m	1,041[3]	170[3]
4 strings, 36 airguns, 6600 in^3	12	>1000 m	6,733[1]	1,864[1]
		100–1000 m	9,468[4]	2,542[4]
		<100 m	12,650[4]	3,924[4]

*An EZ of 100 m would be used as the shut-down distance for sea turtles in all water depths.
[1] Distance is based on L-DEO model results.
[2] Distance is based on L-DEO 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 for details.

TABLE 2. Level A threshold distances for different marine mammal hearing groups and sea turtles for the 36-airgun array and a shot interval of 50 m[1]. Consistent with NMFS (2016a, 2018a), the largest distance (in bold) of the dual criteria (SEL$_{cum}$ or Peak SPL$_{flat}$) was used to calculate Level A takes and threshold distances.

	Level A Threshold Distances (m) for Various Hearing Groups					
	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds/ Sea Otters	Sea Turtles
PTS SEL$_{cum}$	**320.2**	0	1.0	10.4	0	**15.4**
PTS Peak	38.9	**13.6**	**268.3**	**43.7**	**10.6**	10.6

[1] Using the 50-m shot interval provides more conservative distances than the 150-m shot interval.

Five independently contracted PSOs would be on board the survey vessel with rotating shifts to allow two observers to monitor for marine species during daylight hours, and one observer to conduct PAM during day- and night-time seismic operations. The proposed operational mitigation measures are standard for all high-energy seismic cruises, per the PEIS, and are described in the IHA application, and therefore are not discussed further here. Special mitigation measures were considered for this cruise. In order to prevent ship strikes, vessel speed would be reduced to 10 kt or less when mother/calf pairs, pods, or large assemblages of marine mammals are observed (during seismic operations vessel speed would only be ~4.2 kt). Based on recent guidance from NMFS and DFO for a similar survey, we assume vessels would be required to maintain a separation distance of 500 m from any right whale, 200 m from killer whales in Canadian waters, 100 m from large whales (mysticetes and sperm whales) in U.S. waters and all cetaceans except killer whales in Canadian waters, and 50 m from all other marine mammals in U.S. waters, with an exception for those animals that voluntarily approach the vessel (i.e., bow-riding dolphins).

It is unlikely that concentrations of large whales would be encountered within the 160-dB isopleth, but if a group of six or more is encountered, a shut down would be implemented at any distance. In addition, a shut down at any distance would be implemented for a large whale with calf and North Pacific Right Whales, whether they are detected visually or acoustically. The following additional measures would also likely be required by NMFS and/or DFO: shut down at any distance for killer whales (visually or acoustically detected), shut downs for beaked whales within an EZ of 1500 m; within U.S. waters, shut downs for other marine mammals (with the exception of bow-riding dolphins) within an EZ of 500 m; within Canadian waters, shut downs for other marine mammal species and sea turtles within an EZ of 1000 m, except for sperm whales, which would be an EZ of 1500 m.

With the proposed monitoring and mitigation provisions, potential effects on most, if not all, individuals would be expected to be limited to minor behavioral disturbance. Those potential effects would be expected to have negligible impacts both on individual marine mammals and on the associated species and stocks. Ultimately, survey operations would be conducted in accordance with all applicable international and U.S. federal regulations, including IHA and ITS requirements.

2.2 Alternative 1: No Action Alternative

An alternative to conducting the Proposed Action is the "No Action" alternative, i.e., do not issue an IHA and do not conduct the research operations (Table 3). Under the "No Action" alternative, NSF would not support L-DEO to conduct the proposed research operations. From NMFS' perspective, pursuant to its obligation to grant or deny permit applications under the MMPA, the "No Action" alternative entails NMFS denying the application for an IHA. If NMFS were to deny the application, L-DEO would not be authorized to incidentally take marine mammals. If the research was not conducted, the "No Action" alternative would result in no disturbance to marine mammals attributable to the Proposed Action. Although the No-Action Alternative is not considered a reasonable alternative because it does not meet the purpose and need for the Proposed Action, it is included and carried forward for analysis in § 4.3.

2.3 Alternatives Considered but Eliminated from Further Analysis

2.3.1 Alternative E1: Alternative Location

This location is ideally suited for the proposed study in support of the project objectives to characterize crustal and uppermost mantle velocity structure, fault zone architecture and rheology, and seismicity of the QCF (Table 3). This section of the QCF exhibits along-strike changes in transpression and oceanic plate age. The QCF is one of the longest transform faults globally and is mostly offshore, so it is an ideal site for seismic imaging to study transpression and strike-slip tectonics.

2.3.2 Alternative E2: Use of Alternative Technologies

As described in § 2.6 of the PEIS, alternative technologies to the use of airguns were investigated to conduct high-energy seismic surveys (Table 3). At this time, these technologies are still not feasible, commercially viable, or appropriate to meet the Purpose and Need. Additional details about these technologies are given in the Final USGS EA (RPS 2014a).

TABLE 3. Summary of Proposed Action, Alternative Considered, and Alternatives Eliminated.

Proposed Action	Description
Proposed Action: Conduct marine geophysical surveys and associated activities in the Northeast Pacific Ocean	Under this action, research activities are proposed to study earth processes and would involve 2-D seismic surveys. Active seismic portions would be expected to take ~27 days, and additional operational days would be expected for transit; equipment deployment, maintenance, and retrieval; weather; marine mammal activity; and other contingencies. The affected environment, environmental consequences, and cumulative impacts of the proposed activities are described in § III and IV. The standard monitoring and mitigation measures identified in the PEIS would apply, along with any additional requirements identified by regulating agencies in the U.S. All necessary permits and authorizations, including an IHA, would be requested from regulatory bodies.
Alternatives	Description
Alternative 1: No Action	Under this Alternative, no proposed activities would be conducted, and seismic data would not be collected. While this alternative would avoid impacts to marine resources, it would not meet the purpose and need for the Proposed Action. Geological data of scientific value and relevance regarding the characterization of the crustal and uppermost mantle velocity structure, fault zone architecture and rheology, and seismicity of the QCF, and adding to the comprehensive assessment of geohazards for the Pacific Northwest, such as earthquake, tsunami, and submarine landslide hazards, would not be collected. The collection of new data, interpretation of these data, and introduction of new results into the greater scientific community and applicability of these data to other similar settings would not be achieved. No permits and authorizations, including an IHA, would be needed from regulatory bodies, as the Proposed Action would not be conducted.
Alternatives Eliminated from Further Analysis	Description
Alternative E1: Alternative Location	This section of the QCF experiences along-strike changes in transpression and oceanic plate age. The QCF is one of the longest transform faults globally and is mostly offshore, so it is an ideal site for seismic imaging to understand strike-slip tectonics. The data that would be collected would add to the comprehensive assessment of geohazards for the Northeast Pacific region, such as earthquake, tsunami, and submarine landslide hazards. The proposed science underwent the NSF merit review process, and the science, including the site location, was determined to be meritorious.
Alternative E2: Use of Alternative Technologies	Under this alternative, L-DEO would use alternative survey techniques, such as marine vibroseis, that could potentially reduce impacts on the marine environment. Alternative technologies were evaluated in the PEIS, § 2.6. At this time, however, these technologies are still not feasible, commercially viable, or appropriate to meet the Purpose and Need.

III AFFECTED ENVIRONMENT

As described in the PEIS, Chapter 3, the description of the affected environment focuses only on those resources potentially subject to impacts. Accordingly, the discussion of the affected environment (and associated analyses) focuses mainly on those related to marine biological resources, as the proposed short-term activity has the potential to impact marine biological resources within the project area. These resources are identified in § III, and the potential impacts to these resources are discussed in § IV. Initial review and analysis of the proposed Project activity determined that the following resource areas did not require further analysis in this EA:

- *Air Quality/Greenhouse Gases*—Project vessel emissions would result from the proposed activity; however, these short-term emissions would not result in any exceedance of Federal Clean Air standards. Emissions would be expected to have a negligible impact on the air quality within the proposed survey area;
- *Land Use*—All activities are proposed to occur in the marine environment. Thus, no changes to current land uses or activities in the proposed survey area would result from the Project;
- *Safety and Hazardous Materials and Management*—No hazardous materials would be generated or used during the proposed activities. All Project-related wastes would be disposed of in accordance with international, U.S. state, and federal requirements;
- *Geological Resources (Topography, Geology and Soil)*—The proposed Project would result in very minor disturbance to seafloor sediments from OBS deployments during the surveys; small anchors would not be recovered. The proposed activities would not significantly impact geologic resources;
- *Water Resources*—No discharges to the marine environment that would adversely affect marine water quality are expected in the Project area. Therefore, there would be no impacts to water resources resulting from the proposed Project activity;
- *Terrestrial Biological Resources*—All proposed Project activities would occur in the marine environment and would not impact terrestrial biological resources;
- *Visual Resources*—No visual resources would be expected to be negatively impacted as the proposed activities would be short-term;
- *Socioeconomic and Environmental Justice*—Implementation of the proposed project would not affect, beneficially or adversely, socioeconomic resources, environmental justice, or the protection of children. No changes in the population or additional need for housing or schools would occur. Although there are a number of shore-accessible SCUBA diving sites along the coasts of B.C. and Southeast Alaska (see Section 3.9), the proposed activities would occur in water depths >50 m, outside the range for recreational SCUBA diving. Human activities in the area around the survey vessel would be limited to fishing activities, other vessel traffic, and whale watching. However, no significant impacts on fishing, vessel traffic, or whale watching would be anticipated particularly because of the short duration of the proposed activities. Fishing and potential impacts to

fishing are described in further detail in Sections III and IV, respectively. No other socioeconomic impacts would be anticipated as result of the proposed activities.

3.1 Oceanography

The proposed survey area is located in the northeastern Pacific Ocean within the Gulf of Alaska (GOA) Large Marine Ecosystem (LME). The North Pacific Current (NPC) is a warm water current that flows west to east between 40 and 50ºN. The NPC forms the northern part of the clockwise-flowing subtropical gyre; to the north of it, the subarctic gyre flows counterclockwise (Escorza-Treviño 2009). The convergence zone of the subarctic and central gyres, known as the Subarctic Boundary, crosses the western and central North Pacific Ocean at 42ºN (Escorza-Treviño 2009). It is in that area that the change in abundance of cold-water vs. warm-water species is the greatest (Escorza-Treviño 2009). In the eastern Pacific, the NPC splits into the northward flowing Alaska Current and the southward flowing California Current (Escorza-Treviño 2009). The Alaska Coastal Current (ACC) flows northward along the Alaskan coast, changes character and direction three times and is joined by other, narrower currents as it is forced by the coastline to change direction as it flows through the GOA. Coastal circulation is driven in winter by the persistent anti-clockwise wind stress over the GOA and in summer by the density gradient caused by immense freshwater input from coastal sources in B.C. and Southeast Alaska. The GOA includes all waters bordered by the southeastern, southcentral, and southwestern coasts of Alaska from Dixon Entrance to Unimak Pass. The continental shelf is narrowest in Southeast Alaska, ranging in width from 50 km between Dixon Entrance and Cape Spencer, to 100 km or more along the southcentral coast to Seward, and 200 km west of Kodiak Island.

The GOA LME is classified as a Class II, moderately productive (150–300 $gC/m^2/y$) ecosystem (Aquarone and Adams 2009a). Productivity in the GOA appears to be related to upwelling associated with the counterclockwise gyre of the ACC. The GOA's cold, nutrient-rich waters support a diverse ecosystem. Evidence from observations during the past two decades, and the results of modeling studies using historical and recent data, suggest that physical oceanographic processes, particularly climatic regime shifts, might be driving ecosystem-level changes that have been observed in the GOA. Numerous publications have examined the role of climate shifts as a forcing agent on species and community structure of the North Pacific Ocean (e.g., Francis and Hare 1994; Klyashtorin 1998; McGowan et al. 1998; Hollowed et al. 1998; Hare and Mantua 2000). Regime shifts that might impact productivity in the region include the Pacific Decadal Oscillation (PDO) and the El Niño Southern Oscillation. The PDO is similar to a long-lived El Niño-like pattern of climate variability; it is mainly evident in the North Pacific/North American area, whereas El Niños are typical in the tropics (Mantua 1999). PDO "events" persist for 20–30 years, whereas typical El Niño events persist for 6–18 months (Mantua 1999). In the past century, there have been two PDO cycles: "cool" PDO regimes during 1890–1924 and 1947–1976, and "warm" PDO regimes during 1925–1946 and 1977–the mid-1990s (Mantua et al. 1997; Minobe 1997). The latest "cool" period appears to have occurred during the mid-1990s until 2013 (NOAA 2019a).

A mass of warm water, referred to as "the Blob", formed in the GOA during autumn 2013 and grew and spread across the majority of the North Pacific and Bering Sea during spring and summer 2014, resulting in sea surface temperature anomalies ≥4ºC across the region (Peterson et al. 2016). During autumn 2014, decreased upwelling winds caused a portion of this warm water to travel eastward towards the continental shelf off eastern Alaska and the Pacific Northwest, making the sea surface temperature pattern associated with the Blob resemble a "warm" or "positive" PDO pattern (Peterson et al. 2016). Ongoing effects from "the Blob" were further perturbed by a major El Niño arriving from the south and affecting the region during 2015 and 2016, the combination of which reduced the ecosystem's productivity and altered marine community structure for several years (Brodeur et al. 2018). As of May 2016, sea surface temperature anomalies in the outer shelf waters off Oregon remained 2ºC higher, with indications the trend would likely continue well into 2017 (Peterson et al. 2016). Changes in the eastern North Pacific Ocean marine ecosystem have been correlated with changes in the PDO. Warm PDOs showed increased coastal productivity in Alaska and decreased productivity off the U.S. west coast, whereas the opposite north-south pattern of marine ecosystem productivity was seen during cold PDOs (Mantua 1999).

During late 2018, sustained unseasonably warm conditions likely caused the formation of a new mass of warm water encompassing a large portion of the Pacific Ocean, emulating "the Blob" and dubbed the "Son of the Blob" (Britten 2018). Such warm-water masses are speculated to be linked to climate change and have been correlated with warmer weather on land, deceased whales and extreme mortality events of other higher-trophic level organisms, occurrences of uncommon marine taxa, widespread toxic algal blooms, and poor feeding conditions for many fish species (Britten 2018; Brodeur et al. 2018). A significant shift in prey availability and feeding habits was observed for anchovy, sardine, mackerel, herring, and smelt species in the Northern California Current ecosystem off the Washington and Oregon coasts (Brodeur et al. 2018). While the effects of "the Blob" or the "Son of the Blob" are not yet fully understood, the formation of warm water patches are increasingly common in the Pacific Ocean off the western Canadian and American coasts (Britten 2018).

3.2 Protected Areas

3.2.1 Critical Habitat in Alaska, U.S.

Habitats near or within the proposed survey area have been specifically identified as important to U.S. ESA-listed marine mammal species. There is no critical habitat for fish or seabird species in Alaska.

Steller Sea Lion Critical Habitat*.—**Critical habitat for Steller sea lions has been designated around major haulout sites and rookeries in Alaska (NMFS 1993). This species is divided into Western and Eastern DPSs with a boundary at 144°W (NMFS 1993). The proposed survey area lies within the range of the Eastern DPS, which was formerly listed as threatened but was delisted in 2013 (NMFS 2013); the Western DPS is listed as ***endangered. Critical habitat for the Eastern DPS currently includes terrestrial, aquatic, and air zones that extend 3000 ft (0.9 km) landward, seaward, and above each major rookery and major haulout in Alaska. Critical habitat occurs near some of the proposed transect lines in Southeast Alaska (Fig. 1).

Humpback Whale Critical Habitat*.—**On 21 April 2021, NMFS designated critical habitat in nearshore waters of the North Pacific Ocean for the ***endangered Central America and Western North Pacific DPSs and the ***threatened*** Mexico DPS of humpback whale (NMFS 2021). Critical habitat for the Mexico and Western Pacific DPSs includes waters in Alaska, and there is also critical habitat for the Central America and Mexico DPSs off the coasts California, Oregon, (NMFS 2021). There is no critical habitat near or within the proposed survey area.

3.2.2 Critical Habitat in Canada

Several habitats near or within the proposed survey area have been identified as important under Canada's Species at Risk Act (SARA) to listed species, including critical habitat for the northern resident killer whale and northern abalone. Although critical habitat was previously designated for the humpback whale (DFO 2013a), this is no longer in effect as the humpback whale was down-listed to *special concern* under SARA. Critical habitat for the SARA-listed marbled murrelet occurs adjacent to the study area, but this habitat is strictly terrestrial and would not be affected by the proposed activities. According to the

Canadian Department of Fisheries and Oceans (DFO 2018a), critical habitat is defined under SARA as the "habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as such in the recovery strategy or action plan for the species". Critical habitat could include areas used for spawning, rearing young, feeding and migration, depending on the species and may not be destroyed (DFO 2018a).

***Northern Resident Killer Whale Critical Habitat*.—**Critical habitat has been designated in western Dixon Entrance along the north coast of Graham Island, Haida Gwaii, Johnstone Strait and southeastern Queen Charlotte Strait, and the continental shelf waters off southwestern Vancouver Island (DFO 2018a). The critical habitat has features such as prey availability (specifically chinook and chum salmon), appropriate acoustic environment, water quality, and physical space, and suitable physical habitat that provide areas for feeding, foraging, reproduction, socializing, resting, and beach rubbing (DFO 2018a). None of the proposed transect lines intersect the critical habitat (see Fig. 1).

***Northern Abalone Critical Habitat*.—**Critical habitat for northern abalone has been identified within four distinct geospatial areas that include the west and east coasts of Haida Gwaii (Fig. 1), the north and central coasts of B.C., and Barkley Sound and surrounding waters on the southwest coast of Vancouver Island (DFO 2012). The west and east coasts of Haida Gwaii and the north and central coasts of mainland B.C. habitats were identified due to their historical significance in production to the former commercial abalone fishery; the Barkley Sound habitat was identified as an important rebuilding area (DFO 2012).

Abalone are typically found in shallow waters <10 m attached to hard substratum such as rocks, boulders, and bedrock (DFO 2012). Within the identified geographic boundaries, not all habitat comprises critical habitat, but rather only those areas with sites at least 20 m^2 in size with a density of ≥0.1 abalone/m^2 that contain the following physical attributes: appropriate primary substrate consisting of bedrock or boulders for attachment or secondary substrate including some cobble; water with salinity >30 ppt and moderate to high water exchange from tidal currents or wave action; presence of encrusting coralline algae such as *Lithothamnium* spp.; and the presence of macroalgae such as *Nereocystic*, *Macrocystic*, *Pterygophora*, or *Laminaria* spp. Encrusting coralline algae is a primary site of larval settlement and provides feeding and refuge grounds for juveniles (DFO 2012). Critical habitat may be located within or near the proposed project area, although all survey effort would occur in water deeper than 50 m (Fig. 1).

3.2.3 Other Conservation Areas in U.S. Waters

All marine conservation areas near the project area are listed below and shown on Figure 1. Only those areas within 100 km of the proposed survey area are discussed below. Habitat Areas of Particular Concern (HAPCs) are detailed in Section 3.7.3 below.

***Sitka Pinnacles and Edgecumbe Pinnacles Marine Reserve*.—**This marine reserve is an 8.55 km^2 fisheries closure area protecting productive and fragile fish habitat, lingcod, black rockfish, groundfish (including halibut), scallops, and corals (NOAA 2000; MCI 2019). The reserve is also closed to anchoring by commercial groundfish vessels (NOAA 2000). Although the Alaska State Board of Fish considered a closure to salmon fishing, this proposal was rejected, and commercial or recreational salmon fisheries are permissible within the reserve (NOAA 2000). The pinnacle area may be re-evaluated in the future for consideration as a HAPC under the Essential Fish Habitat (EFH) guidelines (O'Connell et al. n.d.). This marine reserve is located ~73 km north of the closest seismic transect.

***Alaska Maritime National Wildlife Refuge*.—**This National Wildlife Refuge includes "islands, islets, headlands, rocks, reefs, spires, and submerged lands" (Pippins 2012) and covers >4.8 million acres (19,425 km^2) extending from Forrester Island to the Aleutian Chain and northward along the coastline to near Barrow (USFWS 2019a). In Southeast Alaska, the refuge includes Forrester Island Wilderness, Hazy Island Wilderness, and St. Lazaria Wilderness (Pippins 2012). Forrester Island Wilderness consists Lowrie, Petrel, and Forrester islands, as well as nearby rocks; various seabirds nest there, including ~780,000 Leach's storm petrels (Pippins 2012). This wilderness is located ~12 km to the east of a seismic transect. Hazy Island Wilderness consists of one main island and four smaller rocks, that are nesting areas for numerous seabird species, including puffins (Pippins 2012). It is located ~9 km from a seismic transect. St. Lazaria Wilderness is located in the entrance to Sitka Sound ~75 km north of the seismic transects; ~half a million birds next here (Pippins 2012).

The Alaska Maritime Wildlife Refuge was established to "conserve marine mammals, seabirds and other migratory birds, and the marine resources upon which they rely" (USFWS 2019a). It provides essential habitat for ≥40 million seabirds (~80% of all breeding seabirds that migrate to Alaska), representing >30 species and including endemic subspecies and rare Asiatic migrants (USFWS 2019a). It also protects the Stellar sea lion, sea otter, fur seal, and salmon streams (USFWS 2019a). Permitted activities include wildlife and bird viewing, and sport fishing in accordance with Alaska Fish and Game regulations (USFWS 2019a). A conservation plan for the refuge provides direction for permitting subsistence use by residents and scientific research of marine resources (USFWS 2019b).

3.2.4 Other Conservation Areas in Canada

Only those conservation areas within 100 km of the proposed survey area, in adjacent waters, are discussed below. None of the seismic transects would enter the conservation areas. There is one rockfish conservation area (RCA) adjacent to the proposed survey area; this RCA is discussed in Section 3.7.5.

***SGaan Kinghlas Bowie Seamount Marine Protected Area*.—**This MPA has an area of 6131 km^2 (Hoyt 2011) and is located ~45 km from the closest seismic transect (Fig. 1). It protects the surrounding waters, seabed, and subsoil, including the SGaan Kinghlas Bowie, Hodgkins, and Davidson seamounts; and it has unique biodiversity and biological productivity (DFO 2019a). It is prohibited to: "(a) disturb, damage or destroy, or remove from the Area, any living marine organism or any part of its habitat; (b) disturb, damage or destroy or remove from the Area, any part of the seabed; or (c) carry out any activity — including depositing, discharging or dumping any substance, or causing any substance to be deposited, discharged or dumped — that is likely to result in the disturbance, damage, destruction or removal of a living marine organism or any part of its habitat" (Government of Canada 2019a).

***Gwaii Haanas National Marine Conservation Area Reserve and Haida Heritage Site*.—**This area is located adjacent to Gwaii Haanas National Park, South Moresby Island, Haida Gwaii, and covers a marine area of 3400 km^2 (Hoyt 2011). According to the Gwaii Haanas Gina 'Waadluxan KilGuhlGa Land-Sea-People Management Plan (Haida Nation and Government of Canada 2018), the archipelago supports resident and migratory animals that depend on, and connect, the sea, the land, and the people. The reserve and heritage site have been internationally recognized for their cultural significance. The island of SGang Gwaay Llanagaay (also known by the English name of "Ninstints") was designated a UNESCO (United Nations Educational, Scientific and Cultural Organization) World Heritage Site and National Historic Site in 1981 due to its illustration of the relationship between Haida and the land and sea (Haida Nation and Government of Canada 2018). The marine reserve is located adjacent to the proposed transect lines. The Gwaii Haanas management plan is intended to achieve key ecological and cultural objectives while minimizing socioeconomic impacts. Three types of zones are designated in the management plan: Restricted Access, Strict Protection, or Multiple Use zones. Traditional-based use of areas is generally allowed in all zones. Other activities (e.g., research, tourism, fishing, aquaculture) and infrastructure (e.g., docks, anchoring, mooring buoys) are prohibited or allowed according to zone type.

***Duu Guusd Heritage Site/Conservancy*.—**This site consists of a marine component and foreshore area of 84,173 ha (BC Parks 2019a) and is located on northwestern Graham Island, Haida Gwaii (Fig. 1). It protects the biological diversity and natural environmental values, and provides a place for the physical expression of culture through monumental art such as totems or establishment of traditional style infrastructure such as longhouses. This site is generally managed to provide sustenance and spiritual values to this and future generations; cultural use is the primary use of this area. Scientific research, respectful observance, and the enjoyment of the natural world are preferred uses (Haida Nation, Province of B.C., and B.C. Parks 2011a). This conservancy is located adjacent to the proposed transect lines.

***Daawuuxusda Heritage Site/Conservancy*.—**This site consists of a marine component and foreshore area of 45,785 ha; it extends from the southern edge of Rennell Sound and Graham Island, along the western shores of Moresby Island to Tasu Sound (BC Parks 2019b; Fig. 1). It protects surfgrass habitat, eelgrass beds, kelp forest, and nine estuaries that border some of the most productive marine habitat on Haida Gwaii. This site is generally managed to provide sustenance and spiritual values to this and future generations; cultural use is the primary use of this area. Scientific research, respectful observance, and the enjoyment of the natural world are preferred uses (Haida Nation, Province of B.C., and B.C. Parks 2011b). This conservancy is located adjacent to the proposed transect lines.

***Nang Xaldangass Site/Conservancy*.—**This site consists of marine component and foreshore area of 9798 ha (BC Parks 2019c) and is located on the northern tip of Graham Island, Haida Gwaii (Fig. 1). This site has a high value intertidal area and kelp forest which help protect unique marine ecosystems, as well as a significant intertidal estuarine wetland complex, including habitat for waterfowl. This site is generally managed to provide sustenance and spiritual values to this and future generations; cultural use is the primary use of this area. Scientific research, respectful observance, and the enjoyment of the natural world are preferred uses (Haida Nation, Province of B.C., and B.C. Parks 2011c). It is located 14 km from the nearest seismic transect (Fig. 1).

***B.C. Northern Shelf MPA Network*.—**This initiative aims to build a network of MPAs for the shelf of B.C., stretching from the western shelf of northern Vancouver Island to Alaska (MPANetwork 2019), including the survey area off the west coast of Haida Gwaii and Dixon Entrance. The Northern Shelf consists of diverse ecosystems that provides important habitat for a variety of species. The network is being developed by the Government of Canada, the Province of B.C., and First Nations.

***Ecologically and Biologically Significant Areas*.—**An Ecologically and Biologically Significant Area (EBSA) is an area of relatively higher ecological or biological significance than surrounding areas (Rubidge et al. 2018). As determined by DFO, an EBSA is a biologically rich environment, with high diversity of marine mammals and fish, and it is important habitat for marine mammal species listed under SARA. The scientific criteria to identify an EBSA have been established at the national level by DFO (2004a) and at the international level by the Convention on Biological Diversity (CBD 2008). The identification of an EBSA does not imply specific protection, rather it is a means of recognizing the special features within the area and the management of activities within the area are required to exhibit greater risk aversion (Ban et al. 2016). In order for an area to be protected under the National Marine Conservation Areas Act or be designated as an MPA in Canada, it must first be identified as an EBSA, and the societal values and potential threats must be identified, in addition to the implementation of a management plan (Ban et al. 2016). There are three EBSAs within the survey area (Fig. 2; Table 4).

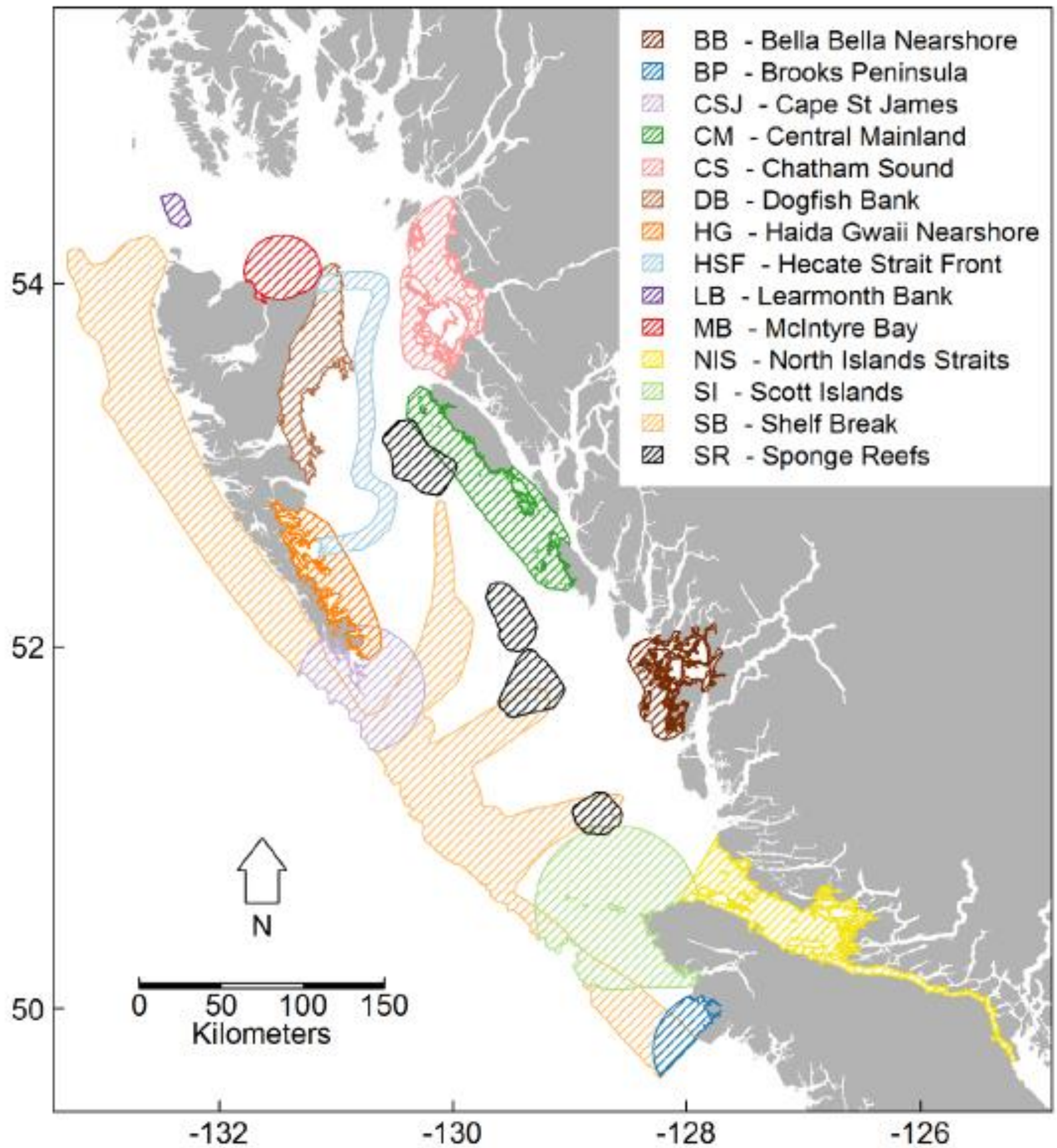

FIGURE 2. EBSAs off the B.C. Coast in the Pacific Northern Shelf Bioregion (Source: Rubidge et al. 2018).

TABLE 4. Summary of the Ecologically or Biologically Significant Marine Areas within Canadian Waters of the Proposed Survey Area.

EBSA	Location	Significance	References
Learmonth Bank (LB)	Northwest of Langara Island and on the western end of Dixon Entrance trough, which lies between northern B.C. and southern Alaska	• Isolated bank traps plankton • Feeding area for marine birds Important species: • Migration routes: gray whale • Aggregation: Fin whale, coral	Clarke and Jamieson (2006); Neves et al. (2014); Rubidge et al. (2018)
Northern Shelf Break (NSB)	West coast of Haida Gwaii from 54°–49°N down to the Brooks Peninsula on Vancouver Island along the shelf, stretching eastward towards Banks Island	• Circulation features • Aggregation of plankton Important species: • Threatened species: sperm, blue, and fin whales • Spawning, breeding, or rearing: sablefish, Dover sole, Pacific Ocean perch, yellowtail rockfish, yellowmouth rockfish, Cassin's auklet, Rhinoceros auklet, tufted puffin, storm petrel • Feeding: humpback whale • Migration routes: Pacific hake, gray whale • Aggregation: tanner crab, coral, sponge	Clarke and Jamieson (2006); DFO (2013b); Rubidge et al. (2018)
Cape St. James (CSJ)	South coast of Haida Gwaii, from Jedway down to the tip of the archipelago	• Formation of offshore Haida eddies • Strong currents connecting Hecate Strait and offshore regions • Aggregation of plankton Important species: • Spawning, breeding, or rearing: Pacific halibut, Steller sea lion • Aggregation: humpback, blue, and fin whales, coral, sponge	Clarke and Jamieson (2006); DFO (2013b); Rubidge et al. (2018)

***Haida Gwaii Management Zones*.—**The Haida Gwaii Marine Plan outlines marine spatial zoning for Haida Gwaii, including General Management Zones, Protection Management Zones, and Special Management Zones (MaPP 2015). Most of the proposed activities would occur in General Management Zones, where the full range of sustainable marine uses and activities can occur (MaPP 2015). Some activities would occur in the Protection Management Zones, that are managed to conserve natural values, including in high-protection zones with a strong emphasis on natural values and in medium zones, where the focus is mainly on specific species and ecosystems (MaPP 2015). Some survey effort would occur adjacent to low-protection zones with a mix of conservation and sustainable human uses (MaPP 2015).

3.3 Marine Mammals

Twenty-three marine mammal species could occur in or near the proposed survey area, including 7 mysticetes (baleen whales), 10 odontocetes (toothed whales, such as dolphins), 5 pinnipeds (seals and sea lions), and the northern sea otter (Table 5). Several species that could occur in the proposed survey area are listed under the U.S. ESA as ***endangered***, including the sperm, sei, fin, blue, and North Pacific right whales, Western North Pacific DPS of gray whales, and Western DPS of Steller sea lions. The ***threatened*** Mexico DPS of the humpback whale could also occur in the proposed survey area, but it is unlikely that humpback whales from the Central America DPS or killer whales from the Southern Resident DPS would occur in the proposed survey area, both of which are ***endangered***.

TABLE 5. The habitat, abundance, and conservation status of marine mammals that could occur in or near the proposed seismic survey area in the Northeast Pacific Ocean. N.A. means not available.

Species	Occurrence in Area[1]	Habitat	Abund-ance[2]	U.S. *ESA*[3]	Canada		IUCN[6]	CITES[7]
					COSEWI	SARA[5]		
Mysticetes								
North Pacific right whale	Rare	Coastal, shelf, offshore	400-500[8]	EN	EN	EN	CR[9]	I
Gray whale	Uncommon	Coastal, shelf	26,960[10]	EN/DL[11]	EN[12]	NS	LC[13]	I
Humpback whale	Common	Mainly nearshore	10,103[14]	EN/T[15]	SC	SC	LC	I
Common minke whale	Uncommon	Nearshore,	28,000[16]	NL	NAR	NS	LC	I
Sei whale	Rare	Mostly pelagic	27,197[17]	EN	EN	EN	EN	I
Fin whale	Common	Slope, pelagic	13,620-18,680[18]	EN	SC	T	VU	I
Blue whale	Rare	Pelagic and coastal	1,496[19]	EN	EN	EN	EN	I
Odontocetes								
Sperm whale	Common	Pelagic, steep topography	26,300[20]	EN	NAR	NS	VU	I
Cuvier's beaked whale	Uncommon	Pelagic	3,274[21]	NL	NAR	NS	LC	II
Baird's beaked whale	Uncommon	Pelagic	2,697[21]	NL	NAR	NS	DD	I
Stejneger's beaked	Uncommon	Slope, offshore	3,044[21,22]	NL	NAR	NS	DD	II
Pacific white-sided dolphin	Common	Offshore, slope	26,880[3]	NL	NAR	NS	LC	II
Northern right whale dolphin	Uncommon	Slope, offshore waters	26,556[21]	NL	NAR	NS	LC	II
Risso's dolphin	Uncommon	Shelf, slope, mounts	6,336[21]	NL	NAR	NS	LC	II
Killer whale	Common	Widely distributed	75[24] 243[25] 2,347[26] 302[27] 587[28] 300[29]	EN[30]	EN/T[31]	EN/T[31]	DD	II
Harbor porpoise	Common	Shelf	11,146[32]	NL	SC	SC	LC	II
Dall's porpoise	Common	Shelf, slope, offshore	83,400[33]	NL	NAR	NS	LC	II
Pinnipeds								
Northern fur seal	Uncommon	Pelagic, offshore	620,660[34]	NL	T	NS	VU	N.A.
Northern elephant seal	Common	Coastal, pelagic in migration	179,000[35]	NL	NAR	NS	LC	N.A.
Steller sea lion	Common	Coastal, offshore	43,201[36]	EN/DL[37]	SC	SC	NT[38]	N.A.
California sea lion	Uncommon	Coastal	257,606[39]	NL	NAR	NS	LC	N.A.
Harbor seal	Common	Coastal	85,269[40] 7,455[41] 13,388[42] 13,289[43] 23,478[44] 27,659[45]	NL	NAR	NS	LC	N.A.
Fissiped								
Northern Sea Otter	Rare	Coastal	25,712[46]	NL[47]	SC	SC	EN	II

[1] Occurrence in area at the time of the survey; based on professional opinion and available data.
[2] Abundance for the Eastern North Pacific or U.S. stock, unless otherwise stated.
[3] U.S. Endangered Species Act (ESA; NOAA 2019b): EN = Endangered; T = Threatened; DL = Delisted; NL = Not listed.
[4] Committee on the Status of Endangered Wildlife in Canada (COSEWIC) status (Government of Canada 2019b); EN = Endangered; T = Threatened; SC = Special Concern; NAR = Not at Risk.
[5] Pacific Population for Canada's Species at Risk Act (SARA) Schedule 1 species, unless otherwise noted (Government of Canada 2019b); EN = endangered; T = Threatened; SC = Special Concern; NS = No Status.
[6] Classification from the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species (IUCN 2020);

CR = Critically Endangered; EN = Endangered; VU = Vulnerable; LC = Least Concern; NT = Near Threatened; DD = Data Deficient.

[7] Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES; UNEP-WCMC 2020): Appendix I = Threatened with extinction; Appendix II = not necessarily now threatened with extinction but may become so unless trade is closely controlled.

[8] North Pacific (Jefferson et al. 2015).

[9] The Northeast Pacific subpopulation is listed as critically endangered; globally, the North Pacific right whale is considered endangered.

[10] Eastern North Pacific population (Durban et al. 2017 *in* Carretta et al. 2020); Western North Pacific population is estimated at 290 (Carretta et al. 2020).

[11] Although the Eastern North Pacific DPS was delisted under the ESA, the Western North Pacific DPS is listed as endangered.

[12] Pacific Coast Feeding Aggregation and Western Pacific populations are listed as endangered; the Northern Pacific Migratory population is not at risk.

[13] Globally considered as least concern; western population listed as endangered.

[14] Central North Pacific stock (Muto et al. 2020).

[15] The Central America DPS is endangered, and the Mexico DPS is threatened; the Hawaii DPS was delisted in 2016 (81 FR 62260, 8 September 2016).

[16] Northwest Pacific and Okhotsk Sea for 1990-1991 (IWC 2021).

[17] Central and Eastern North Pacific (Hakamada and Matsuoka 2015).

[18] North Pacific (Ohsumi and Wada 1974).

[19] Eastern North Pacific Stock (Carretta et al. 2020).

[20] Eastern Temperate Pacific; estimate based on visual sightings (Barlow and Taylor 2005).

[21] California/Oregon/Washington stock (Carretta et al. 2020).

[22] All mesoplodont whales (Moore and Barlow 2017; Carretta et al. 2020).

[23] North Pacific stock (Muto et al. 2020).

[24] Eastern North Pacific Southern Resident stock (Carretta et al. 2020).

[25] West Coast Transient stock; minimum estimate (Muto et al. 2020).

[26] Alaska Resident stock (Muto et al. 2020).

[27] Northern Resident stock (Muto et al. 2020).

[28] Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock (Muto et al. 2020).

[29] North Pacific Offshore stock (Carretta et al. 2020).

[30] The Southern Resident DPS is listed as endangered; no other stocks are listed.

[31] Southern resident population is listed as endangered; the northern resident, offshore, and transient populations are listed as threatened.

[32] Southeast Alaska stock (Hobbs and Waite 2010).

[33] Alaska stock (Muto et al. 2020).

[34] Eastern Pacific stock (Muto et al. 2020).

[35] California breeding stock (Carretta et al. 2020).

[36] Abundance estimate for eastern U.S. stock; Western U.S. stock abundance is 53,624 (Muto et al. 2020).

[37] The Eastern DPS was delisted in 2013 (NMFS 2013); the Western DPS is listed as endangered.

[38] Globally considered as near threatened; western population listed as endangered.

[39] U.S. stock (Carretta et al. 2020).

[40] Total of harbor seal stocks in Southeast Alaska (Muto et al. 2020).

[41] Glacier Bay/Icy Strait stock (Muto et al. 2020).

[42] Lynn Canal/Stephens Passage stock (Muto et al. 2020).

[43] Sitka/Chatham Strait stock (Muto et al. 2020).

[44] Dixon/Cape Decision stock (Muto et al. 2020).

[45] Clarence Strait stock (Muto et al. 2020).

[46] Southeast Alaska stock (Muto et al. 2020).

[47] Southwest Alaska DPS is listed as threatened.

Blainville's beaked whale (*Mesoplodon densirostris*), pygmy sperm whale (*Kogia breviceps*), dwarf sperm whale (*K. sima*), Hubbs' beaked whale (*Mesoplodon caelhubbsi*), false killer whale (*Pseudorca crassidens*), short-finned pilot whale (*Globicephala macrorhynchus*), common bottlenose dolphin (*Tursiops truncatus*), short-beaked common dolphin (*Delphius delphis*), long-beaked common dolphin (*D. capensis*), striped dolphin (*Stenella coeruleoalba*), and rough-toothed dolphin (*Steno bredanensis*) are distributed farther to the south, and belugas (*Delphinapterus leucas*) occur farther to the north, with a population in Yakutat Bay, Southeast Alaska. Based on the known distribution ranges and information provided in Ford (2014), the aforementioned species are unlikely to be seen in the proposed survey area and are not addressed in the summaries below.

General information on the taxonomy, ecology, distribution and movements, and acoustic capabilities of marine mammals are given in § 3.6.1, § 3.7.1, and § 3.8.1 of the PEIS. One of the qualitative analysis areas (QAAs) defined in the PEIS, the B.C. Coast (specifically the Queen Charlotte Basin), is located just to the south of the proposed survey area. The general distribution of mysticetes, odontocetes, pinnipeds, and sea otters off the B.C. Coast is discussed in § 3.6.3.2, § 3.7.3.2, § 3.8.3.2, and § 3.9.3.1 of the PEIS, respectively. In B.C., systematic surveys have been conducted in coastal and inland waters (e.g., Williams and Thomas 2007; Ford et al. 2010a; Best et al. 2015; Harvey et al. 2017). Surveys in coastal as well as offshore waters were conducted by DFO during 2002 to 2008 (Ford et al. 2010a). The western GOA was chosen as a detailed analysis area (DAA) in the PEIS. The general distribution of mysticetes, odontocetes, pinnipeds, and sea otters in the western GOA is discussed in § 3.6.2.4, § 3.7.2.4, § 3.8.2.4, and § 3.9.2.3 of the PEIS, respectively. Few systematic surveys have been conducted in Southeast Alaska, especially in offshore waters. However, Dahlheim et al. (2008, 2009) conducted surveys in inland waters of Southeast Alaska and presented abundance estimates for the region. The rest of this section deals specifically with species distribution in the proposed survey area.

3.3.1 Mysticetes

3.3.1.1 North Pacific Right Whale *(Eubalaena japonica)*

North Pacific right whales summer in the northern North Pacific, primarily in the Okhotsk Sea (Brownell et al. 2001) and in the Bering Sea (Shelden et al. 2005; Wade et al. 2006). This species is divided into western and eastern North Pacific stocks. The eastern North Pacific stock that occurs in U.S. waters numbers only ~31 individuals (Wade et al. 2011a), and critical habitat has been designated in the eastern Bering Sea and in the GOA, south of Kodiak Island (NOAA 2019c). Wintering and breeding areas are unknown, but have been suggested to include the Hawaiian Islands, Ryukyu Islands, and Sea of Japan (Allen 1942; Banfield 1974; Gilmore 1978; Reeves et al. 1978; Herman et al. 1980; Omura 1986).

Since the 1960s, North Pacific right whale sightings have been relatively rare (e.g., Clapham et al. 2004; Shelden et al. 2005). However, starting in 1996, right whales have been seen regularly in the southeast Bering Sea, including calves in some years (Goddard and Rugh 1998; LeDuc et al. 2001; Moore et al. 2000, 2002a; Wade et al. 2006; Zerbini et al. 2009); they have also been detected there acoustically (McDonald and Moore 2002; Munger et al. 2003; 2005, 2008; Berchok et al. 2009). They are known to occur in the southeastern Bering Sea from May–December (e.g., Tynan et al. 2001; Hildebrand and Munger 2005; Munger et al. 2005, 2008).

In March 1979, a group of four right whales was seen in Yakutat Bay (Waite et al. 2003), but there were no further reports of right whale sightings in the GOA until July 1998, when a single whale was seen southeast of Kodiak Island (Waite et al. 2003). Since 2000, several other sightings and acoustic detections have been made in the western GOA during summer (Waite et al. 2003; Mellinger et al. 2004; RPS 2011;

Wade et al. 2011a,b; Rone et al. 2014). A biologically important area (BIA) for feeding for North Pacific right whales was designated east of the Kodiak Archipelago, encompassing the GOA critical habitat and extending south of 56°N and north of 58°N and beyond the shelf edge (Ferguson et al. 2015).

South of 50ºN in the eastern North Pacific, only 29 reliable sightings were recorded from 1900–1994 (Scarff 1986, 1991; Carretta et al. 1994). Despite many miles of systematic aerial and ship-based surveys for marine mammals off the coasts of California/Oregon/Washington over the years, only seven documented sightings of right whales were made from 1990–2000 (Waite et al. 2003). Two North Pacific right whale calls were detected on a bottom-mounted hydrophone off the Washington coast on 29 June 2013 (Širović et al. 2014).

Right whales have been scarce in B.C. since 1900 (Ford 2014). In the 1900s, there were only six records of right whales for B.C., 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 only been four confirmed records. A sighting of one individual 15 km off the west coast of Haida Gwaii was made on 9 June 2013 and another sighting occurred on 25 October 2013 on Swiftsure Bank near the entrance to the Strait of Juan de Fuca (Ford 2014; Ford et al. 2016; DFO 2017a). Another sighting was made off Haida Gwaii in June 2018 (CBC 2018a), and the most recent sighting was made during DFO surveys off Haida Gwaii during June 2021 (Kloster 2021). There have been two additional unconfirmed records for B.C., including one off Haida Gwaii in 1970 and another for the Strait of Juan de Fuca in 1983 (Brownell et al. 2001; DFO 2011a; Ford 2014).

Based on the very low abundance of this species, its rarity off the coasts of B.C. and Southeast Alaska in recent decades, and the likelihood that animals would be feeding in the Bering Sea and western GOA at the time of the survey, it is possible although unlikely that a North Pacific right whale could be encountered in the proposed survey area during the period of operations.

3.3.1.2 Gray Whale (*Eschrichtius robustus*)

Two separate populations of gray whales have been recognized in the North Pacific: the eastern North Pacific and western North Pacific (or Korean-Okhotsk) stocks (LeDuc et al. 2002; Weller et al. 2013). However, the distinction between these two populations has been recently debated owing to evidence that whales from the western feeding area also travel to breeding areas in the eastern North Pacific (Weller et al. 2012, 2013; Mate et al. 2015). Thus, it is possible that whales from either the U.S. ESA-listed ***endangered*** Western North Pacific DPS or the delisted Eastern North Pacific DPS could occur in the proposed survey area.

Gray whale populations were severely reduced by whaling, and the western population has remained highly depleted, but the eastern North Pacific population is considered to have recovered. Punt and Wade (2012) estimated the eastern North Pacific population to be at 85% of its carrying capacity in 2009. The eastern North Pacific gray whale breeds and winters in Baja, California, and migrates north to summer feeding grounds in the northern Bering Sea, Chukchi Sea, and western Beaufort Sea (Rice and Wolman 1971; Rice 1998; Jefferson et al. 2015). The migration northward occurs from late February to June (Rice and Wolman 1971), with a peak into the GOA during mid-April (Braham 1984). Most gray whales follow the coast during migration and stay within 2 km of the shoreline, except when crossing major bays, straits, and inlets from Southeast Alaska to the eastern Bering Sea (Braham 1984).

Gray whales are regularly seen and detected acoustically in the western GOA during the summer (e.g., Wade et al. 2003; Calambokidis et al. 2004; Calambokidis 2007; Moore et al. 2007; Rice et al. 2015; Rone et al. 2017). A BIA for feeding gray whales has been identified in Southeast Alaska (in the waters surrounding Sitka, north of the survey area) and along the eastern coast of Kodiak Island; the Southeast

Alaska BIA is used by ~100 whales from May through November (Ferguson et al. 2015). Additionally, a gray whale migratory corridor BIA has been established extending from Unimak Pass in the western GOA to the Canadian border in the eastern GOA (Ferguson et al. 2015). Gray whales occur in this area in high densities from November through January (southbound) and March through May (northbound).

Instead of migrating to arctic and subarctic waters, some individuals spend the summer months scattered along the coast from California to Southeast Alaska (Rice and Wolman 1971; Nerini 1984; Darling et al. 1998; Calambokidis and Quan 1999; Dunham and Duffus 2001, 2002; Calambokidis et al. 2002, 2015, 2017). There is recent genetic evidence indicating the existence of this Pacific Coast Feeding Group (PCFG) as a distinct local subpopulation (Frasier et al. 2011; Lang et al. 2014); however, the status of the PCFG as a separate stock is currently unresolved (Weller et al. 2013). In Canada, three designatable units (DUs) are recognized including the Northern Pacific Migratory, PCFG, and Western Pacific populations (COSEWIC 2017). For the purposes of abundance estimates, it is defined to occur between 41°N to 52°N from 1 June to 30 November (IWC 2012); the 2015 abundance estimate was 243 whales (Calambokidis et al. 2017). Approximately 100 of those may occur in BC during summer (Ford 2014). In B.C., most summer resident gray whales are found in Clayoquot Sound, Barkley Sound, and along the southwestern shore of Vancouver Island, and near Cape Caution, on mainland B.C. off the northeastern tip of Vancouver Island; other summer residents are scattered along the mainland coast, including off Dundas Island (east of the northern tip of Haida Gwaii), and Porcher and Aristazabal islands (Ford 2014).

Gray whales are common off Haida Gwaii and western Vancouver Island (Williams and Thomas 2007), in particular during the migration. Whales travel southbound along the coast of B.C. 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 ~5 km from shore (Ford 2014), although some individuals have been sighted more than 10 km from shore (Ford et al. 2010a, 2013). Based on acoustic detections described by Meyer (2017 *in* COSEWIC 2017), the southward migration also takes place in shallow shelf waters. During surveys in B.C. waters during summer, most sightings were made within 10 km from the coast in water shallower than 100 m (Ford et al. 2010a).

After leaving the waters off Vancouver Island, gray whales typically use Hecate Strait and Dixon Entrance as opposed to the west coast of Haida Gwaii as their main migratory corridor through Southeast Alaska during the northbound migration (Ford et al. 2013); during the southbound migration, gray whales likely migrate past the outer coast of Haida Gwaii (Ford 2014; Mate et al. 2015; COSEWIC 2017). A female gray whale was reported off Haida Gwaii after traveling across the Pacific Ocean from Sakhalin Island (Ford 2014). Other sightings have also been made off the coast of Haida Gwaii, including in Dixon Entrance, Hecate Strait, and along the west coast of Haida Gwaii, including in or near the survey area during the month of August (Williams and Thomas 2007; Ford et al. 2010a; Ford 2014). Calambokidis et al. (2002) reported the results of a collaborative study to photo-identify a feeding aggregation of gray whales from California to Southeast Alaska in 1998. They completed one survey near Sitka in November 1998 and identified four individual gray whales, one of which had been identified in previous years off Washington.

The proposed surveys would occur during the summer feeding season; at this time, most individuals from the eastern North Pacific stock occur farther north; however, some individuals from the PCFG are feeding further south, and some individuals are feeding in the Southeast Alaska BIA to the north. Nonetheless, some individuals could be encountered in nearshore waters of the proposed project area; few are expected to be seen more than 10 km from shore. NOAA (2020a) has declared an unusual mortality event (UME) for gray whales in 2019–2020, as an elevated number of strandings have occurred along the coast of the Pacific Northwest since January 2019. As of 14 October 2020, a total of 384 strandings have been reported in 2019 and 2020, including 200 in the U.S. (46 in Washington; 9 in Oregon), 168 in Mexico, and 16 in B.C.; some of the whales were emaciated. UMEs for gray whales were also declared in 1999 and 2000 (NOAA 2020a).

3.3.1.3 Humpback Whale (*Megaptera novaeangliae*)

The humpback whale is found throughout all oceans of the World (Clapham 2018). Based on genetic data, there could be three subspecies, occurring in the North Pacific, North Atlantic, and Southern Hemisphere (Jackson et al. 2014). Nonetheless, genetic analyses suggest some gene flow (either past or present) between the North and South Pacific (e.g., Jackson et al. 2014; Bettridge et al. 2015). Although considered to be mainly a coastal species, humpback whales often traverse deep pelagic areas while migrating (Calambokidis et al. 2001; Garrigue et al. 2002, 2015; Zerbini et al. 2011). Humpbacks migrate between summer feeding grounds in high latitudes and winter calving and breeding grounds in tropical waters (Clapham and Mead 1999).

North Pacific humpback whales summer in feeding grounds along the Pacific Rim and in the Bering and Okhotsk seas (Pike and MacAskie 1969; Rice 1978; Winn and Reichley 1985; Calambokidis et al. 2000, 2001, 2008; 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 (Calambokidis et al. 2008; 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; NMFS 2016b). 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 (NMFS 2016b). 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 B.C. and Southeast Alaska (Calambokidis et al. 2008; Ford 2014). According to Wade (2017), ~3.8% of humpbacks occurring in Southeast Alaska and northern B.C. are likely to be from the Mexico DPS; the rest would be from the Hawaii DPS.

During summer, most eastern North Pacific humpback whales are on feeding grounds in Alaska, with smaller numbers summering off the U.S. west coast and B.C. (Calambokidis et al. 2001, 2008). Currently, two stocks of humpback whales are recognized as occurring in Alaskan waters. The Central North Pacific Stock occurs from Southeast Alaska to the Alaska Peninsula, and the Western North Pacific Stock occurs from the Aleutians to the Bering Sea and Russia. These two stocks overlap on feeding grounds in the eastern Bering Sea and the western GOA (Muto et al. 2020). Numerous feeding BIAs have been designated in the GOA, including in Southeast Alaska, where the BIAs change on a seasonal basis (Ferguson et al. 2015). During summer, the northern-most portion of the survey area occurs in a portion of the BIA.

Peak abundance in Southeast Alaska occurs during September and October (Dahlheim et al. 2009; Straley et al. 2018), but humpback whales occur in the GOA year-round (Straley 1990; Zerbini et al. 2006; Stafford et al. 2007). Hendrix et al. (2012) reported an abundance estimate of 1585 humpbacks for Southeast Alaska in 2008 based on photographic studies. Calambokidis et al. (2008) estimated the

Southeast Alaska/northern B.C. feeding aggregation to number 6000 individuals, where individuals feed on herring and euphausiids (Moran et al. 2018; Straley et al. 2018). Dahlheim et al. (2009) encountered concentrations in Icy Strait, Lynn Canal, Stephens Passage, Chatham Strait, and Frederick Sound; sightings were also made around Prince of Wale Island. MacLean and Koski (2005) reported concentrations of humpbacks in Sitka Sound, Icy Strait, and Lynn Canal during surveys of Southeast Alaska in August–September 2004; sightings were also made off Baranof Island and Prince of Wales Island, including in Dixon Entrance and Cordova Bay. During an L-DEO cruise from Oregon to Alaska, humpback whales were seen within the proposed survey area off Southeast Alaska during September (Hauser and Holst 2009). Humpbacks typically move between Glacier Bay/Icy Strait and other areas of Southeast Alaska (Baker 1986; Baker et al. 1990; Straley 1994; Straley et al. 1995). During a vessel transit to a survey area in the western GOA during June 2013, humpbacks were seen just outside of Sitka (Rone et al. 2017).

Humpback whales are common in the waters of B.C., where they occur in inshore, outer coastal, continental shelf waters, as well as offshore (Ford 2014). Williams and Thomas (2007) estimated an abundance of 1310 humpback whales in inshore coastal waters of B.C. based on surveys conducted in 2004 and 2005. Best et al. (2015) provided an estimate of 1029 humpbacks based on surveys during 2004–2008. In B.C., humpbacks are typically seen within 20 km from the coast, in water <500 m deep (Ford et al. 2010a). They were the most frequently sighted cetacean during DFO surveys in 2002–2008 (Ford et al. 2010a). The highest densities occur off Haida Gwaii, especially the eastern coast of Moresby Island and around Langara Island in Dixon Entrance (Ford et al. 2010a; Ford 2014; Harvey et al. 2017); humpbacks are also commonly seen along the west coast of Haida Gwaii (Ford et al. 2010a; Ford 2014). During past L-DEO surveys, humpback whales were seen off the west coast of Haida Gwaii during September (MacLean and Koski 2005; Hauser and Holst 2009).

The greatest numbers are seen in B.C. between April and November, although humpbacks are known to occur there throughout the year (Ford et al. 2010a; Ford 2014). Gregr et al. (2000) also presented evidence of widespread winter foraging in B.C. based on whaling records. Humpback whales are thought to belong to at least two distinct feeding stocks in B.C.; those identified off southern B.C. show little interchange with those seen off northern B.C. (Calambokidis et al. 2001, 2008). However, humpback whales from northern B.C. do interchange with those from the GOA and Southeast Alaska (Calambokidis et al. 2008). Humpback whales that feed off southern and northern B.C. migrate to several wintering grounds without a clear preference, including Mexico, Hawaii, and Ogasawara off Japan (Darling et al. 1996; Urbán et al. 2000; Calambokidis et al. 2001). Humpback whales are likely to be common in the proposed survey area, especially in nearshore waters.

3.3.1.4 Common Minke Whale (*Balaenoptera acutorostrata scammoni*)

The minke whale has a cosmopolitan distribution that spans from tropical to polar regions in both hemispheres (Jefferson et al. 2015). In the Northern Hemisphere, the minke whale is usually seen in coastal areas, but can also be seen in pelagic waters during its northward migration in spring and summer and southward migration in autumn (Stewart and Leatherwood 1985). In the North Pacific, the summer range of the minke whale extends to the Chukchi Sea; in the winter, the whales move south to within 2º of the Equator (Perrin et al. 2018).

The International Whaling Commission (IWC) recognizes three stocks of minke whales in the North Pacific: the Sea of Japan/East China Sea, the rest of the western Pacific west of 180ºN, and the remainder of the Pacific (Donovan 1991). Minke whales are relatively common in the Bering and Chukchi seas and in the GOA but are not considered abundant in any other part of the eastern Pacific (Brueggeman et al.

1990). In the far north, minke whales are thought to be migratory, but they are believed to be year-round residents in nearshore waters off west coast of the U.S. (Dorsey et al. 1990).

Although sightings have made in the western GOA (Waite 2003; Zerbini et al. 2006; Rone et al. 2017), minke whales were encountered infrequently during surveys of the inland waters of Southeast Alaska; sightings were made during spring, summer, and fall, with concentrations near the entrance of Glacier Bay (Dahlheim et al. 2009). One sighting was made in eastern Dixon Entrance during summer (Dahlheim et al. 2009). During a vessel transit to a survey area in the western GOA during June 2013, a sighting was made in pelagic waters west of Sitka (Rone et al. 2017). Low numbers of minke whales are seen regularly around Glacier Bay in Southeast Alaska and in central Icy Strait (Gabriele and Lewis 2000).

Minke whales are sighted regularly in nearshore waters of B.C., but they are not abundant (COSEWIC 2006). They are most frequently sighted around the Gulf Islands and off northeastern Vancouver Island (Ford 2014). They are also regularly seen off the east coast of Moresby Island, and in Dixon Entrance, Hecate Strait, Queen Charlotte Sound, and the west coast of Vancouver Island (Ford et al. 2010a; Ford 2014; Harvey et al. 2017); there are also several sightings off the west coast of Haida Gwaii (Ford et al. 2010a; Ford 2014). Williams and Thomas (2007) estimated minke whale abundance for inshore coastal waters of B.C. at 388 individuals based on surveys conducted in 2004 and 2005. Best et al. (2015) provided an estimate of 522 minke whales based on surveys during 2004–2008. Most sightings have been made during July and August; although most minke whales are likely to migrate south during the winter, they can be seen in B.C. waters throughout the year; however, few sightings occur from December through February (Ford 2014). Minke whales are expected to be uncommon in the proposed survey area.

3.3.1.5 Sei Whale (*Balaenoptera borealis*)

The sei whale occurs in all ocean basins (Horwood 2018), but appears to prefer mid-latitude temperate waters (Jefferson et al. 2015). It undertakes seasonal migrations to feed in subpolar latitudes during summer and returns to lower latitudes during winter to calve (Horwood 2018). The sei whale is pelagic and generally not found in coastal waters (Harwood and Wilson 2001). It occurs in deeper waters characteristic of the continental shelf edge region (Hain et al. 1985) and in other regions of steep bathymetric relief such as seamounts and canyons (Kenney and Winn 1987; Gregr and Trites 2001). On feeding grounds, sei whales associate with oceanic frontal systems (Horwood 1987) such as the cold eastern currents in the North Pacific (Perry et al. 1999a). Sei whales migrate from temperate zones occupied in winter to higher latitudes in the summer, where most feeding takes place (Gambell 1985a). During summer in the North Pacific, the sei whale can be found from the Bering Sea to the GOA and down to southern California, as well as in the western Pacific from Japan to Korea. Sightings have been made in the western GOA (RPS 2011; Rone et al. 2017). Its winter distribution is concentrated at ~20°N (Rice 1998).

Off the west coast of B.C., 4002 sei whales were caught from 1908–1967; the majority were taken from 1960–1967 during April–June (Gregr et al. 2000). The pattern of seasonal abundance suggested that the whales were caught as they migrated to summer feeding grounds, with the peak of the migration in July and offshore movement in summer, from ~25 km to ~100 km from shore (Gregr et al. 2000). Historical whaling data show that sei whales used to be distributed along the continental slope of B.C. and over a large area off the northwest coast of Vancouver Island (Gregr and Trites 2001).

Sei whales are now considered rare in Pacific waters of the U.S. and Canada; in B.C., 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 B.C., 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. 2010b). 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.

3.3.1.6 Fin Whale (*Balaenoptera physalus*)

The fin whale is widely distributed in all the World's oceans (Gambell 1985b), although it is most abundant in temperate and cold waters (Aguilar and García-Vernet 2018). Nonetheless, its overall range and distribution are not well known (Jefferson et al. 2015). A review of fin whale distribution in the North Pacific noted the lack of sightings across pelagic waters between eastern and western winter areas (Mizroch et al. 2009). Fin whales most commonly occur offshore, but can also be found in coastal areas (Jefferson et al. 2015).

Most populations migrate seasonally between temperate waters where mating and calving occur in winter, and polar waters where feeding occurs in summer (Aguilar and García-Vernet 2018). Some animals may remain at high latitudes in winter or low latitudes in summer (Edwards et al. 2015). The northern and southern fin whale populations likely do not interact owing to their alternate seasonal migration; the resulting genetic isolation has led to the recognition of two subspecies, *B. physalus quoyi* and *B. p. physalus* in the Southern and Northern hemispheres, respectively (Anguilar and García-Vernet 2018). The fin whale is known to use the shelf edge as a migration route (Evans 1987). Sergeant (1977) suggested that fin whales tend to follow steep slope contours, either because they detect them readily, or because the contours are areas of high biological productivity. However, fin whale movements have been reported to be complex (Jefferson et al. 2015). Stafford et al. (2009) noted that sea-surface temperature is a good predictor variable for fin whale call detections in the North Pacific.

North Pacific fin whales summer from the Chukchi Sea to California and winter from California southwards (Gambell 1985b). Information about the seasonal distribution of fin whales in the North Pacific has been obtained from the detection of fin whale calls by bottom-mounted, offshore hydrophone arrays along the U.S. Pacific coast, in the central North Pacific, and in the western Aleutian Islands (Moore et al. 1998, 2006; Watkins et al. 2000a,b; Stafford et al. 2007, 2009). Fin whale calls are recorded in the North Pacific year-round, including the GOA (e.g., Moore et al. 2006; Stafford et al. 2007, 2009; Edwards et al. 2015). In the central North Pacific, the GOA, and the Aleutian Islands, call rates peak during fall and winter (Moore et al. 1998, 2006; Watkins et al. 2000a,b; Stafford et al. 2009).

Sightings have also been made in the western GOA (Rice and Wolman 1982; Waite 2003; Zerbini et al. 2006). A BIA for fin whale feeding has been designated southward from the Kenai Peninsula inshore of the Kodiak Archipelago and along the Alaska Peninsula; densities of fin whales are highest in this area during June through August (Ferguson et al. 2015). Rice and Wolfman (1982) also reported sightings in the eastern GOA during June 1980. During a vessel transit to a survey area in the western GOA during June 2013, fin whales were seen just outside of Sitka (Rone et al. 2017). In Southeast Alaska, fin whales have been seen during summer near Prince of Wales Island, including northern Dixon Entrance (Dahlheim et al. 2009). Edwards et al. (2015) showed sightings off Southeast Alaska throughout the year, with most sightings reported for June to August, followed by September to November.

From 1908–1967, 7605 fin whales were caught off the west coast of B.C. by whalers; catches increased gradually from March to a peak in July, then decreased rapidly to very few in September and October (Gregr et al. 2000). Fin whales occur throughout B.C. waters near and past the continental shelf break, as well as in inshore waters (Ford 2014). Williams and Thomas (2007) estimated fin whale abundance in inland coastal B.C. waters at 496 based on surveys conducted in 2004 and 2005. Best et al. (2015) provided an estimate of 329 whales based on surveys during 2004–2008. Although fin whale records exist throughout the year, few sightings have been made from November through March (Ford 2014; Edwards et al. 2015). Fin whales were the second most common cetacean sighted during DFO surveys in 2002–2008 (Ford et al. 2010a). They are common in Dixon Entrance and in southern Hecate Strait along the east coast of Gwaii Haanas National Park Reserve (Ford 2014); sightings have also been made in Queen Charlotte Sound and the west coast of Haida Gwaii, within the proposed project area (Ford et al. 2010a; Calambokidis et al. 2003; Williams and Thomas 2007; Ford 2014).

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. 2010b). 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). Fin whales are likely to be encountered in the proposed survey area.

3.3.1.7 Blue Whale (*Balaenoptera musculus*)

The blue whale has a cosmopolitan distribution and tends to be pelagic, only coming nearshore to feed and possibly to breed (Jefferson et al. 2015). The distribution of the species, at least during times of the year when feeding is a major activity, occurs in areas that provide large seasonal concentrations of euphausiids (Yochem and Leatherwood 1985). Although it has been suggested that there are at least five subpopulations of blue whales in the North Pacific (NMFS 1998), analysis of blue whale calls monitored from the U.S. Navy Sound Surveillance System (SOSUS) and other offshore hydrophones (see Stafford et al. 1999, 2001, 2007; Watkins et al. 2000a; Stafford 2003) suggests that there are two separate populations: the eastern and central (formerly western) stocks (Carretta et al. 2020). The status of these two populations could differ substantially, as little is known about the population size in the western North Pacific (Branch et al. 2016). Blue whales from the eastern stock winter in Mexico and Central America (Stafford et al. 1999, 2001) and feed off the U.S. West Coast, as well as the GOA (Carretta et al. 2020). The central North Pacific stock feeds off Kamchatka, south of the Aleutians and in the GOA during summer (Stafford 2003; Watkins et al. 2000b) and migrates to the western and central Pacific (including Hawaii) to breed in winter (Stafford et al. 2001; Carretta et al. 2020).

In the North Pacific, blue whale calls are detected year-round (Stafford et al. 2001, 2009; Moore et al. 2002b, 2006; 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 GOA since the late 1960s (NOAA 2004a; Calambokidis et al. 2009) until blue whale calls were recorded in the area during 1999–2002 (Stafford 2003; Stafford and Moore 2005; Moore et al. 2006; 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 2003; 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 GOA concurrently (Baumann-Pickering et al. 2012; Debich et al. 2013; 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.

Before 2004, sightings of blue whales had not been documented in Alaska for at least 30 years. In July 2004, three blue whales were sighted in the GOA. The first blue whale was seen on 14 July ~185 km southeast of Prince William Sound; two more blue whales were seen ~275 km southeast of Prince William Sound (NOAA 2004a; 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 an L-DEO 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.

Whalers used to take blue whales in offshore waters of B.C.; from 1908–1967, 1398 blue whales were caught (Gregr et al. 2000). Since then, sightings have been rare (Gregr et al. 2006; Ford 2014; DFO 2017a), and there is no abundance estimate for B.C. waters (Nichol and Ford 2012). During surveys of B.C. waters from 2002–2013, 16 sightings of blue whales were made, all of which occurred just to the south or west of Haida Gwaii during June, July, and August (Ford 2014). Seventeen blue whales have been photo identified off Haida Gwaii, and three were matched with whales occurring off California (Calambokidis et al. 2004b; Nichol and Ford 2012; Ford 2014). There have also been sightings off Vancouver Island during summer and fall (Calambokidis et al. 2004b; Ford 2014); the most recent sighting was reported off southwestern Haida Gwaii in July 2019 (CBC 2019). Blue whales were regularly detected on bottom-mounted hydrophones deployed off B.C. (Sears and Calambokidis 2002). Blue whale calls off Vancouver Island begin during August, increase in September and October, continue through November–February, and decline by March (Burtenshaw et al. 2004; Ford et al. 2010b; Ford 2014). They were detected on La Pérouse Bank, off southwestern Vancouver Island, during September 2007, but no calls were detected at Union Seamount, offshore from northwestern Vancouver Island (Ford et al. 2010b). The waters off western Haida Gwaii and Dixon Entrance were identified as blue whale important areas by PNCIMAI (2011). Blue whales could be encountered in the proposed survey area, but are considered rare in the region.

3.3.2 Odontocetes

3.3.2.1 Sperm Whale (*Physeter macrocephalus*)

The sperm whale is widely distributed, occurring from the edge of the polar pack ice to the Equator in both hemispheres, with the sexes occupying different distributions (Whitehead 2018). In general, it is distributed over large temperate and tropical areas that have high secondary productivity and steep underwater topography, such as volcanic islands (Jaquet and Whitehead 1996). Its distribution and relative abundance can vary in response to prey availability, most notably squid (Jaquet and Gendron 2002). Females generally inhabit waters >1000 m deep at latitudes <40º where sea surface temperatures are <15ºC; adult males move to higher latitudes as they grow older and larger in size, returning to warm-water breeding grounds according to an unknown schedule (Whitehead 2018).

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 (Kasuya and Miyashita 1988). Most of the information regarding sperm whale distribution in the GOA (especially the eastern GOA) and Southeast Alaska has come from anecdotal observations from fishermen and reports from fisheries observers aboard commercial fishing vessels (e.g., Dahlheim 1988). Fishery observers have identified interactions (e.g., depredation) between longline vessels and sperm whales in the GOA and Southeast Alaska since at least the mid-1970s (e.g., Hill et al. 1999; Straley et al. 2005; 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 GOA. Sperm whales are commonly sighted during surveys in the Aleutians and the central and western GOA (e.g., Forney and Brownell 1996; Moore 2001; Waite 2003; Wade et al. 2003; Zerbini et al. 2004; Barlow and Henry 2005; Ireland et al. 2005; Straley et al. 2005; Rone et al. 2017). In contrast, there are fewer reports on the occurrence of sperm whales in the eastern GOA (e.g., Rice and Wolman 1982; Mellinger et al. 2004a; MacLean and Koski 2005; Rone et al. 2010).

From 1908–1967, 6158 sperm whales were caught off the west coast of B.C. They were taken in large numbers in April, with a peak in May. Analysis of data on catch locations, sex of the catch, and fetus lengths indicated that males and females were both 50–80 km from shore while mating in April and May, and that by July and August, adult females had moved to waters >100 km offshore to calve), and adult males had moved to within ~25 km of shore (Gregr et al. 2000). At least in the whaling era, females did not travel north of Vancouver Island whereas males were observed in deep water off Haida Gwaii (Gregr et al. 2000). After the whaling era, sperm whales have been sighted and detected acoustically in B.C. 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. 2010b). Sightings west of Vancouver Island and Haida Gwaii indicate that this species still occurs in B.C. 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). Sperm whales are likely to be encountered in the proposed survey area.

3.3.2.2 Cuvier’s Beaked Whale (*Ziphius cavirostris*)

Cuvier’s beaked whale is probably the most widespread and common of the beaked whales, although it is not found in high-latitude polar waters (Heyning 1989; Baird 2018a). It is rarely observed at sea and is known mostly from strandings; it strands more commonly than any other beaked whale (Heyning 1989). Cuvier’s beaked whale is found in deep water in the open ocean and over and near the continental slope (Gannier and Epinat 2008; Baird 2018a). Its inconspicuous blows, deep-diving behavior, and tendency to avoid vessels all help to explain the infrequent sightings (Barlow and Gisiner 2006).

Cuvier’s beaked whale ranges north to the GOA, including Southeast Alaska, Aleutian Islands, and Commander Islands (Rice 1986, 1998). Most reported sightings have been in the Aleutian Islands (e.g., Leatherwood et al. 1983; Forney and Brownell 1996; Brueggeman et al. 1987), but several sightings have also been made in the western GOA (Waite 2003; Rone et al. 2017). Additionally, there were 34 acoustic encounters with Cuvier's beaked whales during the 2013 towed-hydrophone survey in the western GOA (Rone et al. 2014). Cuvier's beaked whales were detected occasionally at deep-water sites (900–1000 m) during the 2011–2015 fixed-PAM studies in the U.S. Navy training area. They were infrequently detected on the slope site but more commonly detected at Pratt and Quinn seamounts; detections occurred May to July 2014 at Pratt Seamount and October 2014 to March 2015 at Quinn Seamount (Rice et al. 2015).

Records of Cuvier’s beaked whale in B.C. are scarce, although 20 strandings, one incidental catch, and five sightings have been reported (Ford 2014). For Haida Gwaii, strandings have been reported along the west and east costs, as well as Dixon Entrance, and two sightings have been made in Hecate Strait; most strandings have been reported in summer (Ford 2014). Cuvier’s beaked whales could be encountered during the proposed survey.

3.3.2.3 Baird's Beaked Whale (*Berardius bairdii*)

Baird's beaked whale has a fairly extensive range across the North Pacific north of 30˚N, and strandings have occurred as far north as the Pribilof Islands (Rice 1986). Two forms of Baird's beaked whales have been recognized – the common slate-gray form and a smaller, rare black form (Morin et al. 2017). The gray form is seen off Japan, in the Aleutians, and on the west coast of North America, whereas the black from has been reported for northern Japan and the Aleutians (Morin et al. 2017). Recent genetic studies suggest that the black form could be a separate species (Morin et al. 2017). Baird's beaked whale is currently divided into three distinct stocks: Sea of Japan, Okhotsk Sea, and Bering Sea/eastern North Pacific (Balcomb 1989; Reyes 1991). Baird's beaked whales sometimes are seen close to shore, but their primary habitat is over or near the continental slope and oceanic seamounts in waters 1000–3000 m deep (Jefferson et al. 2015).

There are numerous sighting records of Baird's beaked whale from the central GOA to the Aleutian Islands and the southern Bering Sea (Leatherwood et al. 1983; Kasuya and Ohsumi 1984; Forney and Brownell 1996; Brueggeman et al. 1987; Moore et al. 2002b; Waite 2003; Wade et al. 2003; Rone et al. 2017). Additionally, there were nine acoustic encounters with Baird's beaked whales during a 2013 towed-hydrophone survey in the GOA (Rone et al. 2014). Baird's beaked whales were detected acoustically during fixed-PAM studies in this area during 2011–2012 and 2012–2013, but not in 2014–2015 (Baumann-Pickering et al. 2012; Debich et al. 2013; Rice et al. 2015). They were detected regularly at the slope site from November through and January and at the Pratt Seamount site during most months. One sighting was made just outside of Sitka during 2013 (Rone et al. 2017).

There are whaler's reports of Baird's beaked whales off the west coast of Vancouver Island throughout the whaling season (May–September), especially in July and August (Reeves and Mitchell 1993). From 1908–1967, there was a recorded catch of 41 Baird's beaked whales, which were not favored because of their small size and low commercial value (Gregr et al. 2000). Twenty-four sightings have been made in B.C. since the whaling era, including off southwestern Haida Gwaii, near the EEZ limit west of Haida Gwaii, Queen Charlotte Sound, and off the west coast of Vancouver Island (Ford 2014). Three strandings have also been reported, including one on northeastern Haida Gwaii and two on the west coast of Vancouver Island. Baird's beaked whales could be encountered in the proposed survey area.

3.3.2.4 Stejneger's Beaked Whale (*Mesoplodon stejnegeri*)

Stejneger's beaked whale occurs in subarctic and cool temperate waters of the North Pacific (Mead 1989). Most records are from Alaskan waters, and the Aleutian Islands appear to be its center of distribution (Mead 1989; Wade et al. 2003). There have been no confirmed sightings of Stejneger's beaked whale in the GOA since 1986 (Wade et al. 2003). However, they have been detected acoustically in the Aleutian Islands during summer, fall, and winter (Baumann-Pickering et al. 2014) and were detected year-round at deep-water sites during the 2011–2015 fixed-PAM studies in the U.S. Navy training area east of Kodiak; peak detections occurred in September and October (Debich et al. 2013; Rice et al. 2015). Additionally, there were six acoustic encounters with Stejneger's beaked whales during the 2013 towed-hydrophone survey in the western GOA (Rone et al. 2014). At least five stranding records exist for B.C. (Houston 1990; Willis and Baird 1998; Ford 2014), including two strandings on the west coast of Haida Gwaii and two strandings on the west coast of Vancouver Island (Ford 2014). A possible sighting was made on the east coast of Vancouver Island (Ford 2014). Stejneger's beaked whales could be encountered during the proposed survey.

3.3.2.5 Pacific White-sided Dolphin (*Lagenorhynchus obliquidens*)

The Pacific white-sided dolphin is found in cool temperate waters of the North Pacific from the southern Gulf of California to Alaska. Across the North Pacific, it appears to have a relatively narrow distribution between 38°N and 47°N (Brownell et al. 1999). In the eastern North Pacific Ocean, the Pacific white-sided dolphin is one of the most common cetacean species, occurring primarily in shelf and slope waters (Green et al. 1993; Barlow 2003, 2010). It is known to occur close to shore in certain regions, including (seasonally) southern California (Brownell et al. 1999).

Pacific white-sided dolphins were seen throughout the North Pacific during surveys conducted during 1983–1990 (Buckland et al. 1993; Miyashita 1993), including in the proposed survey area. During winter, this species is most abundant in California slope and offshore areas (Green et al. 1992, 1993; Forney 1994; Forney et al. 1995; Buchanan et al. 2001; Barlow 2003). During the summer, Pacific white-sided dolphins occur north into the GOA and west to Amchitka in the Aleutian Islands; sightings have been documented in the spring and summer (Wade et al. 2003; Waite 2003; Rone et al. 2010, 2017). Sightings for Southeast Alaska have also been reported for spring, summer, and fall (Dahlheim and Towell 1994; Dalheim et al. 2009).

Pacific white-sided dolphins are common throughout the waters of B.C., including Dixon Entrance, Hecate Strait, Queen Charlotte Sound, the west coast of Haida Gwaii, as well as western Vancouver Island, and the mainland coast (Ford 2014). Stacey and Baird (1991) compiled 156 published and unpublished records to 1988 of the Pacific white-sided dolphin within the Canadian 320-km extended EEZ. These dolphins move inshore and offshore seasonally (Stacey and Baird 1991). There were inshore records for all months except July, and offshore records from all months except December. Offshore sightings were much more common than inshore sightings, especially in June–October; the mean water depth was ~1100 m. Ford et al. (2010a) reported that most sightings occur in water depths <500 m and within 20 km from shore. During an L-DEO cruise from Oregon to Alaska in 2008, Pacific white-sided dolphins were seen west of Haida Gwaii in mid-September during the northbound transit and in early October during the southbound transit (Hauser and Holst 2009). All sightings were made in water deeper than 1000 m (Hauser and Holst 2009). Williams and Thomas (2007) estimated an abundance of 25,900 Pacific white-sided dolphins in inshore coastal B.C. waters based on surveys conducted in 2004 and 2005. Best et al. (2015) provided an estimate of 22,160 individuals based on surveys during 2004–2008. Pacific white-sided dolphins are likely to be common in the proposed survey area.

3.3.2.6 Northern Right Whale Dolphin (*Lissodelphis borealis*)

The northern right whale dolphin is found in cool temperate and sub-arctic waters of the North Pacific, from the Gulf of Alaska to near northern Baja California, ranging from 30°N to 50°N (Reeves et al. 2002). In the eastern North Pacific Ocean, the northern right whale dolphin is one of the most common marine mammal species, occurring primarily in shelf and slope waters ~100 to >2000 m deep (Green et al. 1993; Barlow 2003). The northern right whale dolphin comes closer to shore where there is deep water, such as over submarine canyons (Reeves et al. 2002).

Northern right whale dolphins do not occur as far north as Alaska, but there have been 47 records for B.C., mostly in deep water off the west coast of Vancouver Island; however, sightings have also been made in deep water off the west coast of Haida Gwaii, as well as in the Gwaii Haanas National Marine Conservation Area (Ford 2014). Most sightings have occurred in water depths >900 m (Baird and Stacey 1991). One group of six northern right whale dolphins was sighted west of Vancouver Island in water deeper than 2500 m during a recent survey from Oregon to Alaska (Hauser and Holst 2009). Northern right whale dolphins could be encountered in the proposed survey area.

3.3.2.7 Risso's Dolphin (*Grampus griseus*)

Risso's dolphin is distributed worldwide in mid-temperate and tropical oceans (Kruse et al. 1999). although it shows a preference for mid-temperate waters of the shelf and slope between 30° and 45° (Jefferson et al. 2014). Although it occurs from coastal to deep water (~200–1000 m depth), it shows a strong preference for mid-temperate waters of upper continental slopes and steep shelf-edge areas (Hartman 2018).

Risso's dolphins are uncommon to rare in the GOA. Risso's dolphins have been sighted near Chirikof Island (southwest of Kodiak Island) and offshore in the GOA (Consiglieri et al. 1980; Braham 1983). They were detected acoustically once in January 2013, near Pratt Seamount during fixed-PAM studies from 2011–2015 in the U.S. Navy training area (Debich et al. 2013). The Department of the Navy (DoN 2014) considers this species as an occasional visitor to the GOA training area.

Risso's dolphin was once considered rare in B.C., but there have been numerous sightings since the 1970s (Ford 2014). In B.C., most sightings have been made in Gwaii Haanas National Park Reserve, Haida Gwaii, but there have also been sightings in Dixon Entrance, off the west coast of Haida Gwaii, Queen Charlotte Sound, as well as to the west of Vancouver Island (Ford 2014). Strandings have mainly been reported for the Strait of Georgia (Ford 2014). Risso's dolphins could be encountered in the proposed survey area.

3.3.2.8 Killer Whale (*Orcinus orca*)

The killer whale is cosmopolitan and globally fairly abundant; it has been observed in all oceans of the world (Ford 2018). 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 2014).

There are eight killer whale stocks recognized in the Pacific U.S.: (1) Alaska Residents, occurring from Southeast Alaska to the Bering Sea; (2) Northern Residents, from B.C. through parts of Southeast Alaska; (3) Southern Residents, mainly in inland waters of Washington State and southern B.C.; (4) Gulf of Alaska, Aleutians, and Bering Sea Transients, from Prince William Sound through to the Aleutians and Bering Sea; (5) AT1 Transients, from Prince William Sound through the Kenai Fjords; (6) West Coast Transients, from California through Southeast Alaska; (7) Offshore, from California through Alaska; and (8) Hawaiian (Carretta et al. 2020; Muto et al. 2020). Individuals from the Northern Resident; Alaska Resident; West Coast Transient; Offshore; and Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stocks could be encountered in the proposed project area. Although possible, it is unlikely that individuals from the ***endangered*** Southern Resident stock would be encountered during the proposed survey. Dalheim et al. (2009) reported sightings of killer whales during spring, summer, and fall for the inland waters of Southeast Alaska.

Alaska Resident killer whales occur in Southeast Alaska, GOA, Aleutian Islands, and the Bering Sea (Muto et al. 2020). In the past, they were considered to be the same stock as Northern Residents (Muto et al. 2020), but acoustic and genetic data confirmed that these are separate stocks (e.g., Yurk et al. 2002; Hoelzel et al. 2002). In B.C., the northern residents inhabit the central and northern Strait of Georgia, Johnstone Strait, Queen Charlotte Strait, the west coast of Vancouver Island, and the entire central and north coast of mainland B.C.; their range also extends northward to Southeast Alaska (Muto et al. 2020). Many sightings have been made in Dixon Entrance (which is designated as critical habitat) and eastern Hecate Strait, which is also considered important habitat (Ford 2014). Critical habitat for this population in B.C. also includes the waters off southwestern Vancouver Island, where both northern and southern resident killer whales often forage in the summer (Ford 2014).

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 (Ford et al. 1994; Baird 2001; Carretta et al. 2020); however, their range may extend into Southeast Alaska (Carretta et al. 2020). These aforementioned areas in B.C. and Washington have been designated as critical habitat either by the U.S. or Canada. 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). Southern resident killer whales mainly feed on salmon, in particular Chinook, and their movements coincide with those of their prey (Ford 2014).

The main diet of transient killer whales consists of marine mammals, in particular porpoises and seals (Andersen Garcia et al. 2016). Two stocks of transient killer whales could occur in the survey area. The Gulf of Alaska, Aleutian Islands, and Bering Sea transient stock is known to occur as far east as Southeast Alaska and the west coast of Haida Gwaii. Dahlheim et al. (2009) and Dalheim and White (2010) reported sightings throughout Southeast Alaska, including eastern Dixon Entrance and around Prince of Wales Island. West coast transient whales (also known as Bigg's killer whales) range from Southeast Alaska to California (Muto et al. 2020). The seasonal movements of transients are largely unpredictable, although there is a tendency to investigate harbor seal haulouts off Vancouver Island more frequently during the pupping season in August and September (Baird 1994; Ford 2014). Transients have been sighted throughout B.C. waters, including the waters around Haida Gwaii.

Little is known about offshore killer whales, but they occur primarily over shelf waters and feed on fish, especially sharks (Ford 2014). Dahlheim et al. (2008, 2009) reported sightings in Southeast Alaska during spring and summer. Relatively few sightings have been reported in the waters of B.C.; there have been 103 records since 1988 (Ford 2014). The number of sightings are likely influenced by the fact that these whales prefer deeper waters near the slope, where little sighting effort has taken place (Ford 2014). Most sightings are from Haida Gwaii, including Dixon Entrance and the west coast, and 15 km or more off the west coast of Vancouver Island near the continental slope (Ford et al. 1994). Offshore killer whales are mainly seen off B.C. during summer and off California during winter, but they can occur in B.C. waters year-round (Ford 2014). Based on surveys conducted during 2004–2008, Best et al. (2015) estimated that 371 killer whales (all ecotypes) occur in coastal waters of B.C. Killer whales could be encountered during the proposed surveys.

3.3.2.9 Harbor Porpoise (*Phocoena phocoena*)

The harbor porpoise inhabits temperate, subarctic, and arctic waters. It is typically found in shallow water (<100 m) nearshore but is occasionally sighted in deeper offshore water (Jefferson et al. 2015); abundance declines linearly as depth increases (Barlow 1988). In the eastern North Pacific, its range extends from Point Barrow, Alaska, to Point Conception, California. Their seasonal movements appear to be inshore-offshore, rather than north-south, as a response to the abundance and distribution of food resources (Dohl et al. 1983; Barlow 1988). Genetic testing has also shown that harbor porpoises along the west coast of North America are not migratory and occupy restricted home ranges (Rosel et al. 1995).

In Alaska, three stocks of harbor porpoise are currently recognized: Southeast Alaska, GOA, and Bering Sea. However, genetic variation shown by environmental DNA (eDNA) studies for the Southeast Alaska stock, indicates that this population could be comprised of multiple stocks (Parsons et al. 2018). Only the Southeast Alaska Stock could be encountered in the proposed survey area; it occurs from northern

B.C. to Cape Suckling. Harbor porpoises are sighted regularly in the eastern and central GOA and Southeast Alaska (Dahlheim et al. 2000, 2009; MacLean and Koski 2005; Rone et al. 2010, 2017). During surveys of Southeast Alaska, harbor porpoise distribution was concentrated in Icy Strait/Glacier Bay, Wrangell area, and Zarembo Island (Dahlheim et al. 2009, 2015). The highest density (0.18 animals/km^2) occurred in the region of Sumner Strait/Wrangell/Zarembo Island; Dalheim et al. (2019) noted that the patchy distribution of harbor porpoise in Southeast Alaska did not lend itself to determining a single density estimate for the entire region. The abundance was estimated to be 975 animals for Southeast Alaska based on data collected during 2010–2012.

Based on surveys conducted during 2004 and 2005, Williams and Thomas (2007) estimated that 9120 harbor porpoises are present in inshore coastal waters of B.C. Best et al. (2015) provided an estimate of 8091 based on surveys during 2004–2008. Harbor porpoises are found along the coast year-round, primarily in coastal shallow waters, harbors, bays, and river mouths of B.C. (Osborne et al. 1988), but can also be found in deep water over the continental shelf and over offshore banks that are no deeper than 150 m (Ford 2014; COSEWIC 2016a). Many sightings exist for nearshore waters surrounding Haida Gwaii and Vancouver Island (Ford 2014), including within the proposed survey area. Occasionally sightings have also been made in shallow water of Queen Charlotte Sound, Hecate Strait, and Dixon Entrance, as well as off southwestern Vancouver Island on Swiftsure and La Pérouse banks (Ford 2014). Sightings are made year-round (Ford 2014). Harbor porpoises could be encountered in shallower water in the eastern portions of the proposed survey area.

3.3.2.10 Dall's Porpoise (*Phocoenoides dalli*)

Dall's porpoise is found in temperate to subarctic waters of the North Pacific and adjacent seas (Jefferson et al. 2015). It is widely distributed across the North Pacific over the continental shelf and slope waters, and over deep (>2500 m) oceanic waters (Hall 1979). It is probably the most abundant small cetacean in the North Pacific Ocean, and its abundance changes seasonally, likely in relation to water temperature (Becker 2007). Dall's porpoise is widely distributed over shelf and slope waters, with concentrations near shelf edges, but is also commonly sighted in pelagic offshore waters (e.g., Green et al. 1992; Becker et al. 2014; Carretta et al. 2020).

Dall's porpoise occurs throughout Alaska. It was one of the most frequently sighted species during summer seismic surveys in the central and eastern GOA and Southeast Alaska (MacLean and Koski 2005; Hauser and Holst 2009; Dahlheim et al. 2009), as well as systematic surveys in GOA (e.g., Rone et al. 2014, 2017). Dahlheim et al. (2009) and Jefferson et al. (2019) reported this species to be more common in Southeast Alaska during the spring and summer than in fall; sightings in the summer were made throughout the region, including in eastern Dixon Entrance and around Baranoff and Prince of Wales islands. According to Jefferson et al. (2019), summer densities ranged from 6 to 24.4 porpoises/100 km^2, and summer abundance in Southeast Alaska was estimated at 2680 animals.

In B.C. waters, Dall's porpoise is common inshore and offshore throughout the year (Jefferson 1990; Ford 2014). It is most common over the continental shelf and slope, but also occurs >2400 km from the coast (Pike and MacAskie 1969 *in* Jefferson 1990), and sightings have been made throughout the proposed survey area (Ford 2014). There appears to be a distributional shift inshore during the summer and offshore in winter (Ford 2014). Based on surveys conducted in 2004 and 2005, Williams and Thomas (2007) estimated that there are 4910 Dall's porpoises in inshore coastal waters of B.C. High densities occur in Dixon Entrance (Harvey et al. 2017). Best et al. (2015) provided an estimate of 5303 individuals based on surveys during 2004–2008. During an L-DEO cruise from Oregon to Alaska, Dall's porpoises were sighted west of Vancouver Island and Haida Gwaii in early October during the southbound transit; all sightings were made in water deeper than 2000 m (Hauser and Holst 2009). MacLean and Koski (2005) also reported a sighting west of Haida Gwaii during August. Dall's porpoise is likely to be encountered during the proposed seismic survey.

3.3.3 Pinnipeds

3.3.3.1 Northern Fur Seal (*Callorhinus ursinus*)

The northern fur seal is endemic to the North Pacific Ocean and occurs from southern California to the Bering Sea, Okhotsk Sea, and Honshu Island, Japan (Muto et al. 2020). During the breeding season, most of the worldwide population of northern fur seals inhabits the Pribilof Islands in the southern Bering Sea (NMFS 2007; Lee et al. 2014; Muto et al. 2020). The rest of the population occurs at rookeries on Bogoslof Island in the Bering Sea, in Russia (Commander Islands, Robben Island, Kuril Islands), on San Miguel Island in southern California (NMFS 1993; Lee et al. 2014), and on the Farallon Islands off central California (Muto et al. 2020). In the U.S., two stocks are recognized—the Eastern Pacific and the California stocks (Muto et al. 2020). The Eastern Pacific stock ranges from the Pribilof Islands and Bogoslof Island in the Bering Sea during summer to California during winter (Muto et al. 2020).

When not on rookery islands, northern fur seals are primarily pelagic but occasionally haul out on rocky shorelines (Muto et al. 2020). During the breeding season, adult males usually come ashore in May–August and may sometimes be present until November; adult females are found ashore from June–November (Carretta et al. 2020; Muto et al. 2020). After reproduction, northern fur seals spend the next 7–8 months feeding at sea (Roppel 1984). Immature seals can remain in southern foraging areas year-round until they are old enough to mate (NMFS 2007). In November, females and pups leave the Pribilof Islands and migrate through the GOA to feeding areas primarily off the coasts of B.C., Washington, Oregon, and California before migrating north again to the rookeries in spring (Ream et al. 2005; Pelland et al. 2014). Pups travel through Aleutian passes and spend the first two years at sea before returning to their islands of origin.

Males usually migrate only as far south as the GOA (Kajimura 1984). Ream et al. (2005) showed that migrating females moved over the continental shelf as they migrated southeasterly. Instead of following depth contours, their travel corresponded with movements of the Alaska Gyre and the North Pacific Current (Ream et al. 2005). Their foraging areas were associated with eddies, the subarctic-subtropical transition region, and coastal mixing (Ream et al. 2005; Alford et al. 2005). Some juveniles and non-pregnant females may remain in the GOA throughout the summer (Calkins 1986). The northern fur seal spends ~90% of its time at sea, typically in areas of upwelling along the continental slopes and over seamounts (Gentry 1981). The remainder of its life is spent on or near rookery islands or haulouts.

Northern fur seals were seen throughout the North Pacific during surveys conducted during 1987–1990, including off Vancouver Island and in the western GOA (Buckland et al. 1993). Tagged adult fur seals were tracked from the Pribilof Islands to the waters off Washington/Oregon/California and B.C. with recorded movement through the proposed project area (Pelland et al. 2014). Tracked adult male fur seals that were tagged on St. Paul Island in the Bering Sea in October 2009, wintered in the Bering Sea or northern North Pacific Ocean; females migrated to the GOA and the California Current, including off the west coasts of Haida Gwaii and Vancouver Island (Sterling et al. 2014). Some individuals reach California by December, after which time numbers increase off the west coast of North America (Ford 2014). The peak density shift over the course of the winter and spring, with peak densities occurring in California in February, April off Oregon and Washington, and May off B.C. and Southeast Alaska (Ford 2014). The use of continental shelf and slope waters of B.C. and the northwestern U.S. by adult females during winter is well documented from pelagic sealing data (Bigg 1990).

Off B.C., females and subadult males are typically found during the winter off the continental shelf (Bigg 1990). They start arriving from Alaska during December and most will leave the B.C. waters by July (Ford 2014). Tagged adult female fur seals were shown to concentrate their habitat utilization within 200 km of the shelf break along the west coast of North America; several traveled through the proposed survey area off Haida Gwaii and western Vancouver Island (Pelland et al. 2014). Ford (2014) also reported the occurrence of northern fur seals throughout B.C. waters, including Dixon Entrance, Hecate Strait, Queen Charlotte Sound, and off the west coasts of Haida Gwaii and Vancouver Island, with concentrations over the shelf and slope, especially on La Pérouse Bank, southwestern Vancouver Island. A few animals are seen in inshore waters in B.C., and individuals occasionally come ashore, usually at sea lion haulouts (e.g., Race Rocks, off southern Vancouver Island) during winter and spring (Baird and Hanson 1997). Approximately 125,000 fur seals occur in B.C. over the winter and spring (Ford 2014). Although fur seals sometimes haul out in B.C., there are no breeding rookeries.

Northern fur seals, in particular juveniles, could be observed in the proposed survey area, although adult males are generally ashore at rookeries in the Bering Sea during the reproductive season from May to August, and adult females are generally ashore from June through November.

3.3.3.2 California Sea Lion (*Zalophus californianus*)

The primary range of the California sea lion includes the coastal areas and offshore islands of the eastern North Pacific Ocean from B.C. to central Mexico, including the Gulf of California (Jefferson et al. 2015). However, its distribution is expanding (Jefferson et al. 2015), and its secondary range extends into the GOA (Maniscalco et al. 2004) and southern Mexico (Gallo-Reynoso and Solórzano-Velasco 1991), where it is occasionally recorded.

California sea lion rookeries are on islands located in southern California, western Baja California, and the Gulf of California (Carretta et al. 2020). A single stock is recognized in U.S. waters, but there are five genetically distinct geographic populations (1) Pacific Temperate (includes rookeries in U.S. waters and the Coronados Islands to the south), (2) Pacific Subtropical, (3) Southern Gulf of California, (4) Central Gulf of California, and (5) Northern Gulf of California (Schramm et al. 2009). Animals from the Pacific Temperate population occur in the proposed project area.

In California and Baja California, births occur on land from mid-May to late-June. During August and September, after the mating season, the adult males migrate northward to feeding areas as far north as Washington (Puget Sound) and B.C. (Lowry et al. 1992). They remain there until spring (March–May), when they migrate back to the breeding colonies (Lowry et al. 1992; Weise et al. 2006). The distribution of immature California sea lions is less well known but some make northward migrations that are shorter in length than the migrations of adult males (Huber 1991). However, most immature seals are presumed to remain near the rookeries for most of the year, as are females and pups (Lowry et al. 1992).

California sea lions that are sighted in Alaska are typically seen at Steller sea lion rookeries or haulouts, with most sightings occurring between March and May, although they can be found in the GOA year-round (Maniscalco et al. 2004). California sea lions used to be rare in B.C., but their numbers have increased substantially during the 1970s and 1980s (Ford 2014). Wintering California sea lion numbers have increased off southern Vancouver Island since the 1970s, likely as a result of the increasing California breeding population (Olesiuk and Bigg 1984). Several thousand occur in the waters of B.C. from fall to spring (Ford 2014). Adult and subadult male California sea lions are mainly seen in B.C. during the winter

(Olesiuk and Bigg 1984). They are mostly seen off the west coast of Vancouver Island and in the Strait of Georgia, but they are also known to haul out along the coasts of Haida Gwaii, including Dixon Entrance, and the mainland (Ford 2014). California sea lions could be encountered in the proposed project area.

3.3.3.3 Steller Sea Lion (*Eumetopias jubatus*)

The Steller sea lion occurs along the North Pacific Rim from northern Japan to California (Loughlin et al. 1984). It is distributed around the coasts to the outer shelf from northern Japan through the Kuril Islands and Okhotsk Sea, through the Aleutian Islands, central Bering Sea, southern Alaska, and south to California (NOAA 2019d). There are two stocks, or DPSs, of Steller sea lions – the Western and Eastern DPSs, which are divided at 144°W longitude (Muto et al. 2020). The Western DPS is listed as ***endangered*** and includes animals that occur in Japan and Russia (Muto et al. 2020); the Eastern DPS was delisted from *threatened* in 2013 (NMFS 2013a). Although most individuals that could occur in the proposed survey area would be from the Eastern DPS, it is possible that some individuals from the Western DPS could occur in the northern portion of the proposed survey area (e.g., Jemison et al. 2013, 2017; Hastings et al. 2019).

Steller sea lions typically inhabit waters from the coast to the outer continental shelf and slope throughout their range; they are not considered migratory, although foraging animals can travel long distances (Loughlin et al. 2003; Raum-Suryan et al. 2002). Rookeries of Steller sea lions from the Eastern DPS are located in Southeast Alaska, B.C., Oregon, and California; there are no rookeries in Washington (NMFS 2013a; Muto et al. 2020). Breeding adults occupy rookeries from late-May to early-July (NMFS 2008).

Non-breeding adults use haulouts or occupy sites at the periphery of rookeries during the breeding season (NMFS 2008). Pupping occurs from mid-May to mid-July (Pitcher and Calkins 1981) and peaks in June (Pitcher et al. 2002). Territorial males fast and remain on land during the breeding season (NMFS 2008). Females with pups generally stay within 30 km of the rookeries in shallow (30–120 m) water when feeding (NMFS 2008). Tagged juvenile sea lions showed localized movements near shore (Briggs et al. 2005). Loughlin et al. (2003) reported that most (88%) at-sea movements of juvenile Steller sea lions in the Aleutian Islands were short (<15 km) foraging trips. The mean distance of juvenile sea lion trips at sea was 16.6 km, and the maximum trip distance recorded was 447 km. Long-range trips represented 6% of all trips at sea, and trip distance and duration increase with age (Loughlin et al. 2003; Call et al. 2007). Although Steller sea lions are not considered migratory, foraging animals can travel long distances outside of the breeding season (Loughlin et al. 2003; Raum-Suryan et al. 2002). During the summer, they mostly forage within 60 km from the coast; during winter, they can range up to 200 km from shore (Ford 2014).

Steller sea lions are present in Alaska year-round, with centers of abundance in the GOA 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 (Calkins et al. 1999; Raum-Suryan and Pitcher 2000; Raum-Suryan 2001; Gelatt et al. 2007; Hastings et al. 2017; 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 (Fig. 1). Numerous other haulouts occur through Southeast Alaska (Sweeney et al. 2017). During an L-DEO 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 B.C., 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. Haul outs 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 B.C., but there are currently around 30 (Ford 2014). The total pup and non-pup count of Steller sea lions in B.C. in 2002 was 15,438; this represents a minimum population estimate (Pitcher et al. 2007). The highest pup counts in B.C. occur in July (Bigg 1988). Steller sea lions could be encountered in the proposed project areas, especially in the waters closer to shore.

3.3.3.4 Northern Elephant Seal (*Mirounga angustirostris*)

The northern elephant seal breeds in California and Baja California, primarily on offshore islands, from Cedros off the west coast of Baja California, north to the Farallons in Central California (Stewart et al. 1994). Adult elephant seals engage in two long northward migrations per year, one following the breeding season, and another following the annual molt (Stewart and DeLong 1995). Between the two foraging periods, they return to land to molt, with females returning earlier than males (March–April vs. July–August). After the molt, adults then return to their northern feeding areas until the next winter breeding season. Breeding occurs from December–March (Stewart and Huber 1993). Females arrive in late December or January and give birth within ~1 week of their arrival. Juvenile elephant seals typically leave the rookeries in April or May and head north, traveling an average of 900–1000 km. Most elephant seals return to their natal rookeries when they start breeding (Huber et al. 1991).

When not at their breeding rookeries, adults feed at sea far from the rookeries. Adult females and juveniles forage in the California current off California to B.C. (Le Boeuf et al. 1986, 1993, 2000). Males may feed as far north as the eastern Aleutian Islands and the GOA, whereas females feed south of 45ºN (Le Boeuf et al. 1993; Stewart and Huber 1993). Adult male elephant seals migrate north via the California current to the GOA during foraging trips, and could potentially be passing through the waters off Washington in May and August (migrating to and from molting periods) and November and February (migrating to and from breeding periods). Northern elephant seals that were satellite-tagged at a California rookery have been recorded traveling as far west as ~175°E (Le Boeuf et al. 2000; Robinson et al. 2012), and were recorded traveling through the proposed survey area off Southeast Alaska and B.C. Post-molting seals traveled longer and farther than post-breeding seals (Robinson et al. 2012).

Race Rocks Ecological Reserve, located off southern Vancouver Island, is one of the few spots in B.C. where elephant seals regularly haul out. Based on their size and general appearance, most animals using Race Rocks are adult females or subadults, although a few adult males also haul out there. Use of Race Rocks by northern elephant seals has increased substantially in recent years, most likely as a result of the species' dramatic recovery from near extinction in the early 20th century and its tendency to be highly migratory. A peak number (22) of adults and subadults were observed in spring 2003 (Demarchi and Bentley 2004); pups have also been born there primarily during December and January (Ford 2014). Haul outs can also be found on the western and northeastern coasts of Haida Gwaii, and along the coasts of Vancouver Island (Ford 2014). Juveniles are sometimes seen molting on beaches along the coast of B.C.

from December–May, but sometimes also in summer and autumn (Ford 2014). This species could be encountered during the proposed seismic survey.

3.3.3.5 Harbor Seal (*Phoca vitulina*)

Two subspecies of harbor seal occur in the Pacific: *P.v. stejnegeri* in the northwest Pacific Ocean and *P.v. richardsi* in the eastern Pacific Ocean. *P.v. richardsi* occurs in nearshore, coastal, and estuarine areas ranging from Baja California, Mexico, north to the Pribilof Islands in Alaska (Carretta et al. 2020). Twelve stocks of harbor seals are recognized in Alaska: (1) Aleutian Islands, (2) Pibilof Islands, (3) Bristol Bay, (4) North Kodiak, (5) South Kodiak, (6) Prince William Sound, (7) Cook Inlet/Shelikof Strait, (8) Glacier Bay/Icy Strait, (9) Lynn Canal/Stephens Passage, (10) Sitka/Chatahm Strait, (11) Dixon/Cape Decision, and (12) Clarence Strait (Muto et al. 2020). Three of these stocks (Sitka/Chatham Strait, Dixon/Cape Decision, Clarence Strait) could occur in nearshore waters of the proposed survey area.

The Sitka/Chatham Strait stock ranges along Baranof Island from Cape Bingham to Cape Ommaney (directly east of a survey transect), as well as inland to Table Bay on the west side of Kuiu Island, north through Chatham Strait to Cube Point off western Admiralty Island, and east to Cape Bendel on northeastern Kupreanof Island (Muto et al. 2020). The Dixon/Cape Decision stock ranges from Cape Decision on southern Kuiu Island to Point Barrie on Kupreanof Island and south from Port Protection to Cape Chacon along western Prince of Wales Island, northwestern Dixon Entrance to Cape Muzon on Dall Island, and to Forrester Island, and including Coronation Island and all islands off western Prince of Wales Island (Muto et al. 2020). The Clarence Strait stock ranges along the eastern Prince of Wales Island from Cape Chacon north to Clarence Strait and Point Baker, and along the east coast of Mitkof and Kupreanof Islands north to Bay Point, including Ernest Sound, Behm Canal, and Pearse Canal (Muto et al. 2020).

Harbor seals inhabit estuarine and coastal waters, hauling out on rocks, reefs, beaches, and glacial ice flows. They are generally non-migratory, but move locally with the tides, weather, season, food availability, and reproduction (Scheffer and Slipp 1944; Fisher 1952; Bigg 1969, 1981). Female harbor seals give birth to a single pup while hauled out on shore or on glacial ice flows; pups are born from May to mid-July. When molting, which occurs primarily in late August, seals spend the majority of the time hauled out on shore, glacial ice, or other substrates.

Juvenile harbor seals can travel significant distances (525 km) to forage or disperse, whereas adults were generally found within 190 km of their tagging location in Prince William Sound (Lowry et al. 2001). The smaller home range used by adults is suggestive of a strong site fidelity (Pitcher and Calkins 1979; Pitcher and McAllister 1981; Lowry et al. 2001). Pups tagged in the GOA most commonly undertook multiple return trips of more than 75 km from natal areas, followed by movements of <25 km from the natal area (Small et al. 2005). Pups tagged in Prince William Sound traveled a mean maximum distance of 43.2 km from their tagging location, whereas those tagged in the GOA moved a mean maximum distance of 86.6 km (Small et al. 2005). Ford (2014) noted that harbor seals generally occur within 20 km from shore but can be seen u to 100 km from the coast.

Williams and Thomas (2007) noted an abundance estimate of 19,400 harbor seals for the inshore coastal waters of B.C. based on surveys in 2004 and 2005. Best et al. (2015) provided an abundance estimate of 24,916 seals based on coastal surveys during 2004–2008. The total population in B.C. was estimated at ~105,000 in 2008 (Ford 2014). Harbor seals occur along all coastal areas of B.C., including the western coast of Haida Gwaii and Vancouver Island, with the highest concentration in the Strait of Georgia (13.1 seals per kilometre of coast); average densities elsewhere are 2.6 seals per kilometre (Ford 2014). Almost 1400 haul outs have been reported for B.C., many of them in the Strait of Georgia

(Ford 2014). Given their preference for coastal waters, harbor seals could be encountered in the easternmost parts of the proposed project area.

3.3.4 Fissiped

3.3.4.1 Northern Sea Otter (*Enhydra lutris kenyoni*)

The northern sea otter can be found along the coast of North America from Alaska to Washington. Sea otters generally occur in shallow (<40 m), nearshore waters in areas with sandy or rocky bottoms, where they feed on a wide variety of sessile and slow-moving benthic invertebrates (Rotterman and Simon-Jackson 1988; Bodkin and Udevitz 1999; Tinker et al. 2019). Sea otters are generally not migratory and do not disperse over long distances; however, individual sea otters are capable of travelling in excess of 100 km (Garshelis and Garshelis 1984), although movements are likely limited by geographic barriers, high energy requirements of animals, and social behavior. Before commercial exploitation, the worldwide population of sea otters was estimated to be between 150,000 (Kenyon 1969) and 300,000 (Johnson 1982). Commercial exploitation reduced the total sea otter population to as low as 2000 in 13 locations (Kenyon 1969). In 1911, sea otters received protection under the North Pacific Fur Seal Convention, and populations recovered quickly (Kenyon 1969). The world sea otter population is currently estimated at ~150,000 (Davis et al. 2019).

In Alaska, three stocks or DPSs of sea otters are recognized: the Southeast Alaska Stock, Southcentral Alaska Stock, and the Southwest Alaska Stock (USFWS 2014). Only the Southeast Alaska DPS occurs in the proposed survey area. Although southern Southeast Alaska supports a greater number of otters than northern Southeast Alaska, most otters in northern Southeast Alaska occur in Glacier Bay (Tinker et al. 2019). High-density areas occur in water depths <40 m; low-density habitat consists of water <100 m deep or up to 2 km offshore (Tinker et al. 2019). During an L-DEO survey off Southeast Alaska during August–September 2004, MacLean and Koski (2005) reported 13 sightings of sea otters; sightings were made in inland waters of Baranof and Chichagof islands and deep in Yakutat Bay, all to the north of the proposed survey area. During L-DEO's STEEP seismic survey during late summer/fall 2008, two sightings of four sea otters were made in Yakutat Bay (Hauser and Holst 2009).

Sea otters were translocated from Alaska to B.C. (Bigg and MacAskie 1978). In 2013, the B.C. population was estimated to number at least 6754 individuals (DFO 2015a; Nichol et al. 2015). In B.C., sea otters regularly occur off northern and western Vancouver Island, and along the central mainland coast (Ford 2014; DFO 2015a; Nichol et al. 2015). Although most individuals occur north of Clayoquot Sound (Nichol et al. 2015), some animals occur in Barkley Sound and in the Strait of Juan de Fuca to Victoria (Ford 2014). Occasionally sightings of lone individuals (mostly males) have been made along the coast of Haida Gwaii (Ford 2014); they likely occurred off Haida Gwaii in large numbers in the past (Nichol et al. 2015). Given that in Canadian waters the survey would likely occur in water >100 m, sea otters are expected to be rare during the proposed survey. However, some sea otters could occur within the area that is ensonified by airgun sounds.

3.4 Sea Turtles

Four species of sea turtles have been reported in the waters of B.C. and Southeast Alaska: the leatherback (*Dermochelys coriacea*), green (*Chelonia mydas*), loggerhead (*Caretta caretta*), and olive ridley (*Lepidochelys olivacea*) turtles (Hodge and Wing 2000; McAlpine et al. 2004; SitNews 2007; CBC 2011a,b; Halpin et al. 2018). The leatherback turtle is uncommon in the region, although there are numerous records, in particular in B.C. There are also several records of green turtles, but the loggerhead and olive ridley turtles are extremely rare. In Alaska, there are two records of loggerheads and four records of olive ridleys (Woodford 2011). In B.C., there is a single record for the loggerhead (Halpin et al. 2018) and four records of olive ridley turtles, with the most recent one reported on 30 September 2019 (The Marine Detective 2019). The loggerhead was spotted ~45 n.mi. west of Tofino in February 2015.

However, the loggerhead and olive ridley turtles are generally warm-water species and are considered extralimital occurrences in these areas (Buchanan et al. 2001) and are not discussed further here. Thus, only leatherback turtles are likely to occur in the survey area, and green turtles could potentially occur there. Under the ESA, the leatherback turtle and the North Pacific Ocean DPS of the loggerhead turtle are listed as ***endangered***, the olive ridley population on the Pacific coast of Mexico is listed as ***endangered*** whereas other populations are listed as ***threatened***, and the East Pacific DPS of the green turtle is listed as ***threatened***. The leatherback turtle is also listed as endangered under SARA; the other turtle species are not listed. General information on the taxonomy, ecology, distribution and movements, and acoustic capabilities of sea turtles are given in § 3.4.1 of the PEIS. General distribution of sea turtles off B.C. and in the GOA are discussed in § 3.4.3.2 and 3.4.2.3 of the PEIS, respectively. The rest of this section deals specifically with their distribution within the proposed survey area in the Northeast Pacific Ocean.

3.4.1 Leatherback Turtle (*Dermochelys coriacea*)

The leatherback is the largest and most widely distributed sea turtle, ranging far from its tropical and subtropical breeding grounds to feed (Plotkin 2003). There have been significant declines and some extirpations of nesting populations in the Pacific (Spotila et al. 2000; Dutton et al. 2007). Leatherback turtles in the Pacific are divided into two genetically distinct stocks: the East Pacific stock nests at rookeries along the west coast of the Americas from Mexico to Ecuador; and the West Pacific stock nests at rookeries in Papua, Indonesia; Papua New Guinea; and the Solomon Islands (Dutton 2006; Wallace and Hutchinson 2016). The beaches of Birdshead Peninsula in Papua are the largest remaining nesting sites for leatherbacks in the Pacific Ocean (Dutton et al. 2007; Hitipeuw et al. 2007; Benson et al. 2008). Turtles that hatch during the boreal summer in the western Pacific feed and grow in the northern Pacific, including along the west coast of North America (Dutton 2006; Dutton et al. 2009; Benson 2012; Bailey et al. 2012a; Wallace and Hutchinson 2016). The West Pacific subpopulation has declined by 83% over the past three generations and continues to be threatened by human exploitation of females and eggs, low hatching success, fisheries bycatch, low foraging success, and plastic ingestion (Bailey et al. 2012b; Gregr et al. 2015; Wallace and Hutchinson 2016). Nesting beaches in the western Pacific have been estimated to have 2700–4500 breeding females (NMFS and USFWS 2013).

The leatherback turtle is the most widely distributed sea turtle, occurring from 71°N to 47°S (Eckert et al. 2012). During the non-breeding season, it ranges far from its tropical and subtropical nesting grounds, which are located between 38°N and 34°S (Dutton et al. 2009; Eckert et al. 2012). Leatherbacks feed exclusively on gelatinous zooplankton (Fossette et al. 2010, 2012; Dodge et al. 2011; Heaslip et al. 2012) and their presence has been associated with oceanic front systems, such as shelf breaks and the edges of oceanic gyre systems where their prey is concentrated (Morreale et al. 1994; Eckert 1995; Lutcavage 1996; Benson et al. 2011).

Adult leatherbacks appear to migrate along bathymetric contours from 200–3500 m (Morreale et al. 1994). Adults spend the majority of their time in water >1000 m deep and possibly swim more than 10,000 km each year (Eckert 1995). They appear to use the Kuroshio Extension during migrations from Indonesia to the high seas and eastern Pacific (Benson et al. 2008). Hatchling leatherbacks are pelagic, but nothing is known about their distribution for the first four years (Musick and Limpus 1997). Leatherback turtles undertake long migrations from the western, central, or South Pacific toward the California Current

LME (Block et al. 2011; Bailey et al. 2012a,b). Frair et al. (1972) and Greer et al. (1973) reported that leatherback turtles have evolved physiological and anatomical adaptations to cold water, allowing them to venture into higher latitudes than other species of turtle.

Leatherbacks are considered uncommon in Alaska (Hodge and Wing 2000). Nineteen occurrences of leatherbacks were documented in Alaska waters during 1960 to 1998, including within the proposed survey area off Southeast Alaska (Hodge and Wing 2000). All live occurrences were documented during July to September (Hodge and Wing 2000). In B.C., leatherbacks are considered an "uncommon seasonal resident" (McAlpine et al. 2004), and the size of the population that forages there seasonally is not known (COSEWIC 2012). Leatherbacks have been sighted off B.C. in all months except December and January, with a peak during late spring to early-fall when sea surface temperatures are highest (MacAskie and Forrester 1962; Spaven et al. 2009). Sightings of leatherbacks have been made throughout the waters of B.C., including off the coast of Haida Gwaii, Dixon Entrance, and offshore of Vancouver Island (McAlpine et al. 2004; Pacific Leatherback Turtle Recovery Team 2006; Spaven et al. 2009; Holst 2017; CBC 2018b). Thirty-two of the 118 sightings summarized by Spaven et al (2009) occurred along the north coast of B.C. and Haida Gwaii; several occurred within the proposed survey area; most records were for July–September. The majority of sightings in B.C. have been made in coastal waters, although turtles have also been sighted farther offshore in water >2000 m deep (Spaven et al. 2009; Holst 2017).

In the absence of direct observations of leatherback foraging in Pacific Canadian waters, critical feeding habitat along the Pacific coast of Canada was modelled based on habitat preferences inferred from limited sightings data and was predicted to predominantly occur along the west coast of Vancouver Island and to a lesser extent along the east coast of Haida Gwaii (Gregr et al. 2015). However, no critical habitat has been designated off the coast of B.C. The waters off the west and east coasts of Haida Gwaii were also identified as leatherback important areas by PNCIMAI (2011). Although critical habitat has been designated off the U.S. west coast off California, Oregon, and Washington, no critical habitat occurs off Alaska. Leatherback turtles could be encountered in the proposed project area.

3.4.2 Green Turtle (*Chelonia mydas*)

The green turtle is widely distributed in tropical, subtropical, and to a lesser extent, temperate waters, where it often occurs along continental coasts and around islands (SWOT 2011; Seminoff et al. 2015). Green turtles typically migrate along coastal routes from rookeries to feeding grounds, although some populations conduct trans-oceanic migrations (SWOT 2011). Hatchlings are epipelagic (surface dwelling in the open sea) for ~1–3 years. Subsequently, they live in bays and along protected shorelines and feed during the day on seagrass and algae (Bjorndal 1982). Juvenile and sub-adult green turtles may travel thousands of kilometers before they return to breeding and nesting grounds (Carr et al. 1978). Though primarily known to forage in coastal areas, adult green turtles have also been recorded feeding in oceanic waters (Hatase et al. 2006).

Movement of green turtles across the Pacific appears to be restricted by the East Pacific Barrier; thus only turtles from the East Pacific DPS are expected to occur in the eastern Pacific (Seminoff et al. 2015). The East Pacific DPS is estimated at 20,062 nesting females, ~58% of which nest in Michoacán, Mexico, and the population is likely to increase (Seminoff et al. 2015). Nesting occurs in Michoacán from August–January, with a peak in October–November (Alvarado and Figueroa 1995).

Stinson (1984) reviewed sea turtle sighting records from northern Baja California to Alaska, and reported only three sightings of green turtles for B.C. and two sightings for Alaska. Green turtles have been documented as far north as southcentral and Southeast Alaska, including the study area, where they are considered rare (Stinson 1984; Hodge and Wing 2000). Between 1960 and 2011, there were 20 reports of green sea turtles in Alaska (Woodford 2011). Hodge and Wing (2000) reported most green turtles during September to November, with live turtles recorded as late in the year as October.

Green turtles are also considered rare vagrants in B.C. waters (McAlpine et al. 2004). Most records of green turtles in B.C. have been of stranded carcasses, often relatively fresh, discovered from November–January (McAlpine et al. 2004). Two of the six records listed in McAlpine et al. (2004) occurred in the study area off the coast of Vancouver Island. Three live green turtles have recently washed ashore on Vancouver Island, all in the vicinity of the study area (CBC 2011b, 2016). A questionnaire that was sent out to commercial fisherman in 2003 reported 14 sightings of green turtles for B.C. (Spaven 2009). It is possible although unlikely that a green turtle would be encountered in the proposed project area.

3.5 Seabirds

The short-tailed albatross (*Phoebastria albatrus*) which is listed as ***endangered*** under the U.S. ESA and as *threatened* under SARA could occur in or near the proposed survey area. Although the Hawaiian petrel (*Phoebastria albatrus*) is listed as ***endangered*** under the ESA and there have been several accidental occurrences in the region, it is unlikely to be encountered during the proposed survey, but is included here for the sake of completeness. The marbled murrelet (*Brachyramphus marmoratus*) is not listed under the U.S. ESA in Alaska, although it is listed as ***threatened*** in Washington, Oregon, and California, where critical habitat has been designated. In Canada, the marbled murrelet is also listed as *threatened* under SARA. Under SARA, the pink-footed shearwater (*Puffinus creatopus*) is listed as *endangered*, and the ancient murrelet (*Synthliboramphus antiquus*) and black footed albatross (*Phoebastria nigripes*) are considered *special concern*; these species are not listed under the U.S. ESA. The USFWS recently reviewed the status of the tufted puffin (*Fratercula cirrhata*) for potential listing as a DPS range-wide in the U.S., but it was decided not to list this species as threatened or endangered at this time; the tufted puffin is not listed under SARA and is not discussed further here.

In addition to the above species, there are six species listed as *special concern* under SARA which may be encountered in the survey area. These include the offshore black-footed albatross (*Phoebastria nigripes*), Cassin's auklet (*Ptychoramphus aleuticus*), ancient murrelet (*Synthliboramphus antiquus*), nearshore horned grebe (*Podiceps auratus*), and western grebe (*Aechmophorus occidentalis*); and the red-necked phalarope (*Phalaropus lobatus*) which occurs in offshore as well as nearshore locations. In addition, both the horned puffin (*Fratercula corniculate*) and common murre (*Uria aalge*) are considered candidates for endangered or threatened status in B.C. (B.C. CDC 2019) and could also occur within the survey area.

3.5.1 Short-tailed Albatross

Historically, millions of short-tailed albatrosses bred in the western North Pacific on islands off the coast of Japan (USFWS 2008). This species was the most abundant albatross in the North Pacific. However, the entire global population was nearly wiped out during the last century by feather hunters at Japanese breeding colonies. In addition to hunting pressures, the breeding grounds of the remaining birds were threatened by volcanic eruptions in the 1930s. This species was believed to be extinct by 1949; however, breeding was detected in 1950 and 1951, aided by pelagic-dwelling maturing birds which escaped the slaughter (USFWS 2008; BirdLife International 2019a). Due to conservation and management actions the population is increasing; the most recent population estimate is 4200 individuals (Birdlife International 2019a). Current threats to this population include volcanic activity on Torishima, commercial fisheries, and pollutants (USFWS 2008). Interactions with vessels in the eastern Pacific have been noted.

Incidental take due to commercial fisheries has been documented, with one short-tailed albatross taken as bycatch off Oregon during the sablefish demersal fishery in 2011 (USFWS 2017), and 11 mortalities between 1995 and 2015 in the Alaska hook-and-line groundfish fishery (NMFS 2015; USFWS 2017).

Currently, nearly all short-tailed albatrosses breed on two islands off the coast of Japan: Torishima and Minami-kojima (USFWS 2008; BirdLife International 2019a). Single nests have been found in recent years on other islands, including Kita-Kojima, Senkaku; Yomejima Island; and Midway Island, Hawaii; however, nesting attempts in Hawaii have not been successful (USFWS 2008). During the breeding season (December–May), the highest densities are found around Japan (BirdLife International 2019a), with albatross being seen as far south (23°N) as the Northwestern Hawaiian Islands between November and April (USFWS 2008).

During the non-breeding season, short-tailed albatross roam much of the North Pacific Ocean; females spend more time offshore from Japan and Russia, whereas males and juveniles spend more time around the Aleutian Islands and Bering Sea (Suryan et al. 2007). Post-breeding dispersal occurs from April through August (USFWS 2008). After leaving the breeding areas, short-tailed albatrosses seem to spend the majority of time within the EEZs of Japan, Russia, and the U.S., primarily in the Aleutian Islands and Bering Sea (Suryan et al. 2007). They are considered a continental shelf-edge specialist (Piatt et al. 2006). Most short-tailed albatross sightings off the Pacific coast of North America (south to California) are juveniles and sub-adults (USFWS 2008; O'Connor 2013). Satellite-tracked first and second year birds were found in Oregon waters most often during winter and spring, possibly in response to ice conditions in the Bering Sea (O'Connor 2013). Sightings in the eastern North Pacific are increasing, corresponding with global population increases (COSEWIC 2013a). The short-tailed albatross could be encountered in small numbers in the proposed project area.

3.5.2 Hawaiian Petrel

The Hawaiian petrel has an estimated population size of 6000–11,000 (Birdlife International 2019b). Large declines in overall numbers and in the number of breeding colonies appear to pre-date European arrival on the Hawaiian Islands, tracing back to animal introductions, habitat modifications, and hunting by Polynesians (Simons and Hodges 1998). The population of Hawaiian petrels continues to decline, mainly because of predation by introduced vertebrates, including mongooses, cats, and goats, and due to collisions and light attraction (USFWS 2005; Raine et al. 2017).

The Hawaiian petrel is endemic to Hawaii, where it nests at high elevation. Known nesting habitats include lava cavities, burrows on cliff faces or steep slopes, and beneath ferns (USFWS 2005). The majority of eggs are laid in May and June, and most young fledge in December (Mitchell et al. 2005). Hawaiian petrels can travel up to 1300 km away from colonies during foraging trips; at-sea densities decrease with distance from the colony (Spear et al. 1995). Spear et al. (1995) showed the distribution of Hawaiian petrels to be concentrated in the southern portion of the Main Hawaiian Islands (below 20°N) during spring and autumn. The occurrence of Hawaiian petrels is likely accidental off the west coast of the U.S. Off California, where observer coverage is perhaps highest, there are records from March through September (eBird 2019). There are two accepted records of Hawaiian petrel in Washington (September 2008 and May 2014; WBRC 2018) and three in B.C. (July 2013, May 2014, and July 2014; BCBRC 2018). There is also a recent observation of a Hawaiian petrel photographed near the B.C./Alaska maritime border west of Haida Gwaii on 21 August 2019 (see https://ebird.org/view/checklist/ S59158742). It is unlikely that this species would be encountered in the proposed project area.

3.5.3 Marbled Murrelet

Marbled murrelets are widespread along the Pacific coast and are generally found in nearshore waters, usually within 5 km of shore (Nelson 1997). This species was listed as ***threatened*** under the U.S. ESA in the southern part of its range (Washington, Oregon, California) in 1992 (USFWS 1992); however, it is not listed in Alaska. The population(s) of marbled murrelets in California, Oregon, and Washington has declined by nearly 30% from 23,700 individuals in 2000 to 16,700 individuals in 2010 (Miller et al. 2012). The primary reason for declining populations is the fragmentation and destruction of old-growth forest nesting habitat. Marbled murrelets are also threatened by gillnet fishing, nest predation, and oil spills.

In the U.S. (outside of Alaska), nesting critical habitat for marbled murrelets consists of forest stands containing large trees with potential nest platforms (including large branches, deformities, mistletoe infestations) at least 10 m in height; high canopy cover is also important for nesting murrelets (USFWS 2016). Although critical habitat has been identified in B.C. adjacent to the survey area, no critical marine habitat has been designated for marbled murrelets to date, although it could be identified in B.C. in the future (B.C. Government 2018). Marbled murrelet nesting activities in B.C. and Alaska occur between late March and August, and the murrelets remain in waters off B.C. and Alaska during the non-breeding season.

Marbled murrelets feed at sea where they forage on small schooling fish and invertebrates in bays and fiords and in the open ocean (Nelson 1997). Feeding habitat for marbled murrelets is mostly within 2 km of shore in waters up to 30 m deep (USFWS 2006). Although they have been observed more than 40 km from shore in water deeper than 200 m (Adams et al. 2014), the mean offshore distance over a 3-year tracking study was 1.4 km (Hébert and Golightly 2008). Overall marbled murrelets are unlikely to occur in the offshore waters of the proposed study area; however, they can be expected on survey transects that approach within a few kilometers from shore.

3.5.4 Pink-footed Shearwater

The pink-footed shearwater is mostly found in the eastern Pacific from Chile north to Alaska, but only breeds on three islands off the coast of Chile (CEC 2005). On the breeding islands of Isla Mocha, Robinson Crusoe and Santa Clara, pink-footed shearwater populations have declined due to increased nest predation from introduced predators and humans, human disturbance, and habitat degradation (CEC 2005). The total global population is estimated at ~28,000 breeding pairs, plus non-breeders (COSEWIC 2016b), or ~59,000 individuals (BirdLife International 2019c). Up to 20,000 pink-footed shearwaters may use B.C. waters annually (COSEWIC 2016b), a potentially significant portion of the total population.

Pink-footed shearwaters are found in continental shelf (to the 200 m isobath), shelf-break, and continental slope (between the 200 and 500 m isobaths) waters of the eastern Pacific (COSEWIC 2016b). They occur off the North American coast during the northern spring, summer, and autumn, with birds returning southwards in October and November to breed off Chile (CEC 2005). Off the B.C. coast, pink-footed shearwaters are regular visitors from spring through fall, with numbers peaking in June through October (COSEWIC 2016b). Pink-footed shearwaters could be encountered within the proposed survey area.

3.6 Corals

There are 137 distinct taxa of corals that occur throughout Alaskan waters, including octocorals (89 taxa), hydrocorals (24 taxa), antipatharians (12 taxa), and scleractinian corals (12 taxa) (Stone and Cairns 2017). In the eastern GOA, the occurrence of deep corals is widespread but patchy along the shelf and slope, with a reported 46 species (Stone and Shotwell 2007). Gorgonian and cup corals are found most frequently in the region (Heifetz 2000). This includes the red tree coral (*Primnoa pacifica*) which occurs from 6 to 365 m and anecdotally as deep as 772 m, and can form dense groves, five of which were designated as HAPC in 2006 (Stone and Shotwell 2007). One of these HAPCs occurs within the survey area just west of Baranoff Island (see Fig. 1). Other important taxa that occupy this region include the gorgonian *Calcigorgia spiculifera* and the pennatulaceans *Halipteris willemoesi* and *Ptilosarcus gurneyi*, all of which can form dense thickets, as well as several species of stony corals, soft corals, antipatharians, and stylasterids (Stone and Shotwell 2007).

In general, coral diversity in the GOA is lower in deeper water, although corals may be found at depths greater than 4700 m (Alaska Science Outreach 2004; Stone and Shotwell 2007). The most diverse communities occur at 300–350 m and continue to a lesser degree down to 800 m (Alaska Science Outreach 2004). These ecologically important coral communities provide structure and refuge for fish and invertebrates, especially juveniles (Stone and Shotwell 2007). In two separate studies in the Aleutian Islands, one observed 84.7% of commercial fish and crab species were associated with corals and other epibenthic invertebrate structures (Stone 2006); the other recorded 66% of fish species were associated with some type of structure, with rockfish and Pacific cod showing an affinity for sponges (51% of fish-structure associations), rock (23%), and coral (17%) (Rooper et al. 2019). Rockfishes (*Sebastes* spp. and *Sebastolobus alascanus*) and Atka mackerel (*Pleurogrammus monopterygius*) in particular appear to be associated with gorgonian and cup corals (Heifetz 2000).

There are over 80 species of cold-water corals in the waters of B.C. (DFO 2010). There are several coral important areas off Haida Gwaii, including off the north, south, and west coasts (PNCIMAI 2011). Cold-water coral structures consist of solitary individuals or large colonies which provide habitat for fish and invertebrates (PNCIMA 2011). Although there are also sponge-dominated communities in B.C. waters, such as in Hecate Strait/Queen Charlotte Sound, none have been identified for the west coast of Haida Gwaii (PNCIMA 2011).

3.7 Fish and Marine Invertebrates, Essential Fish Habitat, and Habitat Areas of Particular Concern

3.7.1 ESA-Listed Fish Species

The term "species" under the ESA includes species, subspecies, and, for vertebrates only, DPSs or "evolutionarily significant units (ESUs)"; for Pacific salmon, ESUs are essentially equivalent to DPSs for the purpose of the ESA. Although Alaskan fish populations are not listed under the ESA, there are several ESA-listed fish species that spawn on the west coast of the Lower 48 U.S. and may occur in Alaskan and B.C. waters during the marine phases of their life cycles. Species listed as ***endangered*** include the sockeye salmon (*Oncorhynchus nerka*; Snake River ESU) and chinook salmon (*O. tshawytscha*; Upper Columbia River spring-run ESU). Species listed as ***threatened*** include the green sturgeon (*Acipenser medirostris*; Southern DPS), chum salmon (*O. keta*; Hood Canal summer-run ESU), coho salmon (*O. kisutch*; Lower Columbia River ESU), steelhead trout (*O. mykiss*; Snake River Basin DPS, Upper Willamette River DPS, and Lower, Middle, Upper Columbia River DPSs), and chinook salmon (*O. tshawytscha*; Lower Columbia River ESU, Upper Willamette River ESU, Puget Sound ESU, Snake River fall-run ESU, Snake River spring/summer-run ESU) (NOAA 2019e). There is no critical habitat for fish species in Alaska.

3.7.1.1 Salmonids

All Pacific salmon except chinook generally spend the majority of their ocean life in offshore pelagic waters, bounded by brief periods of migration through coastal areas as juveniles and returning adults.

Chinook salmon migrate through coastal areas as juveniles and returning adults, whereas adult chinook salmon undergo extensive migrations and can be found inshore and offshore throughout the North Pacific (Morrow 1980). Pacific salmon and steelhead trout typically spend the majority of their time in the upper water column while at sea (e.g., Daly et al. 2014; PFMC 2014). However, chinook typically occur at depths >30 m from the sea surface (PFMC 2014). The degree to which Pacific salmon and steelhead migrate offshore varies considerably among seasons, years, life stages and/or populations, with stronger upwelling conditions generally leading to wider dispersal from shore (Pearcy 1992). Tag recoveries from high seas fisheries indicate that chinook occur beyond the shelf break (Myers et al. 1996). Once coho salmon emigrate from freshwater, they spend at least several weeks and up to a summer season in coastal waters before migrating north and offshore (PFMC 2014). Tag recoveries from fisheries indicate that coho are distributed as far west as 175ºE (Myers et al. 1996). However, the oceanic distribution of chum salmon is likely the broadest of any Pacific salmon species; it occurs throughout the North Pacific Ocean north of Oregon/Washington (Neave et al. 1976). Sockeye are thought to follow a similar migration pattern as chum once they enter the ocean, moving north and west along the coast before moving offshore (Quinn 2005; Byron and Burke 2014). Sockeye primarily occur east of 160ºW and north of 48ºN; most fish likely depart offshore waters by early August of their second at-sea year to spawn in their natal rivers (French et al. 1976). Steelhead appear to rely on offshore waters for feeding than any other Pacific salmonids, making more extensive migrations offshore in their first year (Quinn and Myers 2004). Light et al. (1989) found that steelhead is distributed throughout the North Pacific year-round, occurring in higher abundance closer to the coasts during spring and winter and being distributed more evenly during summer and autumn. Salmon are not targeted in high seas fisheries, but are targeted in nearshore waters with troll, gillnet, and seine gear.

3.7.1.2 Green Sturgeon

The green sturgeon is distributed from Alaska to California primarily in marine waters up to 110 m deep, migrating to freshwater during the spawning season. It is found from Grave Harbor, AK, and along the entire coast of B.C. during the spring and winter months. The Rogue River, Klamath River, Eel River, Sacramento River, and Feather River have been confirmed as spawning rivers for green sturgeon in the U.S. (NMFS 2018b). There are no documented spawning rivers in Canada (COSEWIC 2004; DFO 2019f). During spawning season in the summer and fall, aggregations of green sturgeon are found in the Columbia River estuary, Willapa Bay, and Grays Harbor, WA, and in the Umpqua River estuary, OR (NMFS 2018b). There are currently no directed fisheries for green sturgeon (DFO 2019f; NOAA 2019f); however, adults are bycaught in commercial groundfish trawls and in recreational fisheries (DFO 2019f).

3.7.2 Essential Fish Habitat

Under the 1976 *Magnuson Fisheries Conservation and Management Act* (renamed *Magnuson Stevens Fisheries Conservation and Management Act* in 1996), Essential Fish Habitat (EFH) is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity". "Waters" include aquatic areas and their associated physical, chemical, and biological properties that are used by fish. "Substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities (NOAA 2019g). Under the 1976 *Magnuson Fisheries Conservation and Management Act* (renamed *Magnuson Stevens Fisheries Conservation and Management Act* in 1996), Essential Fish Habitat (EFH) is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity". "Waters" include aquatic areas and their associated physical, chemical, and biological properties that are used by fish. "Substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities (NOAA 2002). The *Magnuson*

Stevens Fishery Conservation and Management Act (16 U.S.C.§1801–1882) established Regional Fishery Management Councils and mandated that Fishery Management Plans (FMPs) be developed to manage exploited fish and invertebrate species responsibly in federal waters of the U.S. When Congress reauthorized the act in 1996 as the *Sustainable Fisheries Act*, several reforms and changes were made. One change was to charge NMFS with designating and conserving EFH for species managed under existing FMPs. EFH has been designated for groundfish species or species assemblages, salmonids, and invertebrates in different development stages in the GOA (Table 6). NSF will consult with NMFS on EFH.

3.7.3 Habitat Areas of Particular Concern

HAPC is a subset of EFH that provides important ecological functions, is especially vulnerable to degradation, or includes habitat that is rare (NOAA 2019h). In the GOA, 10 areas along the continental slope are designated as HAPCs; they are closed to bottom trawling to protect hard bottom that may be important to rockfish. These areas, which are thought to contain high relief bottom and coral communities, total 7155 km^2 (Witherell and Woodby 2005). Only one of these occurs off Southeast Alaska, but several hundred km north of the proposed survey area. There are several Habitat Protection Areas that have been designated as HAPCs that occur within (e.g., Gulf of Alaska Coral Habitat Protection Area) and near (e.g., Alaska Seamount Habitat Protection Areas) the proposed survey area. These are described below. Additionally, all trawling has been prohibited in the Southeast Alaska Trawl Closure Area east of longitude 140°W since 1998 (Witherell and Woodby 2005).

***Gulf of Alaska Coral Habitat Protection Areas*.—**These Habitat Protection Areas were established to protect coral, specifically dense aggregations of red tree corals (*Primnoa*) which are "large, branching, fragile, and very slow growing structures that enhance the complexity of bottom habitats" and serve as important areas for feeding, reproduction, and/or protection from predators for marine fish and benthic invertebrates (NOAA 2006; NPFMC 2019). There are three known sites with large aggregations of red tree corals that have been identified as HAPCs off Southeast Alaska, totaling 230 km^2 in area (Witherell and Woodby 2005). Five zones within the Habitat Protection Area, totaling 46.3 km^2 are closed to all bottom-contact fishing to protect red tree corals (NOAA 2006; NPFMC 2019). One of these Habitat Protection Areas occurs adjacent to a proposed seismic transect off southwestern Baranof Island (Fig. 1); the other two sites are located >100 km to the north.

***Alaska Seamount Habitat Protected Area*.—** The Alaska Seamount Habitat Protection Area includes the 16 seamounts in Alaskan Federal waters, all of which have been recognized as HAPCs, for a total area of 18,278 km^2; 15 of these occur within the GOA (Witherell and Woodby 2005; NPFMC 2019). These areas were established to protect seamounts, which are sensitive, structural habitats that provide shelter and are important feeding and reproduction areas for marine fish and benthic invertebrates (NOAA 2006; NPFMC 2019). Pelagic fishing gears (e.g., pelagic trawls) may be used within these areas, while bottom-contact fishing is prohibited (NOAA 2006; NPFMC 2019). Four of these Seamount Habitat Protection Areas—Denson, Dickins, Brown, and Welker—occur off Southeast Alaska, to the west of the proposed survey transects (NOAA 2006); Dickins Seamount is the closest to the survey area, located ~40 km away.

3.7.4 SARA-Listed Fish and Marine Invertebrate Species

There are two species that could occur within or near the survey area that are listed as *endangered* under SARA, including the basking shark and northern abalone (Table 7). However, northern abalone are not expected to occur in water deeper than 10 m and are not discussed further here; information regarding critical habitat was provided in Section 2.1.3. The *endangered* basking shark is the only SARA-listed fish

TABLE 6. Species with Essential Fish Habitat (EFH) in the Gulf of Alaska.

Species	Eggs	Larvae	Early Juvenile	Late Juvenile	Adult
Walleye pollock	✓	✓	-	✓	✓
Pacific cod	✓	✓	-	✓	✓
Yellowfin sole	✓	✓	-	✓	✓
Arrowtooth flounder	-	✓	-	✓	✓
Northern rock sole	-	✓	-	✓	✓
Southern rock sole	-	✓	-	✓	✓
Alaska plaice	✓	✓	-	✓	✓
Rex sole	✓	✓	-	✓	✓
Dover sole	✓	✓	-	✓	✓
Flathead sole	✓	✓	-	✓	✓
Sablefish	✓	✓	-	✓	✓
Pacific ocean perch	-	✓	-	✓	✓
Shortraker rockfish	-	-	-	-	✓
Blackspotted/rougheye rockfish	-	-	-	-	✓
Northern rockfish	-	-	-	-	✓
Thornyhead rockfish	-	✓	✓	✓	✓
Yelloweye rockfish	-	✓	✓	✓	✓
Dusky rockfish	-	✓	-	-	✓
Atka mackerel	✓	✓	-	-	✓
Sculpins	-	-	-	✓	✓
Skates	-	-	-	-	✓
Sharks	-	-	-	-	-
Forage fish complex	-	-	-	-	-
Squid	-	-	-	✓	✓
Octopus	-	-	-	-	-
Chinook salmon*	-	-	✓	✓	✓
Chum salmon*	-	-	✓	✓	✓
Coho salmon*	-	-	✓	✓	✓
Pink salmon*	-	-	✓	✓	✓
Sockeye salmon*	-	-	✓	✓	✓
Weathervane scallop	-	-	-	✓	✓

–information currently unavailable.
* Salmon egg and larval life stages not included because they occur in freshwater.
Source: Most recent FMPs, available from North Pacific Fishery Management Council website, http://npfmc.org.

TABLE 7. Marine fishes that may occur within the Study Area identified as species at risk under SARA, and their status under COSEWIC and their spatial distribution. Currently, only those species on Schedule 1 of SARA and designated as endangered or threatened are afforded protection measures.

Species	*SARA*[1,2]			COSEWIC[1]			Water Depth Range[2]	Distributional Range[2]
	E	T	SC	E	T	SC		
Marine Fish								
Basking Shark (*Cetorhinus maximus*) Pacific Ocean population	S1			X			1000	B.C. to California
Bluntnose Sixgill Shark (*Hexanchus griseus*) Pacific Ocean population			S1			X	2500	Pacific Coast including the Strait of Georgia
Green Sturgeon (*Acipenser medirostris*) Pacific Ocean population			S1			X	610	Alaska to Mexico
Longspine Thornyhead (*Sebastolobus altivelis*) Pacific Ocean population			S1			X	1600	Alaska to Baja California, Mexico
Rougheye Rockfish Type I and Type II (*Sebastes* sp.) Pacific Ocean population			S1			X	800	Alaska to southern California
Yelloweye Rockfish (*Sebastes ruberrimus*) Pacific Ocean Inside Waters population			S1			X	232	Strait of Georgia, Johnstone Strait, Queen Charlotte Strait
Pacific Ocean Outside Waters population			S1			X	232	Alaska to northern Oregon
Tope (*Galeorhinus galeus*) Pacific Ocean population			S1			X	471	Hecate Strait, B.C., to Gulf of California
Marine Invertebrates								
Northern Abalone (*Haliotis kamtschatkana*) Pacific Ocean population	S1			X			100	Alaska to Baja California, Mexico

[1] Government of Canada (2019b). E = Endangered; T = Threatened; SC = Special Concern; S1 = Schedule 1.
[2] DFO (2019e).

species that could occur in the survey area. The Canadian Pacific population has been classified as *endangered* status under the SARA since 2010 and by COSEWIC since 2007 (DFO 2019d). In addition, several other fish species are listed as *special concern* (Table 6).The basking shark is the second largest fish in the world reaching lengths of 12.2 m and an age of 50 years (DFO 2011b, 2019d). Basking sharks are slow to grow and mature, and exhibit low fecundity making them vulnerable to environmental change and anthropogenic threats. They are planktivorous and primarily filter-feed on copepod zooplankton in surface waters, where they spend ~19% of their time, along coastal shelf areas (DFO 2011b, 2019d). In Canadian Pacific waters, basking sharks are considered a migratory species that winter off California and spend the spring and summer months off B.C. (McFarlane et al. 2009 *in* DFO 2019d). Historically, basking sharks aggregated in large numbers ranging from the hundreds to the thousands in the Canadian Pacific; however, present populations may only number 321–535 individuals, and that estimate is uncertain (DFO 2019d). From 1996–2018, only 37 confirmed or reliable basking shark sightings were recorded in Canadian Pacific waters (DFO 2019d).

The main threats posed to basking sharks are primarily anthropogenic and include net entanglement, collision with vessels, harassment from marine based activities, and prey availability. Historically, net entanglement, bycatch, sport harpooning, government eradication efforts (occurring from 1942–1969), and directed fisheries (during the 1920s and 1940s) were the cause of the dramatic population decline (DFO 2009, 2011b, 2019d).

3.7.5 Rockfish Conservation Areas

***Rockfish Conservation Areas*.—**RCAs were established in 2002 to alleviate rockfish population declines. RCAs are located in marine waters along the B.C. coast. One RCA (Frederick Island) is located within the proposed survey area off northwestern Graham Island, Haida Gwaii, and several RCAs occur in eastern Hecate Strait. Inshore rockfish are protected from mortality associated with recreational and commercial fishing in the RCAs; in addition, fishery monitoring and stock assessment programs are conducted.

3.8 Fisheries

The GOA and adjacent waters of B.C. support substantial finfish resources, including groundfish, forage fish, rockfish, and salmonids, that are important to the area both biologically and economically. Additionally, there are important shellfish and invertebrate resources.

3.8.1 Biologically and Economically Important Species

3.8.1.1 Groundfish

In the GOA, walleye pollock (*Theragra chalcogramma*) occupy demersal habitats along the outer continental shelf and slope during winter. They migrate into shallower waters and aggregate for spawning in winter, with pre-spawning aggregations typically being targeted by the pelagic trawl fishery around the Shelikof Strait and Shumagin Islands. Summer fishing effort is usually focused around Kodiak Island and the Alaska Peninsula (Dorn et al. 2018). Assessment and management of walleye pollock are currently conducted separately for the eastern GOA compared to the central and western regions, and the eastern stock is not undergoing overfishing (Dorn et al. 2018).

Pacific cod (*Gadus macrocephalus*) has been an important commercial species in Alaska since 1882 (Rigby 1984). However, the Pacific cod fishery in Hecate Strait off eastern Haida Gwaii has been closed since 2001 (MaPP 2015). Pacific cod inhabit waters of the continental shelf and upper continental slope waters (100–250 m deep) in the winter (Hart 1973) and move to water <100 m deep in the summer (NOAA 2004b). Spawning generally occurs from January to April in waters 40–120 m deep (Klovach et al. 1995). Eggs and winter concentrations of adults have been found to be associated with coarse sand and cobble bottom types, and it has been inferred that this is optimal spawning habitat (Palsson 1990). Larvae and juveniles are pelagic, and there is some evidence that both larvae and juveniles are transported to nursery habitats by currents (Garrison and Miller 1982). Nursery habitats are associated with shallow water and intertidal areas with a sandy bottom and kelp or eel grass (Miller et. al. 1976). It has been suggested that, with increasing size and age, juveniles move into deeper water (Brodeur et al. 1995).

Sablefish (*Anoplopoma fimbria*), or black cod, inhabit the northeastern Pacific Ocean from northern Mexico to the GOA, westward to the Aleutian Islands, and into the Bering Sea (Wolotira et al. 1993). Adult sablefish occur along the continental slope, shelf gullies, and in deep fjords, generally at depths greater than 200 m. Sablefish observed from a manned submersible were found on or within 1 m of the bottom (Krieger 1997). In contrast to their adult distribution, juvenile sablefish (<40 cm long) spend their first two to three years on the continental shelf. Sablefish are highly migratory for at least part of their life (Heifetz and

Fujioka 1991; Maloney and Heifetz 1997; Kimura et al. 1998) and are allotted fishing quotas by region, with East Yakutat/Southeast being a subregion of the GOA with its own acceptable biological catch (Hanselman et al. 2018). In the GOA, it is harvested primarily by longline and is under an Individual Transferable Quota program in all federal waters. Some sablefish is harvested as trawl bycatch or by pot gear. Sablefish is one of the most valuable fishery in Haida Gwaii waters (MaPP 2015).

The arrowtooth flounder (*Atheresthes stomias*) is the most abundant groundfish species in the GOA, and it ranges from central California to the eastern Bering Sea (Turnock and Wilderbuer 2007) in water depths 20–800 m. Although their stock structure and migratory patterns are poorly understood, they do appear to move to deeper water as they grow (Zimmerman and Goddard 1996), but recent research suggests juveniles may be more ubiquitous across depths than previously thought (Doyle et al. 2018).

Pacific halibut (*Hippoglossus stenolepis*) spawn during the winter, primarily from December through February, off the edge of the continental shelf in waters 350–550 m deep (IPHC 1998). Males reach maturity at ~7 years of age and females at ~8 years. Females are highly fecund, laying two to three million eggs annually. Younger halibut, <10 years of age, are highly migratory and range throughout the GOA. Older halibut tend to be much less migratory; they often use both shallow and deep waters over the annual cycle, but they do not travel as much as the younger fish (IPHC 1998). This species is managed internationally by the International Pacific Halibut Commission (IPHC) and the North Pacific Fishery Management Council (NPFMC). The largest fisheries occur in the GOA, with smaller fisheries in the Bering Sea. In Alaska, halibut are harvested by longline gear only, and the fishery is conducted as an Individual Transferable Quota fishery. Longlining for halibut is one of the most valuable fisheries in Haida Gwaii waters (MaPP 2015).

Other economically and ecologically important groundfish that are found in the Southeast GOA include Atka mackerel (*Pleurogrammus monopterygius*), several species of flatfish, as well as sculpins, skates, and sharks (NPFMC 2015). These species generally are in the same habitats as the previously discussed groundfish species and are often food sources for other fish, birds, and mammals.

3.8.1.2 Forage Fish

Pacific herring (*Clupea pallasii*) is an abundant and widespread forage fish in the GOA. In Gwaii Haanas, however, numbers are depressed, but there is a fishery for herring roe-on-kelp in northern Haida Gwaii (MaPP 2015). Herring are critical prey for a variety of fishes, mammals, and birds. Herring migrate in large schools and generally spawn in the spring (mid-March) in Southeast Alaska. A major spawning stock occurs in Gwaii Haanas, and a minor stock is located on the west coast of Haida Gwaii (MaPP 2015). After spawning, most adults leave inshore waters and move seaward to feed primarily on zooplankton such as copepods and other crustaceans. Herring are seasonal feeders and accumulate fat reserves for periods of relative inactivity. Herring schools often demonstrate a diel vertical migration, spending daylight hours near the seafloor and moving upward during the evening to feed (ADF&G 2007). In Alaska, the largest commercial catches of Pacific herring from 2007 to 2011 occurred in Sitka Sound in Southeast Alaska (Ormseth et al. 2016).

Other forage fish found in the region that are critical food sources to marine mammals, seabirds, and larger fish species include eulachon (*Thaleichthys pacificus*), capelin (*Mallotus villosus*), Pacific sandlance (*Ammodytes hexapterus*), Pacific sandfish (*Trichodon trichodon*), and pricklebacks (*Stichaeidae* sp.), gunnels (*Pholidae* sp.), lanternfishes (*Myctophidae* sp.), blacksmelts (*Bathylagidae* sp.), and bristlemouths (*Gonostomatidae* sp.) (Ormseth et al. 2016). Eulachon are a small species of smelt that spend 95% of their lives in the marine environment, migrating to freshwater rivers to spawn. Their marine range extends from the Bering Sea to California. Eulachon have been reported to spawn in at least 40 rivers in B.C. (Schweigert et al. 2012); spawning occurs after three years, typically in coastal rivers that are associated with glaciers or snowpacks (COSEWIC 2011). Eulachon has an exceptionally high lipid content (~20%) and is an important species in First Nation Food, Social, and Ceremonial (FSC) fisheries (Schweigert et al. 2012). In B.C., eulachon are bycaught in commercial groundfish and shrimp trawls and in pelagic hake nets; however, there is no targeted commercial or recreational fishery (COSEWIC 2011). Eulachon important areas were identified in southern Dixon Entrance by PNCIMAI (2011).

3.8.1.3 Rockfish

Rockfishes (*Sebastes* spp.) range from southern California to the Bering Sea. At least 30 rockfish species inhabit Alaskan waters, many of which support significant fisheries, with Pacific ocean perch (*S. alutus*) being the most common. Pacific ocean perch release their larvae in winter. Larvae and juveniles are pelagic until joining adults in demersal habitats after two or three years. Adults are found primarily on the outer continental shelf and the upper continental slope in depths 150–420 m. In the summer, adults inhabit shallower depths, especially 150–300 m; in the fall, they migrate farther offshore to depths of ~300–420 m. They stay at these deeper depths until about May, when they return to their shallower summer depths (Love et al. 2002; Hanselman et al. 2007). In 1998, a prohibition on rockfish trawling was imposed for the GOA east of 140ºW longitude; rockfish in the GOA are primarily caught in the western region and along the Aleutian Islands.

There are 37 species of rockfish that are typically caught by hook and line in rocky reef habitat along the B.C. coast (DFO 2015b). Inshore rockfish are found at shallow depth, but may occur in water as deep as 600 m; they include yelloweye, quillback, *S. maliger*; copper, *S. caurinus*; china, *S. nebulosus*; and tiger rockfish, *S. nigrocinctus* (DFO 2018b). Shelf species (e.g., bank, *S. rufus*; canary; bocaccio) are typically found in intermediate depths, but also occur at depths up to 600 m (DFO 2018b). Slope species are found at depths of 100–2000 m, and include the Pacific ocean perch (DFO 2018b). Although none of the rockfish species are listed as *endangered* or *threatened* under SARA, rougheye rockfish (e.g., *S. aleutianus*) and yelloweye rockfish are considered *special concern* (Table 7).

3.8.1.4 Shellfish

Crab, shrimp, other crustaceans, and mollusks are harvested from Alaskan and B.C. waters. All these species, grouped in this document as shellfish, inhabit benthic regions as adults, but can occupy pelagic waters as larvae. The most lucrative of the Alaska shellfish fisheries is the crab fishery. Three species of king crab (red, *Paralithodes camtschaticus*; blue, *P. platypus*; golden, *Lithodes aequispinus*) and two species of Tanner crab (Tanner, *Chionoecetes bairdi*; snow, *C. opilio*) occur in the GOA, primarily in central and western regions. The waters off western Haida Gwaii were idenified as Tanner crab important areas by PNCIMAI (2011). The Dungeness crab (*Metacarcinus magister*) fishery on the northeast coast of Graham Island is a valuable fishery on the Haida Gwaii coast (MaPP 2015).

Pandalus shrimp, Geoduck clam (*Panopea generosa*), spot prawn (*Pandalus platyceros*), and Weathervane scallop (*Patinopecten caurinus*) are also important shellfish resources in Alaska. Geoduck clams, California sea cucumber (*Parastichopus californicus*), red sea urchin (*Mesocentrotus franciscanus*), and green sea urchin (*Strongylocentrotus droebachiensis*) are harvested in small hand-pick dive fisheries in the GOA. Traditionally there is also a dive fishery in Alaska for pinto abalone (*Haliotis kamschatkana*), which is now closed commercially (ADF&G 2019a). Geoduck and red sea urchin are also harvested off Haida Gwaii, but there are currently no active dive fisheries for sea cucumber, northern abalone, and green sea urchin (MaPP 2015). Additional species taken off Haida Gwaii include razor clam (*Siliqua patula*) and prawn (MaPP 2015).

3.8.2 Commercial Fisheries

In the North American Pacific Fijordland Marine Ecoregion which stretches from northern Vancouver Island, B.C., to the waters of Southeast Alaska, the primary fish species recorded during 2014 included Alaska pollock (71 t), Pacific cod (29 t), sockeye salmon (26 t), Pacific herring (21 t), pink salmon (13 t), Pacific halibut (6 t), chum salmon (5 t), chinook salmon (4 t), flatfishes (4 t), and coho salmon (2 t); other species account for 91 t of the total catch (Sea Around Us 2016). Historically, Pacific herring was the primary species caught; however landings significantly decreased in 1960s from ~356 t to 12 t in 1970. Alaska pollock landings started to increase during the 1980s and have continued to rise to present day levels (Sea Around Us 2016). In B.C., harvests for commercial pelagic species are primarily taken using mobile gear such as seines, gillnets, and trawls, and fixed gear such as longlines and baited handlines (DFO 2019b). In the GOA, most fishing occurs over the relatively narrow continental shelf and slope.

3.8.3 Indigenous Fisheries

Subsistence fisheries and hunting make up 0.9% of all harvest of fish and game statewide in Alaska, compared to 98.6% taken by commercial fisheries (Fall 2018). Although a small sector overall, subsistence fishing provides crucial sustenance for local communities, on average providing ~276 pounds of food per person per year in rural Alaska (Fall 2018). Of the estimated 34 million pounds of wild foods harvested in rural Alaska communities annually, finish contribute 53.7% from finfish and 3.1% from shellfish (Fall 2018).

In the rural communities along the GOA, salmon species are the most targeted subsistence fish, making up 32.3% of total subsistence harvests (Fall 2018). In 2016, 897,269 salmon were harvested by subsistence fishers in Alaska (Fall et al. 2019). Most of the salmon harvest consisted of sockeye salmon (37%), followed by chum (36%), coho (10%), chinook (9%), and pink (8%) (Fall et al. 2019). The southeastern management area took 5% of the total subsistence salmon harvest in 2016 (Fall et al. 2019).

In 2016, the subsistence catch of halibut made up 2.3% of the total harvest, with 4408 subsistence fishers taking 36,815 halibut, totaling 727,178 pounds (Fall and Koster 2018). The majority of the catch (71%) was taken by setline, and 29% was taken by hand-operated fishing gear (Fall and Koster 2018). Regulatory area 2C (Southeast Alaska) took the greatest percentage of the harvest (37%) (Fall and Koster 2018).

In Canada, subsistence fishing activity is known as "Food, Social, and Ceremonial (FSC)" harvesting and is practiced by indigenous groups. Salmon are the main species harvested by First Nations in FSC fisheries due to their nutritional, cultural, and spiritual significance (Weatherdon et al. 2016). In addition to salmon, the edible red algae (*Porphyra abbottae*) is a nutritionally and culturally important species that is harvested all along the coast of B.C. On Haida Gwaii, it is harvested in May (Turner 2003).

3.8.4 Recreational Fisheries

Recreational fisheries in Alaska are a small but economically valuable sector, taking ~0.2% of total fisheries harvests in 2017 (Fall 2018). In 2018 in the Southeast Alaska Region, 133,401 anglers fished a total of 508,601 angler-days (ADF&G 2019b). The largest portions of recreational harvest by numbers of fish in 2018 were the five species of salmon (~1 million), halibut (351,842), and rockfish (309,117) (ADF&G 2019b). Other major fish species targeted were sablefish, lingcod, Pacific cod, Arctic char, and rainbow trout (ADF&G 2019b).

Since the mid-1980s recreational fishing has been increasing on Haida Gwaii and is one of the largest tourism-related activities; as many as 100,000 angler days were recorded during a 2010 survey generating ~$56 million for B.C. (MaPP 2015). The main species that contribute to the recreational fishery include coho and chinook salmon, and Pacific halibut (MaPP 2015; DFO 2019c). Other species of finfish are also caught recreationally, in addition to bivalve shellfish, crabs, and other invertebrates (DFO 2019c).

3.8.5 Aquaculture

The *Aquatic Farming Act* was approved in Alaska in 1988, allowing for the culture of indigenous shellfish and aquatic plants in nearshore waters. The culture of finfish is prohibited. In 2015, there were 74 permitted operations, including 65 aquatic farms, seven hatcheries, and two nurseries, 49 of which were located in Southeast Alaska in inland bays, straits, and inlets. The 2015 inventory of primary cultured species includes Pacific oyster (15.2 million oysters; 63% of total farm production), blue mussel (8 million), and geoduck clam (910,926). Littleneck clam and several species of urchin, scallop, cockle, and sea cucumber are also produced by permitted operations. Production of several species of kelp and seaweed is becoming a viable part of the aquaculture industry as well. Sales of shellfish and aquatic plants from all operations totaled $1.13 million in 2015 (ADF&G 2016).

Shellfish aquaculture has been practiced on Haida Gwaii since the mid-1980s; Pacific oysters (*Crassostrea gigas*), blue and Gallo mussels (*Mytilus edulis* and *M. galloprovincialis*), Japanese scallops (*Patinopecten yessoensis*), sea cucumber (*Parastichopus californicus*), and geoduck (*Panope abrupta*) are harvested. In 2016, there were 7 licensed shellfish aquaculture facilities on Haida Gwaii near Skidgate, and 4 on the central coast in the vicinity of Queen Charlotte Sound (DFO 2019a). Wild aquatic plants are harvested primarily for the spawn-on-kelp herring fishery, where herring gather to spawn from mid-March to mid-April and their eggs adhere to the blades of kelp, such as giant kelp (*Macrocystis integrifolia*) and bull kelp (*Nerocystis leutkeana*) (DFO 2019b). Extensive kelp beds on the north coast of Graham Island in Haida Gwaii were quantified during the 1976 kelp inventory (Coon et al. 1979). In 2016, there were 10 licensed marine finfish aquaculture facilities in the vicinity of Queen Charlotte Sound; two facilities were on the north end of Vancouver Island, and eight were on the central coast of B.C. (DFO 2019a).

3.9 Cultural Resources

Recreational SCUBA diving occurs in the Southeast Alaska with local dive charters operating in Sitka, Ketchikan, and Juneau. Popular dive sites are primarily located in bays and inlets within reach of shore of several islands from Baranof Island to Haida Gwaii. Several shipwrecks exist in the GOA, but are not frequented as dive sites.

In B.C., ~24,400 divers were estimated to have used the services of dive charter operators in 2003. and the recreational dive charter market was valued at $2,700,000 gross revenues per year (DIABC 2004). Off Haida Gwaii, SCUBA diving makes up 1% of the total number of tourism activities and services (PLC 2006). Between 1786 and 1998, 244 known shipwrecks occurred around Haida Gwaii though only 144 mapped locations have been made public to prevent damage and looting (MaPP 2019). Developments along the coast and inshore of Haida Gwaii, including marine tourism, marine pollution, fishing activities, and infrastructure expansion may threaten cultural and archaeological sites and areas (MaPP 2015).

IV Environmental Consequences

4.1 Proposed Action

4.1.1 Direct Effects on Marine Mammals and Sea Turtles and Their Significance

The material in this section includes a summary of the expected potential effects (or lack thereof) of airgun sounds on marine mammals and sea turtles given in the PEIS, and reference to recent literature that has become available since the PEIS was released in 2011. A more comprehensive review of the relevant background information appears in § 3.4.4.3, § 3.6.4.3, § 3.7.4.3, § 3.8.4.3, and Appendix E of the PEIS. Relevant background information on the hearing abilities of marine mammals and sea turtles can also be found in the PEIS. This section also includes estimates of the numbers of marine mammals that could be affected by the proposed seismic surveys. A description of the rationale for NSF's estimates of the numbers of individuals exposed to received sound levels ≥160 dB re 1 μPa_{rms} is also provided.

4.1.1.1 Summary of Potential Effects of Airgun Sounds

As noted in the PEIS (§ 3.4.4.3, § 3.6.4.3, § 3.7.4.3, § 3.8.4.3), the effects of sounds from airguns could include one or more of the following: tolerance, masking of natural sounds, behavioral disturbance, and at least in theory, temporary or permanent hearing impairment, or non-auditory physical or physiological effects (Richardson et al. 1995; Gordon et al. 2004; Nowacek et al. 2007; Southall et al. 2007; Erbe 2012; Peng et al. 2015; Erbe et al. 2016; Kunc et al. 2016; National Academies of Sciences, Engineering, and Medicine 2017; Weilgart 2017a). In some cases, a behavioral response to a sound can reduce the overall exposure to that sound (e.g., Finneran et al. 2015; Wensveen et al. 2015).

Permanent hearing impairment (PTS), in the unlikely event that it occurred, would constitute injury (Southall et al. 2007; Le Prell 2012). Physical damage to a mammal's hearing apparatus can occur if it is exposed to sound impulses that have very high peak pressures, especially if the impulses have very short rise times (e.g., Morell et al. 2017). However, the impulsive nature of sound is range-dependent, becoming less harmful over distance from the source (Hastie et al. 2019). TTS is not considered an injury (Southall et al. 2007; Le Prell 2012). Rather, the onset of TTS has been considered an indicator that, if the animal is exposed to higher levels of that sound, physical damage is ultimately a possibility. Nonetheless, research has shown that sound exposure can cause cochlear neural degeneration, even when threshold shifts and hair cell damage are reversible (Kujawa and Liberman 2009; Liberman et al. 2016). These findings have raised some doubts as to whether TTS should continue to be considered a non-injurious effect (Weilgart 2014; Tougaard et al. 2015, 2016). Although the possibility cannot be entirely excluded, it is unlikely that the proposed surveys would result in any cases of temporary or permanent hearing impairment, or any significant non-auditory physical or physiological effects. If marine mammals encounter a survey while it is underway, some behavioral disturbance could result, but this would be localized and short-term.

***Tolerance*.—**Numerous studies have shown that pulsed sounds from airguns are often readily detectable in the water at distances of many kilometers (e.g., Nieukirk et al. 2012). Several studies have shown that marine mammals at distances more than a few kilometers from operating seismic vessels often show no apparent response. That is often true even in cases when the pulsed sounds must be readily audible to the animals based on measured received levels and the hearing sensitivity of that mammal group. Although various baleen and toothed whales, and (less frequently) pinnipeds have been shown to react behaviorally to airgun pulses under some conditions, at other times mammals of all three types have shown no overt reactions. The relative responsiveness of baleen and toothed whales are quite variable.

***Masking*.—**Masking effects of pulsed sounds (even from large arrays of airguns) on marine mammal calls and other natural sounds are expected to be limited, although there are few specific data on this. Because of the intermittent nature and low duty cycle of seismic pulses, animals can emit and receive sounds in the relatively quiet intervals between pulses. However, in exceptional situations, reverberation occurs for much or all of the interval between pulses (e.g., Simard et al. 2005; Clark and Gagnon 2006), which could mask calls. Situations with prolonged strong reverberation are infrequent. However, it is common for reverberation to cause some lesser degree of elevation of the background level between airgun pulses (e.g., Gedamke 2011; Guerra et al. 2011, 2016; Klinck et al. 2012; Guan et al. 2015), and this weaker reverberation presumably reduces the detection range of calls and other natural sounds to some degree. Guerra et al. (2016) reported that ambient noise levels between seismic pulses were elevated as a result of reverberation at ranges of 50 km from the seismic source. Based on measurements in deep water of the Southern Ocean, Gedamke (2011) estimated that the slight elevation of background levels during intervals between pulses reduced blue and fin whale communication space by as much as 36–51% when a seismic survey was operating 450–2800 km away. Based on preliminary modeling, Wittekind et al. (2016) reported that airgun sounds could reduce the communication range of blue and fin whales 2000 km from the seismic source. Kyhn et al. (2019) reported that baleen whales and seals were likely masked over an extended period of time during four concurrent seismic surveys in Baffin Bay, Greenland. Nieukirk et al. (2012), Blackwell et al. (2013), and Dunlop (2018) also noted the potential for masking effects from seismic surveys on large whales,

Some baleen and toothed whales are known to continue calling in the presence of seismic pulses, and their calls usually can be heard between the pulses (e.g., Nieukirk et al. 2012; Thode et al. 2012; Bröker et al. 2013; Sciacca et al. 2016). Cerchio et al. (2014) suggested that the breeding display of humpback whales off Angola could be disrupted by seismic sounds, as singing activity declined with increasing received levels. In addition, some cetaceans are known to change their calling rates, shift their peak frequencies, or otherwise modify their vocal behavior in response to airgun sounds (e.g., Di Iorio and Clark 2010; Castellote et al. 2012; Blackwell et al. 2013, 2015). The hearing systems of baleen whales are undoubtedly more sensitive to low-frequency sounds than are the ears of the small odontocetes that have been studied directly (e.g., MacGillivray et al. 2014). The sounds important to small odontocetes are predominantly at much higher frequencies than are the dominant components of airgun sounds, thus limiting the potential for masking. In general, masking effects of seismic pulses are expected to be minor, given the normally intermittent nature of seismic pulses. We are not aware of any information concerning masking of hearing in sea turtles.

***Disturbance Reactions*.—**Disturbance includes a variety of effects, including subtle to conspicuous changes in behavior, movement, and displacement. Based on NMFS (2001, p. 9293), National Research Council (NRC 2005), and Southall et al. (2007), we believe that simple exposure to sound, or brief reactions that do not disrupt behavioral patterns in a potentially significant manner, do not constitute harassment or "taking". By potentially significant, we mean, 'in a manner that might have deleterious effects to the well-being of individual marine mammals or their populations'.

Reactions to sound, if any, depend on species, state of maturity, experience, current activity, reproductive state, time of day, and many other factors (Richardson et al. 1995; Wartzok et al. 2004; Southall et al. 2007; Weilgart 2007; Ellison et al. 2012, 2018). If a marine mammal does react briefly to an underwater sound by changing its behavior or moving a small distance, the impacts of the change are unlikely to be significant to the individual, let alone the stock or population (e.g., New et al. 2013a). However, if a sound source displaces marine mammals from an important feeding or breeding area for a prolonged period, impacts on individuals and populations could be significant (Lusseau and Bejder 2007;

Weilgart 2007; New et al. 2013b; Nowacek et al. 2015; Forney et al. 2017). Some studies have attempted modeling to assess consequences of effects from underwater noise at the population level (e.g., King et al. 2015; Costa et al. 2016a,b; Ellison et al. 2016; Harwood et al. 2016; Nowacek et al. 2016; Farmer et al. 2017).

Given the many uncertainties in predicting the quantity and types of impacts of noise on marine mammals, it is common practice to estimate how many marine mammals would be present within a particular distance of industrial activities and/or exposed to a particular level of industrial sound. In most cases, this approach likely overestimates the numbers of marine mammals that would be affected in some biologically important manner. The sound criteria used to estimate how many marine mammals could be disturbed to some biologically important degree by a seismic program are based primarily on behavioral observations of a few species. Detailed studies have been done on humpback, gray, bowhead, and sperm whales. Less detailed data are available for some other species of baleen whales and small toothed whales, but for many species, there are no data on responses to marine seismic surveys.

Baleen Whales

Baleen whales generally tend to avoid operating airguns, but avoidance radii are quite variable. Whales are often reported to show no overt reactions to pulses from large arrays of airguns at distances beyond a few kilometers, even though the airgun pulses remain well above ambient noise levels out to much longer distances. However, baleen whales exposed to strong noise pulses from airguns often react by deviating from their normal migration route and/or interrupting their feeding and moving away. In the cases of migrating gray and bowhead whales, the observed changes in behavior appeared to be of little or no biological consequence to the animals. They simply avoided the sound source by displacing their migration route to varying degrees, but within the natural boundaries of the migration corridors (Malme et al. 1984; Malme and Miles 1985; Richardson et al. 1995).

Responses of *humpback whales* to seismic surveys have been studied during migration, on summer feeding grounds, and on Angolan winter breeding grounds; there has also been discussion of effects on the Brazilian wintering grounds. Off Western Australia, avoidance reactions began at 5–8 km from the array, and those reactions kept most pods ~3–4 km from the operating seismic boat; there was localized displacement during migration of 4–5 km by traveling pods and 7–12 km by more sensitive resting pods of cow-calf pairs (McCauley et al. 1998, 2000). However, some individual humpback whales, especially males, approached within distances of 100–400 m.

Dunlop et al. (2015) reported that migrating humpback whales in Australia responded to a vessel operating a 20 in^3 airgun by decreasing their dive time and speed of southward migration; however, the same responses were obtained during control trials without an active airgun, suggesting that humpbacks responded to the source vessel rather than the airgun. A ramp up was not superior to triggering humpbacks to move away from the vessel compared with a constant source at a higher level of 140 in^3, although an increase in distance from the airgun(s) was noted for both sources (Dunlop et al. 2016a). Avoidance was also shown when no airguns were operational, indicating that the presence of the vessel itself had an effect on the response (Dunlop et al. 2016a,b). Overall, the results showed that humpbacks were more likely to avoid active small airgun sources (20 and 140 in^3) within 3 km and received levels of at least 140 dB re 1 $\mu Pa^2 \cdot s$ (Dunlop et al. 2017a). Responses to ramp up and use of a large 3130 in^3 array elicited greater behavioral changes in humpbacks when compared with small arrays (Dunlop et al. 2016c). Humpbacks deviated from their southbound migration when they were within 4 km of the active large airgun source, where received levels were >130 dB re 1 $\mu Pa^2 \cdot s$ (Dunlop et al. 2017b, 2018). These results are consistent with earlier studies (e.g., McCauley et al. 2000).

In the northwest Atlantic, sighting rates were significantly greater during non-seismic periods compared with periods when a full array was operating, and humpback whales were more likely to swim away and less likely to swim towards a vessel during seismic vs. non-seismic periods (Moulton and Holst 2010). In contrast, sightings of humpback whales from seismic vessels off the U.K. during 1994–2010 indicated that detection rates were similar during seismic and non-seismic periods, although sample sizes were small (Stone 2015). On their summer feeding grounds in southeast Alaska, there was no clear evidence of avoidance, despite the possibility of subtle effects, at received levels up to 172 re 1 μPa on an approximate rms basis (Malme et al. 1985). It has been suggested that South Atlantic humpback whales wintering off Brazil may be displaced or even strand upon exposure to seismic surveys (Engel et al. 2004), but data from subsequent years indicated that there was no observable direct correlation between strandings and seismic surveys (IWC 2007).

There are no data on reactions of *right whales* to seismic surveys. However, Rolland et al. (2012) suggested that ship noise causes increased stress in right whales; they showed that baseline levels of stress-related faecal hormone metabolites decreased in North Atlantic right whales with a 6-dB decrease in underwater noise from vessels. Wright et al. (2011), Atkinson et al. (2015), Houser et al. (2016), and Lyamin et al. (2016) also reported that sound could be a potential source of stress for marine mammals.

Bowhead whales show that their responsiveness can be quite variable depending on their activity (migrating vs. feeding). Bowhead whales migrating west across the Alaskan Beaufort Sea in autumn, in particular, are unusually responsive, with substantial avoidance occurring out to distances of 20–30 km from a medium-sized airgun source (Miller et al. 1999; Richardson et al. 1999). Subtle but statistically significant changes in surfacing–respiration–dive cycles were shown by traveling and socializing bowheads exposed to airgun sounds in the Beaufort Sea, including shorter surfacings, shorter dives, and decreased number of blows per surfacing (Robertson et al. 2013). More recent research on bowhead whales corroborates earlier evidence that, during the summer feeding season, bowheads are less responsive to seismic sources (e.g., Miller et al. 2005; Robertson et al. 2013).

Bowhead whale calls detected in the presence and absence of airgun sounds have been studied extensively in the Beaufort Sea. Bowheads continue to produce calls of the usual types when exposed to airgun sounds on their summering grounds, although numbers of calls detected are significantly lower in the presence than in the absence of airgun pulses (Blackwell et al. 2013, 2015). Blackwell et al. (2013) reported that calling rates in 2007 declined significantly where received SPLs from airgun sounds were 116–129 dB re 1 µPa; at SPLs <108 dB re 1 µPa, calling rates were not affected. When data for 2007–2010 were analyzed, Blackwell et al. (2015) reported an initial increase in calling rates when airgun pulses became detectable; however, calling rates leveled off at a received $CSEL_{10\text{-min}}$ (cumulative SEL over a 10-min period) of ~94 dB re 1 µ$Pa^2 \cdot s$, decreased at $CSEL_{10\text{-min}}$ >127 dB re 1 µ$Pa^2 \cdot s$, and whales were nearly silent at $CSEL_{10\text{-min}}$ >160 dB re 1 µ$Pa^2 \cdot s$. Thus, bowhead whales in the Beaufort Sea apparently decreased their calling rates in response to seismic operations, although movement out of the area could also have contributed to the lower call detection rate (Blackwell et al. 2013, 2015).

A multivariate analysis of factors affecting the distribution of calling bowhead whales during their fall migration in 2009 noted that the southern edge of the distribution of calling whales was significantly closer to shore with increasing levels of airgun sound from a seismic survey a few hundred kilometers to the east of the study area (i.e., behind the westward-migrating whales; McDonald et al. 2010, 2011). It was not known whether this statistical effect represented a stronger tendency for quieting of the whales farther offshore in deeper water upon exposure to airgun sound, or an actual inshore displacement of whales.

There was no indication that *western gray whales* exposed to seismic sound were displaced from their overall feeding grounds near Sakhalin Island during seismic programs in 1997 (Würsig et al. 1999) and in 2001 (Johnson et al. 2007; Meier et al. 2007; Yazvenko et al. 2007a). However, there were indications of subtle behavioral effects among whales that remained in the areas exposed to airgun sounds (Würsig et al. 1999; Gailey et al. 2007; Weller et al. 2006a) and localized redistribution of some individuals within the nearshore feeding ground so as to avoid close approaches by the seismic vessel (Weller et al. 2002, 2006b; Yazvenko et al. 2007a). Despite the evidence of subtle changes in some quantitative measures of behavior and local redistribution of some individuals, there was no apparent change in the frequency of feeding, as evident from mud plumes visible at the surface (Yazvenko et al. 2007b). Similarly, no large changes in gray whale movement, respiration, or distribution patterns were observed during the seismic programs conducted in 2010 (Bröker et al. 2015; Gailey et al. 2016). Although sighting distances of gray whales from shore increased slightly during a 2-week seismic survey, this result was not significant (Muir et al. 2015). However, there may have been a possible localized avoidance response to high sound levels in the area (Muir et al. 2016). The lack of strong avoidance or other strong responses during the 2001 and 2010 programs was presumably in part a result of the comprehensive combination of real-time monitoring and mitigation measures designed to avoid exposing western gray whales to received SPLs above ~163 dB re 1 μPa_{rms} (Johnson et al. 2007; Nowacek et al. 2012, 2013b). In contrast, preliminary data collected during a seismic program in 2015 showed some displacement of animals from the feeding area and responses to lower sound levels than expected (Gailey et al. 2017; Sychenko et al. 2017).

Gray whales in B.C., Canada, exposed to seismic survey sound levels up to ~170 dB re 1 µPa did not appear to be strongly disturbed (Bain and Williams 2006). The few whales that were observed moved away from the airguns but toward deeper water where sound levels were said to be higher due to propagation effects (Bain and Williams 2006).

Various species of *Balaenoptera* (blue, sei, fin, and minke whales) have occasionally been seen in areas ensonified by airgun pulses. Sightings by observers on seismic vessels using large arrays off the U.K. from 1994–2010 showed that the detection rate for minke whales was significantly higher when airguns were not operating; however, during surveys with small arrays, the detection rates for minke whales were similar during seismic and non-seismic periods (Stone 2015). Sighting rates for fin and sei whales were similar when large arrays of airguns were operating vs. silent (Stone 2015). All baleen whales combined tended to exhibit localized avoidance, remaining significantly farther (on average) from large arrays (median closest point of approach or CPA of ~1.5 km) during seismic operations compared with non-seismic periods (median CPA ~1.0 km; Stone 2015). In addition, fin and minke whales were more often oriented away from the vessel while a large airgun array was active compared with periods of inactivity (Stone 2015). Singing fin whales in the Mediterranean moved away from an operating airgun array, and their song notes had lower bandwidths during periods with vs. without airgun sounds (Castellote et al. 2012).

During seismic surveys in the northwest Atlantic, baleen whales as a group showed localized avoidance of the operating array (Moulton and Holst 2010). Sighting rates were significantly lower during seismic operations compared with non-seismic periods. Baleen whales were seen on average 200 m farther from the vessel during airgun activities vs. non-seismic periods, and these whales more often swam away from the vessel when seismic operations were underway compared with periods when no airguns were operating (Moulton and Holst 2010). Blue whales were seen significantly farther from the vessel during single airgun operations, ramp up, and all other airgun operations compared with non-seismic periods (Moulton and Holst 2010). Similarly, fin whales were seen at significantly farther distances during ramp up than during periods without airgun operations; there was also a trend for fin whales to be sighted farther from the vessel during other airgun operations, but the difference was not significant (Moulton and Holst

2010). Minke whales were seen significantly farther from the vessel during periods with than without seismic operations (Moulton and Holst 2010). Minke whales were also more likely to swim away and less likely to approach during seismic operations compared to periods when airguns were not operating (Moulton and Holst 2010). However, Matos (2015) reported no change in sighting rates of minke whales in Vestfjorden, Norway, during ongoing seismic surveys outside of the fjord. Vilela et al. (2016) cautioned that environmental conditions should be taken into account when comparing sighting rates during seismic surveys, as spatial modeling showed that differences in sighting rates of rorquals (fin and minke whales) during seismic periods and non-seismic periods during a survey in the Gulf of Cadiz could be explained by environmental variables.

Data on short-term reactions by cetaceans to impulsive noises are not necessarily indicative of long-term or biologically significant effects. It is not known whether impulsive sounds affect reproductive rate or distribution and habitat use in subsequent days or years. However, gray whales have continued to migrate annually along the west coast of North America with substantial increases in the population over recent years, despite intermittent seismic exploration (and much ship traffic) in that area for decades. The western Pacific gray whale population continued to feed off Sakhalin Island every summer, despite seismic surveys in the region. In addition, bowhead whales have continued to travel to the eastern Beaufort Sea each summer, and their numbers have increased notably, despite seismic exploration in their summer and autumn range for many years. Pirotta et al. (2018) used a dynamic state model of behavior and physiology to assess the consequences of disturbance (e.g., seismic surveys) on whales (in this case, blue whales). They found that the impact of localized, acute disturbance (e.g., seismic surveys) depended on the whale's behavioral response, with whales that remained in the affected area having a greater risk of reduced reproductive success than whales that avoided the disturbance. Chronic, but weaker disturbance (e.g., vessel traffic) appeared to have less effect on reproductive success.

Toothed Whales

Little systematic information is available about reactions of toothed whales to sound pulses. However, there are recent systematic studies on sperm whales, and there is an increasing amount of information about responses of various odontocetes to seismic surveys based on monitoring studies. Seismic operators and marine mammal observers on seismic vessels regularly see dolphins and other small toothed whales near operating airgun arrays, but in general there is a tendency for most delphinids to show some avoidance of operating seismic vessels (e.g., Stone and Tasker 2006; Moulton and Holst 2010; Barry et al. 2012; Wole and Myade 2014; Stone 2015; Monaco et al. 2016). In most cases, the avoidance radii for delphinids appear to be small, on the order of 1 km or less, and some individuals show no apparent avoidance.

Observations from seismic vessels using large arrays off the U.K. from 1994–2010 indicated that detection rates were significantly higher for killer whales, white-beaked dolphins, and Atlantic white-sided dolphins when airguns were not operating; detection rates during seismic vs. non-seismic periods were similar during seismic surveys using small arrays (Stone 2015). Detection rates for long-finned pilot whales, Risso's dolphins, bottlenose dolphins, and short-beaked common dolphins were similar during seismic (small or large array) vs. non-seismic operations (Stone 2015). CPA distances for killer whales, white-beaked dolphins, and Atlantic white-sided dolphins were significantly farther (>0.5 km) from large airgun arrays during periods of airgun activity compared with periods of inactivity, with significantly more animals traveling away from the vessel during airgun operation (Stone 2015). Observers' records suggested that fewer cetaceans were feeding and fewer delphinids were interacting with the survey vessel (e.g., bow-riding) during periods with airguns operating (Stone 2015).

During seismic surveys in the northwest Atlantic, delphinids as a group showed some localized avoidance of the operating array (Moulton and Holst 2010). The mean initial detection distance was significantly farther (by ~200 m) during seismic operations compared with periods when the seismic source was not active; however, there was no significant difference between sighting rates (Moulton and Holst 2010). The same results were evident when only long-finned pilot whales were considered.

Preliminary findings of a monitoring study of *narwhals* in Melville Bay, Greenland, (summer and fall 2012) showed no short-term effects of seismic survey activity on narwhal distribution, abundance, migration timing, and feeding habits (Heide-Jørgensen et al. 2013a). In addition, there were no reported effects on narwhal hunting. These findings do not seemingly support a suggestion by Heide-Jørgensen et al. (2013b) that seismic surveys in Baffin Bay may have delayed the migration timing of narwhals, thereby increasing the risk of narwhals to ice entrapment.

The beluga, however, is a species that (at least at times) shows long-distance (10s of km) avoidance of seismic vessels (e.g., Miller et al. 2005). Captive bottlenose dolphins and beluga whales exhibited changes in behavior when exposed to strong pulsed sounds similar in duration to those typically used in seismic surveys, but the animals tolerated high received levels of sound before exhibiting aversive behaviors (e.g., Finneran et al. 2000, 2002, 2005). Schlundt et al. (2016) also reported that bottlenose dolphins exposed to multiple airgun pulses exhibited some anticipatory behavior.

Most studies of *sperm whales* exposed to airgun sounds indicate that the sperm whale shows considerable tolerance of airgun pulses; in most cases the whales do not show strong avoidance (e.g., Stone and Tasker 2006; Moulton and Holst 2010). Winsor et al. (2017) outfitted sperm whales in the Gulf of Mexico with satellite tags to examine their spatial distribution in relation to seismic surveys. They found no evidence of avoidance or changes in orientation by sperm whales to active seismic vessels. Based on data collected by observers on seismic vessels off the U.K. from 1994–2010, detection rates for sperm whales were similar when large arrays of airguns were operating vs. silent; however, during surveys with small arrays, the detection rate was significantly higher when the airguns were not in operation (Stone 2015). Foraging behavior can also be altered upon exposure to airgun sound (e.g., Miller et al. 2009), which according to Farmer et al. (2017), could have significant consequences on individual fitness. Preliminary data from the Gulf of Mexico show a correlation between reduced sperm whale acoustic activity and periods with airgun operations (Sidorovskaia et al. 2014).

There are almost no specific data on the behavioral reactions of *beaked whales* to seismic surveys. Most beaked whales tend to avoid approaching vessels of other types (e.g., Würsig et al. 1998) and/or change their behavior in response to sounds from vessels (e.g., Pirotta et al. 2012). Thus, it is likely that most beaked whales would also show strong avoidance of an approaching seismic vessel. Observations from seismic vessels off the U.K. from 1994–2010 indicated that detection rates of beaked whales were significantly higher ($p<0.05$) when airguns were not operating vs. when a large array was in operation, although sample sizes were small (Stone 2015). Some northern bottlenose whales remained in the general area and continued to produce high-frequency clicks when exposed to sound pulses from distant seismic surveys (e.g., Simard et al. 2005).

The limited available data suggest that *harbor porpoises* show stronger avoidance of seismic operations than do Dall's porpoises. The apparent tendency for greater responsiveness in the harbor porpoise is consistent with its relative responsiveness to boat traffic and some other acoustic sources (Richardson et al. 1995; Southall et al. 2007). Based on data collected by observers on seismic vessels off the U.K. from 1994–2010, detection rates of harbor porpoises were significantly higher when airguns were silent vs. when large or small arrays were operating (Stone 2015). In addition, harbor porpoises were seen farther away from the array when it was operating vs. silent, and were most often seen traveling away from the airgun array when it was in operation (Stone 2015). Thompson et al. (2013) reported decreased densities and reduced acoustic detections of harbor porpoise in response to a seismic survey in Moray Firth, Scotland, at ranges of 5–10 km (SPLs of 165–172 dB re 1 μPa, SELs of 145–151 dB $\mu Pa^2 \cdot s$). For the same survey, Pirotta et al. (2014) reported that the probability of recording a porpoise buzz decreased by 15% in the ensonified area, and that the probability was positively related to the distance from the seismic ship; the decreased buzzing occurrence may indicate reduced foraging efficiency. Nonetheless, animals returned to the area within a few hours (Thompson et al. 2013). In a captive facility, harbor porpoise showed avoidance of a pool with elevated sound levels, but search time for prey within that pool was no different than in a quieter pool (Kok et al. 2017).

Kastelein et al. (2013a) reported that a harbor porpoise showed no response to an impulse sound with an SEL below 65 dB, but a 50% brief response rate was noted at an SEL of 92 dB and an SPL of 122 dB re 1 $\mu Pa_{0\text{-peak}}$. However, Kastelein et al. (2012c) reported a 50% detection threshold at a SEL of 60 dB to a similar impulse sound; this difference is likely attributable to the different transducers used during the two studies (Kastelein et al. 2013c). Van Beest et al. (2018) exposed five harbor porpoise to a single 10 in^3 airgun for 1 min at 2–3 s intervals at ranges of 420–690 m and levels of 135–147 dB $\mu Pa^2 \cdot s$. One porpoise moved away from the sound source but returned to natural movement patters within 8 h, and two porpoises had shorter and shallower dives but returned to natural behaviors within 24 h.

Odontocete reactions to large arrays of airguns are variable and, at least for delphinids, seem to be confined to a smaller radius than has been observed for the more responsive of the mysticetes and some other odontocetes. A ≥170 dB disturbance criterion (rather than ≥160 dB) is considered appropriate for delphinids, which tend to be less responsive than the more responsive cetaceans. NMFS is developing new guidance for predicting behavioral effects (Scholik-Schlomer 2015). As behavioral responses are not consistently associated with received levels, some authors have made recommendations on different approaches to assess behavioral reactions (e.g., Gomez et al. 2016; Harris et al. 2017; Tyack and Thomas 2019).

Pinnipeds

Pinnipeds are not likely to show a strong avoidance reaction to an airgun array. Visual monitoring from seismic vessels has shown only slight (if any) avoidance of airguns by pinnipeds and only slight (if any) changes in behavior. However, telemetry work has suggested that avoidance and other behavioral reactions may be stronger than evident to date from visual studies (Thompson et al. 1998). Observations from seismic vessels operating large arrays off the U.K. from 1994–2010 showed that the detection rate for gray seals was significantly higher when airguns were not operating; for surveys using small arrays, the detection rates were similar during seismic vs. non-seismic operations (Stone 2015). No significant differences in detection rates were apparent for harbor seals during seismic and non-seismic periods (Stone 2015). There were no significant differences in CPA distances of grey or harbor seals during seismic vs. non-seismic periods (Stone 2015). Lalas and McConnell (2015) made observations of New Zealand fur seals from a seismic vessel operating a 3090 in^3 airgun array in New Zealand during 2009. However, the results from the study were inconclusive in showing whether New Zealand fur seals respond to seismic sounds. Reichmuth et al. (2016) exposed captive spotted and ringed seals to single airgun pulses; only mild behavioral responses were observed.

Sea Turtles

Several recent papers discuss the morphology of the turtle ear (e.g., Christensen-Dalsgaard et al. 2012; Willis et al. 2013) and the hearing ability of sea turtles (e.g., Martin et al. 2012; Piniak et al. 2012a,b; Lavender et al. 2014). The limited available data indicate that sea turtles will hear airgun sounds and sometimes exhibit localized avoidance (see PEIS, § 3.4.4.3). In additional, Nelms et al. (2016) suggest that sea turtles could be excluded from critical habitats during seismic surveys.

DeRuiter and Doukara (2012) observed that immediately following an airgun pulse, small numbers of basking loggerhead turtles (6 of 86 turtles observed) exhibited an apparent startle response (sudden raising of the head and splashing of flippers, occasionally accompanied by blowing bubbles from the beak and nostrils, followed by a short dive). Diving turtles (49 of 86 individuals) were observed at distances from the center of the airgun array ranging from 50–839 m. The estimated sound level at the median distance of 130 m was 191 dB re 1 μPa_{peak}. These observations were made during ~150 h of vessel-based monitoring from a seismic vessel operating an airgun array (13 airguns, 2440 in^3) off Algeria; there was no corresponding observation effort during periods when the airgun array was inactive (DeRuiter and Doukara 2012).

Based on available data, it is likely that sea turtles will exhibit behavioral changes and/or avoidance within an area of unknown size near a seismic vessel. To the extent that there are any impacts on sea turtles, seismic operations in or near areas where turtles concentrate would likely have the greatest impact. There are no specific data that demonstrate the consequences to sea turtles if seismic operations with large or small arrays of airguns occur in important areas at biologically important times of the year. However, a number of mitigation measures can, on a case-by-case basis, be considered for application in areas important to sea turtles (e.g., Pendoley 1997; van der Wal et al. 2016).

***Hearing Impairment and Other Physical Effects*.—**Temporary or permanent hearing impairment is a possibility when marine mammals are exposed to very strong sounds. TTS has been demonstrated and studied in certain captive odontocetes and pinnipeds exposed to strong sounds (reviewed by Southall et al. 2007; Finneran 2015). However, there has been no specific documentation of TTS let alone permanent hearing damage, i.e., PTS, in free-ranging marine mammals exposed to sequences of airgun pulses during realistic field conditions.

Additional data are needed to determine the received sound levels at which small odontocetes would start to incur TTS upon exposure to repeated, low-frequency pulses of airgun sound with variable received levels. To determine how close an airgun array would need to approach in order to elicit TTS, one would (as a minimum) need to allow for the sequence of distances at which airgun pulses would occur, and for the dependence of received SEL on distance in the region of the seismic operation (e.g., Breitzke and Bohlen 2010; Laws 2012). At the present state of knowledge, it is also necessary to assume that the effect is directly related to total received energy (SEL); however, this assumption is likely an over-simplification (Finneran 2012). There is recent evidence that auditory effects in a given animal are not a simple function of received acoustic energy (Finneran 2015). Frequency, duration of the exposure, and occurrence of gaps within the exposure can also influence the auditory effect (Finneran and Schlundt 2010, 2011, 2013; Finneran et al. 2010a,b; Popov et al. 2011, 2013; Ketten 2012; Finneran 2012, 2015; Kastelein et al. 2012a,b; 2013b,c, 2014, 2015a, 2016a,b, 2017, 2018, 2019a,b; Supin et al. 2016).

Studies have shown that the SEL required for TTS onset to occur increases with intermittent exposures, with some auditory recovery during silent periods between signals (Finneran et al. 2010b; Finneran and Schlundt 2011). Studies on bottlenose dolphins by Finneran et al. (2015) indicate that the potential for seismic surveys using airguns to cause auditory effects on dolphins could be lower than previously thought. Based on behavioral tests, no measurable TTS was detected in three bottlenose dolphins after exposure to 10 impulses from a seismic airgun with a cumulative SEL of up to ~195 dB re 1 µPa2 · s (Finneran et al. 2015; Schlundt et al. 2016). However, auditory evoked potential measurements were more variable; one dolphin showed a small (9 dB) threshold shift at 8 kHz (Finneran et al. 2015; Schlundt et al. 2016).

Studies have also shown that the SEL necessary to elicit TTS can depend substantially on frequency, with susceptibility to TTS increasing with increasing frequency above 3 kHz (Finneran and Schlundt 2010, 2011; Finneran 2012). When beluga whales were exposed to fatiguing noise with sound levels of 165 dB re 1 μPa for durations of 1–30 min at frequencies of 11.2–90 kHz, the highest TTS with the longest recovery time was produced by the lower frequencies (11.2 and 22.5 kHz); TTS effects also gradually increased with prolonged exposure time (Popov et al. 2013). Additionally, Popov et al. (2015) demonstrated that the impacts of TTS include deterioration of signal discrimination. Kastelein et al. (2015b, 2017) reported that exposure to multiple pulses with most energy at low frequencies can lead to TTS at higher frequencies in some cetaceans, such as the harbor porpoise. When a porpoise was exposed to 10 and 20 consecutive shots (mean shot interval ~17 s) from two airguns with a SEL_{cum} of 188 and 191 $\mu Pa^2 \cdot s$, respectively, significant TTS occurred at a hearing frequency of 4 kHz and not at lower hearing frequencies that were tested, despite the fact that most of the airgun energy was <1 kHz; recovery occurred within 12 min post exposure (Kastelein et al. 2017).

Popov et al. (2016) reported that TTS produced by exposure to a fatiguing noise was larger during the first session (or naïve subject state) with a beluga whale than TTS that resulted from the same sound in subsequent sessions (experienced subject state). Similarly, several other studies have shown that some marine mammals (e.g., bottlenose dolphins, false killer whales) can decrease their hearing sensitivity in order to mitigate the impacts of exposure to loud sounds (e.g., Nachtigall and Supin 2013, 2014, 2015, 2016; Nachtigall et al. 2018).

Previous information on TTS for odontocetes was primarily derived from studies on the bottlenose dolphin and beluga, and that for pinnipeds has mostly been obtained from California sea lions and elephant seals (see § 3.6.4.3, § 3.7.4.3, § 3.8.4.3 and Appendix E of the PEIS). Thus, it is inappropriate to assume that onset of TTS occurs at similar received levels in all cetaceans or pinnipeds (*cf.* Southall et al. 2007). Some cetaceans or pinnipeds could incur TTS at lower sound exposures than are necessary to elicit TTS in the beluga and bottlenose dolphin or California sea lion and elephant seal, respectively.

Several studies on TTS in porpoises (e.g., Lucke et al. 2009; Popov et al. 2011; Kastelein et al. 2012a, 2013a,b, 2014, 2015a) indicate that received levels that elicit onset of TTS are lower in porpoises than in other odontocetes. Kastelein et al. (2012a) exposed a harbor porpoise to octave band noise centered at 4 kHz for extended periods. A 6-dB TTS occurred with SELs of 163 dB and 172 dB for low-intensity sound and medium-intensity sound, respectively; high-intensity sound caused a 9-dB TTS at a SEL of 175 dB (Kastelein et al. 2012a). Kastelein et al. (2013b) exposed a harbor porpoise to a long, continuous 1.5-kHz tone, which induced a 14-dB TTS with a total SEL of 190 dB. Popov et al. (2011) examined the effects of fatiguing noise on the hearing threshold of Yangtze finless porpoises when exposed to frequencies of 32–128 kHz at 140–160 dB re 1 μPa for 1–30 min. They found that an exposure of higher level and shorter duration produced a higher TTS than an exposure of equal SEL but of lower level and longer duration. Popov et al. (2011) reported a TTS of 25 dB for a Yangtze finless porpoise that was exposed to high levels of 3-min pulses of half-octave band noise centered at 45 kHz with an SEL of 163 dB.

For the harbor porpoise, Tougaard et al. (2015) have suggested an exposure limit for TTS as an SEL of 100–110 dB above the pure tone hearing threshold at a specific frequency; they also suggested an exposure limit of $L_{\text{eq-fast}}$ (rms average over the duration of the pulse) of 45 dB above the hearing threshold for behavioral responses (i.e., negative phonotaxis). In addition, according to Wensveen et al. (2014) and Tougaard et al. (2015), M-weighting, as used by Southall et al. (2007), might not be appropriate for the harbor porpoise. Thus, Wensveen et al. (2014) developed six auditory weighting functions for the harbor porpoise that could be useful in predicting TTS onset. Mulsow et al. (2015) suggested that basing weighting functions on equal latency/loudness contours may be more appropriate than M-weighting for marine mammals. Simulation modeling to assess the risk of sound exposure to marine mammals (gray seal and harbor porpoise) showed that SEL is most strongly influenced by the weighting function (Donovan et al. 2017). Houser et al. (2017) provide a review of the development and application of auditory weighting functions, as well as recommendations for future work.

Initial evidence from exposures to non-pulses has also suggested that some pinnipeds (harbor seals in particular) incur TTS at somewhat lower received levels than do most small odontocetes exposed for similar durations (Kastak et al. 1999, 2005, 2008; Ketten et al. 2001). Kastelein et al. (2012b) exposed two harbor seals to octave-band white noise centered at 4 kHz at three mean received SPLs of 124, 136, and 148 dB re 1 µPa; TTS >2.5 dB was induced at an SEL of 170 dB (136 dB SPL for 60 min), and the maximum TTS of 10 dB occurred after a 120-min exposure to 148 dB re 1 µPa or an SEL of 187 dB. Kastelein et al. (2013c) reported that a harbor seal unintentionally exposed to the same sound source with a mean received SPL of 163 dB re 1 µPa for 1 h induced a 44 dB TTS. For a harbor seal exposed to octave-band white noise centered at 4 kHz for 60 min with mean SPLs of 124–148 re 1 µPa, the onset of PTS would require a level of at least 22 dB above the TTS onset (Kastelein et al. 2013c). Reichmuth et al. (2016) exposed captive spotted and ringed seals to single airgun pulses with SELs of 165–181 dB and SPLs (peak to peak) of 190–207 re 1 µPa; no low-frequency TTS was observed. Harbor seals may be able to decrease their exposure to underwater sound by swimming just below the surface where sound levels are typically lower than at depth (Kastelein et al. 2018).

Hermannsen et al. (2015) reported that there is little risk of hearing damage to harbor seals or harbor porpoises when using single airguns in shallow water. Similarly, it is unlikely that a marine mammal would remain close enough to a large airgun array for sufficiently long to incur TTS, let alone PTS. However, Gedamke et al. (2011), based on preliminary simulation modeling that attempted to allow for various uncertainties in assumptions and variability around population means, suggested that some baleen whales whose CPA to a seismic vessel is 1 km or more could experience TTS.

There is no specific evidence that exposure to pulses of airgun sound can cause PTS in any marine mammal, even with large arrays of airguns. However, given the possibility that some mammals close to an airgun array might incur at least mild TTS, there has been further speculation about the possibility that some individuals occurring very close to airguns might incur PTS (e.g., Richardson et al. 1995, p. 372ff; Gedamke et al. 2011). In terrestrial animals, exposure to sounds sufficiently strong to elicit a large TTS induces physiological and structural changes in the inner ear, and at some high level of sound exposure, these phenomena become non-recoverable (Le Prell 2012). At this level of sound exposure, TTS grades into PTS. Single or occasional occurrences of mild TTS are not indicative of permanent auditory damage, but repeated or (in some cases) single exposures to a level well above that causing TTS onset might elicit PTS (e.g., Kastak and Reichmuth 2007; Kastak et al. 2008).

The noise exposure criteria for marine mammals that were released by NMFS (2016a, 2018a) account for the newly-available scientific data on TTS, the expected offset between TTS and PTS thresholds, differences in the acoustic frequencies to which different marine mammal groups are sensitive, and other relevant factors. For impulsive sounds, such as airgun pulses, the thresholds use dual metrics of cumulative SEL (SEL_{cum} over 24 hours) and Peak SPL_{flat}. Onset of PTS is assumed to be 15 dB higher when considering SEL_{cum} and 6 dB higher when considering SPL_{flat}. Different thresholds are provided for the various hearing groups, including LF cetaceans (e.g., baleen whales), MF cetaceans (e.g., most delphinids), HF cetaceans (e.g., porpoise and *Kogia* spp.), phocids underwater (PW), and otariids underwater (OW).

Nowacek et al. (2013a) concluded that current scientific data indicate that seismic airguns have a low probability of directly harming marine life, except at close range. Several aspects of the planned monitoring and mitigation measures for this project are designed to detect marine mammals occurring near the airgun array, and to avoid exposing them to sound pulses that might, at least in theory, cause hearing impairment. Also, many marine mammals and (to a limited degree) sea turtles show some avoidance of the area where received levels of airgun sound are high enough such that hearing impairment could potentially occur. In those cases, the avoidance responses of the animals themselves would reduce or (most likely) avoid any possibility of hearing impairment. Aarts et al. (2016) noted that an understanding of animal movement is necessary in order to estimate the impact of anthropogenic sound on cetaceans.

Non-auditory physical effects may also occur in marine mammals exposed to strong underwater pulsed sound. Possible types of non-auditory physiological effects or injuries that might (in theory) occur in mammals close to a strong sound source include stress, neurological effects, bubble formation, and other types of organ or tissue damage. Gray and Van Waerebeek (2011) have suggested a cause-effect relationship between a seismic survey off Liberia in 2009 and the erratic movement, postural instability, and akinesia in a pantropical spotted dolphin based on spatially and temporally close association with the airgun array. It is possible that some marine mammal species (i.e., beaked whales) are especially susceptible to injury and/or stranding when exposed to strong transient sounds (e.g., Southall et al. 2007). Ten cases of cetacean strandings in the general area where a seismic survey was ongoing have led to speculation concerning a possible link between seismic surveys and strandings (Castellote and Llorens 2016). An analysis of stranding data found that the number of long-finned pilot whale strandings along Ireland's coast increased with seismic surveys operating offshore (McGeady et al. 2016). However, there is no definitive evidence that any of these effects occur even for marine mammals in close proximity to large arrays of airguns. Morell et al. (2017) examined the inner ears of long-finned pilot whales after a mass stranding in Scotland and reported damage to the cochlea compatible with over-exposure from underwater noise; however, no seismic surveys were occurring in the vicinity in the days leading up to the stranding.

Since 1991, there have been 70 Marine Mammal Unusual Mortality Events (UME) in the U.S. (NOAA 2020b). In a hearing to examine the Bureau of Ocean Energy Management's 2017–2022 OCS Oil and Gas Leasing Program (https://www.energy.senate.gov/public/index.cfm/2016/5/hearing-is-examine-the-bureau-of-ocean-energy-management-s-2017-2022-ocs-oil-and-gas-leasing-program), it was Dr. Knapp's (a geologist from the University of South Carolina) interpretation that there was no evidence to suggest a correlation between UMEs and seismic surveys given the similar percentages of UMEs in the Pacific, Atlantic, and Gulf of Mexico, and the greater activity of oil and gas exploration in the Gulf of Mexico. Similarly, the large whale UME Core Team found that seismic testing did not contribute to the 2015 UME involving humpbacks and fin whales from Alaska to B.C. (Savage 2017).

Non-auditory effects, if they occur at all, would presumably be limited to short distances and to activities that extend over a prolonged period. Marine mammals that show behavioral avoidance of seismic vessels, including most baleen whales, some odontocetes, and some pinnipeds, are especially unlikely to incur non-auditory physical effects. The brief duration of exposure of any given mammal and the planned monitoring and mitigation measures would further reduce the probability of exposure of marine mammals to sounds strong enough to induce non-auditory physical effects.

Sea Turtles

There is substantial overlap in the frequencies that sea turtles detect versus the frequencies in airgun pulses. We are not aware of measurements of the absolute hearing thresholds of any sea turtle to waterborne sounds similar to airgun pulses. In the absence of relevant absolute threshold data, we cannot estimate how far away an airgun array might be audible. Moein et al. (1994) and Lenhardt (2002) reported TTS for loggerhead turtles exposed to many airgun pulses (see § 3.4.4 of the PEIS). This suggests that sounds from an airgun array might cause temporary hearing impairment in sea turtles if they do not avoid the (unknown) radius where TTS occurs (see Nelms et al. 2016). However, exposure duration during the proposed surveys would be much less than during the aforementioned studies. Also, recent monitoring studies show that some sea turtles do show localized movement away from approaching airguns. At short distances from the source, received sound level diminishes rapidly with increasing distance. In that situation, even a small-scale avoidance response could result in a significant reduction in sound exposure.

The U.S. Navy has proposed the following criteria for the onset of hearing impairment for sea turtles: 232 dB re 1 µPa SPL (peak) and 204 dB re 1 $\mu Pa^2 \cdot s$ SEL_{cum} (weighted) for PTS; and 226 dB peak and 189 dB weighted SEL for TTS (DoN 2017). Although it is possible that exposure to airgun sounds could cause mortality or mortal injuries in sea turtles close to the source, this has not been demonstrated and seems highly unlikely (Popper et al. 2014), especially because sea turtles appear to be resistant to explosives (Ketten et al. 2005 *in* Popper et al. 2014). Nonetheless, Popper et al. (2014) proposed sea turtle mortality/mortal injury criteria of 210 dB SEL or >207 dB_{peak} for sounds from seismic airguns; however, these criteria were largely based on impacts of pile-driving sound on fish.

The PSOs stationed on R/V *Langseth* would watch for sea turtles, and airgun operations would be shut down if a turtle enters the designated EZ.

4.1.1.2 Possible Effects of Other Acoustic Sources

The Kongsberg EM 122 MBES and Knudsen Chirp 3260 SBP would be operated from the source vessel during the proposed surveys. Information about this equipment was provided in § 2.2.3.1 of the PEIS. A review of the expected potential effects (or lack thereof) of MBESs, SBPs, and pingers on marine mammals and sea turtles appears in § 3.4.4.3, § 3.6.4.3, § 3.7.4.3, § 3.8.4.3, and Appendix E of the PEIS.

There has been some recent attention given to the effects of MBES on marine mammals, as a result of a report issued in September 2013 by an IWC independent scientific review panel linking the operation of an MBES to a mass stranding of melon-headed whales off Madagascar (Southall et al. 2013). During May–June 2008, ~100 melon-headed whales entered and stranded in the Loza Lagoon system in northwest Madagascar at the same time that a 12-kHz MBES survey was being conducted ~65 km away off the coast. In conducting a retrospective review of available information on the event, an independent scientific review panel concluded that the Kongsberg EM 120 MBES was the most plausible behavioral trigger for the animals initially entering the lagoon system and eventually stranding. The independent scientific review panel, however, identified that an unequivocal conclusion on causality of the event was not possible because of the lack of information about the event and a number of potentially contributing factors. Additionally, the independent review panel report indicated that this incident was likely the result of a complicated confluence of environmental, social, and other factors that have a very low probability of occurring again in the future, but recommended that the potential be considered in environmental planning. It should be noted that this event is the first known marine mammal mass stranding closely associated with the operation of an MBES. Leading scientific experts knowledgeable about MBES expressed concerns about the independent scientific review panel analyses and findings (Bernstein 2013).

Reference has also been made that two beaked whales stranded in the Gulf of California in 2002 were observed during a seismic survey in the region by the R/V *Ewing* (Malakoff 2002, Cox et al. 2006 *in* PEIS:3-136), which used a similar MBES system. As noted in the PEIS, however, "The link between the stranding and the seismic surveys was inconclusive and not based on any physical evidence" (Hogarth 2002, Yoder 2002 *in* PEIS:3-190).

Lurton (2016) modeled MBES radiation characteristics (pulse design, source level, and radiation directivity pattern) applied to a low-frequency (12-kHz), 240-dB source-level system like that used on R/V *Langseth*. Using Southall et al. (2007) thresholds, he found that injury impacts were possible only at very short distances, e.g., at 5 m for maximum SPL and 12 m for cumulative SEL for cetaceans; corresponding distances for behavioral response were 9 m and 70 m. For pinnipeds, "all ranges are multiplied by a factor of 4" (Lurton 2016:209).

There is nearly no available information on marine mammal behavioral responses to MBES sounds (Southall et al. 2013) or sea turtle responses to MBES systems. Much of the literature on marine mammal response to sonars relates to the types of sonars used in naval operations, including low-frequency, mid-frequency, and high-frequency active sonars (see review by Southall et al. 2016). However, the MBES sounds are quite different from naval sonars. Ping duration of the MBES is very short relative to naval sonars. Also, at any given location, an individual marine mammal would be in the beam of the MBES for much less time given the generally downward orientation of the beam and its narrow fore-aft beamwidth; naval sonars often use near-horizontally-directed sound. In addition, naval sonars have higher duty cycles. These factors would all reduce the sound energy received from the MBES relative to that from naval sonars.

During a recent study, group vocal periods (GVP) were used as proxies to assess foraging behavior of Cuvier's beaked whales during multibeam mapping in southern California (Varghese et al. 2019). The study found that there was no significant difference between GVP during multibeam mapping and non-exposure periods, but the number of GVP was significantly greater after MBES exposure than before MBES exposure. During an analogous study assessing Naval sonar (McCarthy et al. 2011), significantly fewer GVPs were recorded during sonar transmission (McCarthy et al. 2011; Varghese et al. 2019).

In the fall of 2006, an Ocean Acoustic Waveguide Remote Sensing (OAWRS) experiment was carried out in the Gulf of Maine (Gong et al. 2014); the OAWRS emitted three frequency-modulated (FM) pulses centered at frequencies of 415, 734, and 949 Hz (Risch et al. 2012). Risch et al. (2012) found a reduction in humpback whale song in the Stellwagen Bank National Marine Sanctuary during OAWRS activities that were carried out ~200 km away; received levels in the sanctuary were 88–110 dB re 1 µPa. In contrast, Gong et al. (2014) reported no effect of the OAWRS signals on humpback whale vocalizations in the Gulf of Maine. Range to the source, ambient noise, and/or behavioral state may have differentially influenced the behavioral responses of humpbacks in the two areas (Risch et al. 2014).

Deng et al. (2014) measured the spectral properties of pulses transmitted by three 200-kHz echosounders and found that they generated weaker sounds at frequencies below the center frequency (90–130 kHz). These sounds are within the hearing range of some marine mammals, and the authors suggested that they could be strong enough to elicit behavioral responses within close proximity to the sources, although they would be well below potentially harmful levels. Hastie et al. (2014) reported behavioral responses by gray seals to echosounders with frequencies of 200 and 375 kHz. Short-finned pilot whales increased their heading variance in response to an EK60 echosounder with a resonant frequency of 38 kHz (Quick et al. 2017), and significantly fewer beaked whale vocalizations were detected while an EK60 echosounder was active vs. passive (Cholewiak et al. 2017).

Despite the aforementioned information that has recently become available, this Final EA remains in agreement with the assessment presented in § 3.4.7, 3.6.7, 3.7.7, and 3.8.7 of the PEIS that operation of MBESs, SBPs, and pingers is not likely to impact marine mammals and is not expected to affect sea turtles, (1) given the lower acoustic exposures relative to airguns and (2) because the intermittent and/or narrow downward-directed nature of these sounds would result in no more than one or two brief ping exposures of any individual marine mammal or sea turtle given the movement and speed of the vessel. Also, for sea turtles, the associated frequency ranges are above their known hearing range.

4.1.1.3 Other Possible Effects of Seismic Surveys

Other possible effects of seismic surveys on marine mammals and/or sea turtles include masking by vessel noise, disturbance by vessel presence or noise, and injury or mortality from collisions with vessels or entanglement in seismic gear.

Vessel noise from R/V *Langseth* could affect marine animals in the proposed survey area. Houghton et al. (2015) proposed that vessel speed is the most important predictor of received noise levels, and Putland et al. (2017) also reported reduced sound levels with decreased vessel speed. Sounds produced by large vessels generally dominate ambient noise at frequencies from 20–300 Hz (Richardson et al. 1995). However, some energy is also produced at higher frequencies (Hermannsen et al. 2014); low levels of high-frequency sound from vessels have been shown to elicit responses in harbor porpoise (Dyndo et al. 2015). Increased levels of ship noise also affect foraging by porpoise (Teilmann et al. 2015; Wisniewska et al. 2018). Wisniewska et al. (2018) suggest that a decrease in foraging success could have long-term fitness consequences.

Ship noise, through masking, can reduce the effective communication distance of a marine mammal if the frequency of the sound source is close to that used by the animal, and if the sound is present for a significant fraction of time (e.g., Richardson et al. 1995; Clark et al. 2009; Jensen et al. 2009; Gervaise et al. 2012; Hatch et al. 2012; Rice et al. 2014; Dunlop 2015; Erbe et al. 2016; Jones et al. 2017; Putland et al. 2017; Cholewiak et al. 2018). In addition to the frequency and duration of the masking sound, the strength, temporal pattern, and location of the introduced sound also play a role in the extent of the masking (Branstetter et al. 2013, 2016; Finneran and Branstetter 2013; Sills et al. 2017). Branstetter et al. (2013) reported that time-domain metrics are also important in describing and predicting masking. In order to compensate for increased ambient noise, some cetaceans are known to increase the source levels of their calls in the presence of elevated noise levels from shipping, shift their peak frequencies, or otherwise change their vocal behavior (e.g., Parks et al. 2011, 2012, 2016a,b; Castellote et al. 2012; Melcón et al. 2012; Azzara et al. 2013; Tyack and Janik 2013; Luís et al. 2014; Sairanen 2014; Papale et al. 2015; Bittencourt et al. 2016; Dahlheim and Castellote 2016; Gospić and Picciulin 2016; Gridley et al. 2016; Heiler et al. 2016; Martins et al. 2016; O'Brien et al. 2016; Tenessen and Parks 2016; Fornet et al. 2018). Similarly, harbor seals increased the minimum frequency and amplitude of their calls in response to vessel noise (Matthews 2017); however, harp seals did not increase their call frequencies in environments with increased low-frequency sounds (Terhune and Bosker 2016).

Holt et al. (2015) reported that changes in vocal modifications can have increased energetic costs for individual marine mammals. A negative correlation between the presence of some cetacean species and the number of vessels in an area has been demonstrated by several studies (e.g., Campana et al. 2015; Culloch et al. 2016; Oakley et al. 2017). Based on modeling, Halliday et al. (2017) suggested that shipping noise can be audible more than 100 km away and could affect the behavior of a marine mammal at a distance of 52 km in the case of tankers.

Baleen whales are thought to be more sensitive to sound at these low frequencies than are toothed whales (e.g., MacGillivray et al. 2014), possibly causing localized avoidance of the proposed survey areas during seismic operations. Reactions of gray and humpback whales to vessels have been studied, and there is limited information available about the reactions of right whales and rorquals (fin, blue, and minke whales). Reactions of humpback whales to boats are variable, ranging from approach to avoidance (Payne 1978; Salden 1993). Baker et al. (1982, 1983) and Baker and Herman (1989) found humpbacks often move away when vessels are within several kilometers. Humpbacks seem less likely to react overtly when actively feeding than when resting or engaged in other activities (Krieger and Wing 1984, 1986). Increased levels of ship noise have been shown to affect foraging by humpback whales (Blair et al. 2016). Fin whale sightings in the western Mediterranean were negatively correlated with the number of vessels in the area (Campana et al. 2015). Minke whales and gray seals have shown slight displacement in response to construction-related vessel traffic (Anderwald et al. 2013).

Many odontocetes show considerable tolerance of vessel traffic, although they sometimes react at long distances if confined by ice or shallow water, if previously harassed by vessels, or have had little or no recent exposure to ships (Richardson et al. 1995). Dolphins of many species tolerate and sometimes approach vessels (e.g., Anderwald et al. 2013). Some dolphin species approach moving vessels to ride the bow or stern waves (Williams et al. 1992). Physical presence of vessels, not just ship noise, has been shown to disturb the foraging activity of bottlenose dolphins (Pirotta et al. 2015) and blue whales (Lesage et al. 2017). Sightings of striped dolphin, Risso's dolphin, sperm whale, and Cuvier's beaked whale in the western Mediterranean were negatively correlated with the number of vessels in the area (Campana et al. 2015). Killer whales rarely show avoidance to boats within 400 m (Duffus and Dearden 1993), but when more than one boat is nearby, they sometimes swim faster towards less confined waters (e.g., Williams et al. 2002a,b). Killer whales have also been shown to increase travelling and decrease foraging behavior because of the presence of nearby vessels (Williams et al. 2002a,b, 2009; Lusseau et al. 2009; Noren et al. 2009; Holt et al. 2021).

There are few data on the behavioral reactions of beaked whales to vessel noise, though they seem to avoid approaching vessels (e.g., Würsig et al. 1998) or dive for an extended period when approached by a vessel (e.g., Kasuya 1986). Based on a single observation, Aguilar Soto et al. (2006) suggest foraging efficiency of Cuvier's beaked whales may be reduced by close approach of vessels. Tyson et al. (2017) suggested that a juvenile green sea turtle dove during vessel passes and remained still near the sea floor.

The PEIS concluded that project vessel sounds would not be at levels expected to cause anything more than possible localized and temporary behavioral changes in marine mammals or sea turtles, and would not be expected to result in significant negative effects on individuals or at the population level. In addition, in all oceans of the world, large vessel traffic is currently so prevalent that it is commonly considered a usual source of ambient sound.

Another concern with vessel traffic is the potential for striking marine mammals or sea turtles (e.g., Redfern et al. 2013). Information on vessel strikes is reviewed in § 3.4.4.4, § 3.6.4.4, and § 3.8.4.4 of the PEIS. Wiley et al. (2016) concluded that reducing ship speed is one of the most reliable ways to avoid ship strikes. Similarly, Currie et al. (2017) found a significant decrease in close encounters with humpback whales in the Hawaiian Islands, and therefore reduced likelihood of ship strike, when vessels speeds were below 12.5 kt. However, McKenna et al. (2015) noted the potential absence of lateral avoidance demonstrated by blue whales and perhaps other large whale species to vessels. The PEIS concluded that the risk of collision of seismic vessels or towed/deployed equipment with marine mammals or sea turtles exists but is extremely unlikely, because of the relatively slow operating speed (typically 7–9 km/h) of the vessel during seismic operations, and the generally straight-line movement of the seismic vessel. There has been no history of marine mammal vessel strikes with R/V *Langseth*, or its predecessor, R/V *Maurice Ewing* over the last two decades.

Entanglement of sea turtles in seismic gear is also a concern (Nelms et al. 2016). There have been reports of turtles being trapped and killed between the gaps in tail-buoys offshore from West Africa (Weir 2007); however, these tailbuoys are significantly different than those used on R/V *Langseth*. In

April 2011, a dead olive ridley turtle was found in a deflector foil of the seismic gear on R/V *Langseth* during equipment recovery at the conclusion of a survey off Costa Rica, where sea turtles were numerous. Such incidents are possible, but that was the only case of sea turtle entanglement in seismic gear for R/V *Langseth*, which has been conducting seismic surveys since 2008, or for its predecessor, R/V *Maurice Ewing*, during 2003–2007. Towing the seismic equipment during the proposed surveys is not expected to significantly interfere with sea turtle movements, including migration.

4.1.1.4 Mitigation Measures

Several mitigation measures are built into the proposed seismic surveys as an integral part of the planned activity. These measures include the following: ramp ups; typically two, however a minimum of one dedicated observer maintaining a visual watch during all daytime airgun operations; two observers for 30 min before and during ramp ups; PAM during the day and night to complement visual monitoring (unless the system is temporarily damaged during operations); shut downs when marine mammals are detected in or about to enter the designated EZ; and power downs (or if necessary shut downs) when sea turtles or ESA-listed diving seabirds are detected in or about to enter EZ. These mitigation measures are described in § 2.4.4.1 of the PEIS and summarized earlier in this document, in § II (2.1.3), along with the special mitigation measures required. The fact that the airgun array, because of its design, would direct the majority of the energy downward, and less energy laterally, is also an inherent mitigation measure. In addition, mitigation measures to reduce the potential of bird strandings on the vessel include downward-pointing deck lighting and curtains/shades on all cabin windows.

Previous and subsequent analysis of the potential impacts takes account of these planned mitigation measures. It would not be meaningful to analyze the effects of the planned activity without mitigation, as the mitigation (and associated monitoring) measures are a basic part of the activity and would be implemented under the Proposed Action.

4.1.1.5 Potential Numbers of Marine Mammals Exposed to Received Sound Levels ≥160 dB

All takes would be anticipated to be Level B "takes by harassment" as described in § I, involving temporary changes in behavior. Consistent with past similar proposed actions, NSF has followed the NOAA *Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing* for estimating Level A takes. Although NMFS may issue Level A takes for the remote possibility of low-level physiological effects, because of the characteristics of the proposed activities and the proposed monitoring and mitigation measures, in addition to the general avoidance by marine mammals of loud sounds, injurious takes would not be expected. (However, as noted earlier and in the PEIS, there is no specific information demonstrating that injurious Level A "takes" would occur even in the absence of the planned mitigation measures.) In the sections below, we describe methods to estimate the number of potential exposures to Level A and Level B sound levels and present estimates of the numbers of marine mammals that could be affected during the proposed seismic surveys. The estimates are based on consideration of the number of marine mammals that could be harassed by sound (Level B takes) produced by the seismic surveys in the Northeast Pacific outside of Canadian Territorial Waters; they are based on the originally planned 2020 tracklines and remain adequately representative of the current survey plan.

The Level B estimates are based on a consideration of the number of marine mammals that could be within the area around the operating airgun array where received levels of sound ≥160 dB re 1 μPa_{rms} are predicted to occur (see Table 1). The estimated numbers are based on the densities (numbers per unit area) of marine mammals expected to occur in the survey area in the absence of a seismic survey. To the extent that marine mammals tend to move away from seismic sources before the sound level reaches the criterion level and tend not to approach an operating airgun array, these estimates likely overestimate the numbers actually exposed to the specified level of sound. The overestimation is expected to be particularly large when dealing with the higher sound level criteria, i.e., the PTS thresholds (Level A), as animals are more likely to move away when received levels are higher. Thus, they are less likely to approach within the PTS threshold radii than they are to approach within the considerably larger ≥160 dB (Level B) radius.

For the majority of species, we used a combination of habitat-based stratified marine mammal densities developed by the U.S. Navy for assessing potential impacts of training activities in the GOA (DoN 2014) and densities for Behm Canal in Southeast Alaska (DoN 2019). Based on recommendations by NMFS, the GOA densities were used for offshore areas, and the Behm Canal densities were used for coastal waters. Consistent with Rone et al. (2014), four strata were defined by DoN (2014) for the GOA including (1) Inshore: all waters <1000 m deep; (2) Slope: from 1000 m 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 GOA were used for offshore waters. If no densities were available for Behm Canal, then 'Inshore' densities were used for coastal waters (shallow and intermediate depths); 'Offshore' densities were used for offshore waters.

For pinnipeds, we used densities from Behm Canal, when available, for shallow water (<100 m), 'Inshore' densities for intermediate-depth water (100–1000 m), and 'Offshore' densities for offshore waters. 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 GOA 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. Densities for harbor porpoise, northern right whale dolphin, California sea lion, northern sea otter, and leatherback turtle were determined using alternate density sources (see Appendix B for details).

Densities for sea otters are based on Tinker et al. (2019) and are presented in Appendix C; densities for cetaceans, pinnipeds, and turtles are presented in Table 8 and detailed in Appendix B. When seasonal densities were available (e.g., as for Behm Canal for humpback, killer, and minke whales; Pacific white-sided dolphin; Steller sea lion; and harbor seal), the calculated exposures were based on summer densities, which were deemed to be most representative of the proposed survey timing. For all other species, summer densities were either not available or the same as for other seasons. There is some uncertainty related to the estimated density data and the assumptions used in their calculations, as with all density data estimates. However, the approach used here is based on the best available data. The calculated exposures that are based on these densities are best estimates for the proposed survey.

Oceanographic conditions, including occasional El Niño and La Niña events, influence the distribution and numbers of marine mammals present in the North Pacific Ocean, resulting in considerable year-to-year variation in the distribution and abundance of many marine mammal species (Forney and Barlow 1998; Buchanan et al. 2001; Ferrero et al. 2002; Philbrick et al. 2003; Escorza-Treviño 2009). Thus, for some species, the densities derived from past surveys may not be representative of the densities that would be encountered during the proposed seismic surveys. However, the approach used here is based on the best available data.

The estimated numbers of individuals potentially exposed are based on the 160-dB re 1 μPa_{rms} criterion for all marine mammals. It is assumed that marine mammals exposed to airgun sounds that strong could change their behavior sufficiently to be considered "taken by harassment". Table 9 shows the

TABLE 8. Densities of marine mammals and sea turtles that could be exposed to Level B and Level A thresholds for NMFS defined hearing groups during the proposed survey. See Appendix B for more detail.

	Shallow Water <100 m	Intermediate Water 100-1000 m	Deep Water >1000 m
LF Cetaceans			
North Pacific right whale	0.00000	0.00000	0.00003
Humpback whale	0.01170	0.01170	0.00100
Blue whale	0.00010	0.00010	0.00050
Fin whale	0.00010	0.00010	0.01600
Sei whale	0.00040	0.00040	0.00040
Minke whale	0.00080	0.00080	0.00060
Gray whale	0.04857	0.04857	0
MF Cetaceans			
Sperm whale	0.00200	0.00200	0.00130
Baird's beaked whale	0	0	0.00050
Cuvier's beaked whale	0	0	0.00200
Stejneger's beaked whale	0	0	0.00210
Pacific white-sided dolphin	0.00750	0.00750	0.02000
Northern right-whale dolphin	0.01100	0.02763	0.03673
Risso's dolphin	0.00001	0.00001	0.00001
Killer whale	0.00570	0.00570	0.00200
HF Cetaceans			
Dall's porpoise	0.12100	0.12100	0.03700
Harbor porpoise	0.03300	0.03300	0
Otariid Seals			
Northern fur seal	0.06610	0.06610	0.06610
California sea lion	0.02880	0.02880	0.00650
Steller sea lion	0.31616	0.05700	0.00000
Phocid Seals			
Northern elephant seal	0.07790	0.07790	0.07790
Harbor seal	0.78110	0.14070	0
Sea Turtle			
Leatherback Turtle	0.000114	0.000114	0.000114

N.A. means not available/not applicable.

TABLE 9. Estimates of the possible numbers of marine mammals and sea turtles that could be exposed to Level B and Level A thresholds for various hearing groups during the proposed seismic surveys in the Northeast Pacific Ocean during summer 2021. Takes for Canadian Territorial Waters are not included here.

Species	Calculated Take		Regional Population Size	Level B + Level A as % of Pop.[3]	Requested Take Authorization[4]
	Level B[1]	Level A[2]			
LF Cetaceans					
North Pacific right whale	2	0	400	0	2
Humpback whale[5]	403	14	10,103	4.1	417
Blue whale	31	1	1,496	2.1	32
Fin whale	873	44	18,680	4.9	917
Sei whale	34	1	519	6.78	35
Minke whale	57	2	28,000	0.2	59
Gray whale[6]	1,450	45	26,960	5.5	1,495
MF Cetaceans					
Sperm whale	131	0	26,300	0.5	131
Baird's beaked whale	29	0	2,697	1.1	29
Cuvier's beaked whale	114	0	3,274	3.8	114
Stejneger's beaked whale	120	0	3,044	0.4	120
Pacific white-sided dolphin	1,371	3	26,880	5.1	1,374
Northern right-whale dolphin[7]	922	5	26,556	3.5	927
Risso's dolphin[8]	1	0	6,336	0.01	22
Killer whale[9]	290	0	3,738	7.8	290
HF Cetaceans					
Dall's porpoise	5,661	178	83,400	7.0	5,839
Harbor porpoise	990	26	11,146	9.1	1,016
Otariid Seals					
Northern fur seal	5,804	8	608,143	1.0	5,812
California sea lion	1,257	1	257,606	0.5	1,258
Steller sea lion[10]	2,433	2	43,201	5.6	2,435
Phocid Seal					
Northern elephant seal	6,811	39	179,000	3.8	6,850
Harbor seal	5,992	21	13,289	45.2	6,012
Marine Fissiped					
Northern Sea Otter[11]	49	0	25,584	0.2	49
Sea Turtle					
Leatherback turtle	3	0	N.A.	N.A.	3

N.A. means not applicable or not available.

[1] Level B takes, based on the 160-dB criterion, excluding exposures to sound levels equivalent to PTS thresholds.

[2] Level A takes if there were no mitigation measures.

[3] Requested take authorization (Level A + Level B) expressed as % of population (see Table 5).

[4] Requested take authorization is Level A plus Level B calculated takes, except as indicated otherwise.

[5] Fifteen takes from Mexico DPS; remainder from Hawaii DPS (assumes 3.8% of humpbacks that occur in southeast Alaska and northern B.C. are from the Mexico DPS (Wade 2017).

[6] Two Level B takes and zero Level A takes from western DPS; remainder from Eastern North Pacific DPS (assumes 0.1% of gray whales could be from the Western North Pacific DPS (NMSF pers. comm. based on Carretta et al. 2019, 2020).

[7] All takes expected to occur in Canadian waters (takes in territorial waters not included here).

[8] Requested take increased to mean group size (Barlow 2016).

[9] Takes include individuals from all stocks that could occur in survey area; no takes expected for Southern Resident DPS.

[10] Fifty-four Level B takes and zero Level A takes would be from the Western DPS; remainder of takes from Eastern DPS (based on Hastings et al. (2019), it is expected that 2.2% of Steller sea lions in the central outer coast region of southeast Alaska would be from the endangered Western DPS.

[11] Takes calculated by USFWS and detailed in Appendix C.

estimates of the number of marine mammals that potentially could be exposed to ≥160 dB re 1 µPa_{rms} during the proposed seismic surveys if no animals moved away from the survey vessel (see Appendices B and C for more details), along with the *Requested Take Authorization*. It should be noted that the exposure estimates assume that the proposed surveys would be completed; in fact, the calculated takes for cetaceans, pinnipeds, and sea turtles ***have been increased by 25%*** (see below). Thus, the following estimates of the numbers of marine mammals potentially exposed to sounds ≥160 dB re 1 µPa_{rms} are precautionary and probably overestimate the actual numbers of marine mammals that could be involved.

Consideration should be given to the hypothesis that delphinids are less responsive to airgun sounds than are mysticetes, as referenced in the NSF/USGS PEIS. The 160-dB_{rms} criterion currently applied by NMFS, on which the Level B estimates are based, was developed primarily using data from gray and bowhead whales. The estimates of "takes by harassment" of delphinids are thus considered precautionary. Available data suggest that the current use of a 160-dB criterion could be improved upon, as behavioral response might not occur for some percentage of marine mammals exposed to received levels >160 dB, whereas other individuals or groups might respond in a manner considered as "taken" to sound levels <160 dB (NMFS 2016c). It has become evident that the context of an exposure of a marine mammal to sound can affect the animal's initial response to the sound (NMFS 2016c).

The number of cetaceans and pinnipeds that could be exposed to airgun sounds with received levels ≥160 dB re 1 µPa_{rms} (Level B)on one or more occasions have been estimated using a method recommended by NMFS for calculating the marine area that would be within the Level B threshold around the operating seismic source, along with the expected density of animals in the area. This method was developed to account in some way for the number of exposures as well as the number of individuals exposed. It involves selecting a seismic trackline(s) that could be surveyed on one day, in this case 187 km. A representative line(s) were chosen for the survey effort in the US and Canada. The area expected to be ensonified on that day was determined by entering the planned survey lines into a MapInfo GIS, using GIS to identify the relevant areas by "drawing" the applicable 160-dB (Table 1) and PTS threshold buffers (Table 2) around each line. The ensonified areas for each country were then multiplied by the number of survey days (11 days for survey effort off Canada; 16 days for the US) increased by 25%; this is equivalent to adding an additional 25% to the proposed line kilometers (see Appendix D for more details). The approach assumes that no marine mammals would move away or toward the trackline in response to increasing sound levels before the levels reach the specific thresholds as R/V *Langseth* approaches. The number of sea otters that could be exposed to airgun sounds with received levels ≥160 dB re 1 µPa_{rms} (Level B) on one or more occasions have been estimated by USFWS; the details are outlined in Appendix C.

Estimates of the numbers of marine mammals and sea turtles that could be exposed to seismic sounds with received levels equal to Level A thresholds for various hearing groups (see Table 2), if there were no mitigation measures (shut downs when PSOs observe animals approaching or inside the EZs), are also given in Table 9. Those numbers likely overestimate actual Level A takes because the predicted Level A EZs are small and mitigation measures would further reduce the chances of, if not eliminate, any such takes. In addition, most marine mammals would move away from a sound source before they are exposed to sound levels that could result in a Level A take. Dall's porpoise could be more susceptible to exposure to sound levels that exceed the PTS threshold than other marine mammals, as it is known to approach vessels to bowride. However, Level A takes are considered highly unlikely for most marine mammal species that could be encountered in the proposed survey area, in particular sea otters, which spend a substantial amount of time each day on the surface of the water.

4.1.1.6 Conclusions for Marine Mammals and Sea Turtles

The proposed seismic surveys would involve towing a 36-airgun array, which introduces pulsed sounds into the ocean. Routine vessel operations, other than the proposed seismic operations, are conventionally assumed not to affect marine mammals sufficiently to constitute "taking".

***Marine Mammals*.**— In § 3.6.7, § 3.7.7, § 3.8.7, and § 3.9.7 of the PEIS concluded that airgun operations with implementation of the proposed monitoring and mitigation measures could result in a small number of Level B behavioral effects in some mysticete, odontocete, and pinniped species, as well as sea otters, and that Level A effects were highly unlikely. Consistent with past similar proposed actions, NSF has followed the *Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing* for estimating Level A takes for the Proposed Action, however, following a different methodology than used in the PEIS and most previous analyses for NSF-funded seismic surveys. For recently NSF-funded seismic surveys, NMFS issued small numbers of Level A take for some marine mammal species for the remote possibility of low-level physiological effects; however, NMFS expected neither mortality nor serious injury of marine mammals to result from the surveys (e.g., NMFS 2019a,b).

In this analysis, estimates of the numbers of marine mammals that could be exposed to airgun sounds during the proposed program have been presented, together with the requested "take authorization". The estimated numbers of animals potentially exposed to sound levels sufficient to cause Level A and/or B harassment are low percentages of the regional population sizes (Table 9). The proposed activities are likely to adversely affect ESA-listed species for which takes are being requested (Table 10). However, the relatively short-term exposures are unlikely to result in any long-term negative consequences for the individuals or their populations.

In decades of seismic surveys carried out by R/V *Langseth* and its predecessor, R/V *Ewing*, PSOs and other crew members have seen no seismic sound-related marine mammal injuries or mortality. A similar survey conducted in the region in the past (Marine Geophysical Surveys by R/V *Marcus G. Langseth* in the Northeastern Pacific Ocean, June–July 2012) had no observed significant impacts. Also, actual numbers of animals potentially exposed to sound levels sufficient to cause disturbance (i.e., are considered takes) have almost always been much lower than predicted and authorized takes. For example, during an NSF-funded, ~5000-km, 2-D seismic survey conducted by R/V *Langseth* off the coast of North Carolina in September–October 2014, only 296 cetaceans were observed within the predicted 160-dB zone and potentially taken, representing <2% of the 15,498 takes authorized by NMFS (RPS 2015). During an USGS-funded, ~2700 km, 2-D seismic survey conducted by R/V *Langseth* along the U.S. east coast in August–September 2014, only 3 unidentified dolphins were observed within the predicted 160-dB zone and potentially taken, representing <0.03% of the 11,367 authorized takes (RPS 2014b). Furthermore, as defined, all animals exposed to sound levels >160 dB are Level B 'takes' whether or not a behavioral response occurred. The Level B estimates are thought to be conservative; thus, not all animals detected within this threshold distance would be expected to have been exposed to actual sound levels >160 dB.

***Sea Turtles*.—**In § 3.4.7, the PEIS concluded that with implementation of the proposed monitoring and mitigation measures, no significant impacts of airgun operations are likely to sea turtle populations in any of the analysis areas, and that any effects are likely to be limited to short-term behavioral disturbance and short-term localized avoidance of an area of unknown size near the active airguns. In decades of seismic surveys carried out by R/V *Langseth* and its predecessor, R/V *Ewing*, PSOs and other crew members have seen no seismic sound-related sea turtle injuries or mortality. Given the proposed activities, impacts would not be anticipated to be significant or likely to adversely affect green turtles, but they would likely adversely affect the leatherback sea turtle (Table 11).

TABLE 10. ESA determination for marine mammal species expected to be encountered during the proposed surveys in the Northeast Pacific Ocean during summer 2021.

	ESA Determination		
Species	**No Effect**	**May Affect – Not Likely to Adversely Affect**	**May Affect – Likely to Adversely Affect**
North Pacific Right Whale			√
Humpback Whale (Central America DPS)		√	
Humpback Whale (Mexico DPS)			√
Humpback Whale (Western North Pacific DPS)	√		
Sei Whale			√
Fin Whale			√
Blue Whale			√
Sperm Whale			√
Killer Whale (Southern Resident DPS)		√	

TABLE 11. ESA determination for sea turtle species expected to be encountered during the proposed surveys in the Northeast Pacific Ocean during summer 2021.

	ESA Determination		
Species	**No Effect**	**May Affect – Not Likely to Adversely Affect**	**May Affect – Likely to Adversely Affect**
Leatherback Turtle			√
Green Turtle (East Pacific DPS)		√	

4.1.2 Direct Effects on Marine Invertebrates, Fish, and Fisheries, and Their Significance

Effects of seismic sound on marine invertebrates (crustaceans and cephalopods), marine fish, and their fisheries are discussed in § 3.2.4 and § 3.3.4 and Appendix D of the PEIS. Relevant new studies on the effects of sound on marine invertebrates, fish, and fisheries that have been published since the release of the PEIS are summarized below. Although research on the effects of exposure to airgun sound on marine invertebrates and fishes is increasing, many data gaps remain (Hawkins et al. 2015; Carroll et al. 2017), including how particle motion rather than sound pressure levels affect invertebrates and fishes that are exposed to sound (Hawkins and Popper 2017; Popper and Hawkins 2018). It is important to note that while all invertebrates and fishes are likely sensitive to particle motion, no invertebrates and not all fishes (e.g., sharks) are sensitive to the sound pressure component.

Substrate vibrations caused by sounds may also affect the epibenthos, but sensitivities are largely unknown (Roberts and Elliott 2017). Activities directly contacting the seabed would be expected to have localized impacts on invertebrates and fishes that use the benthic habitat. A risk assessment of the potential impacts of airgun surveys on marine invertebrates and fish in Western Australia concluded that the greater the intensity of sound and the shallower the water, the greater the risk to these animals (Webster et al. 2018). In water >250 m deep, the impact of seismic surveying on fish and marine invertebrates was assessed as acceptable, while in water <250 m deep, risk ranged from negligible to severe, depending on depth, resource-type, and sound intensity (Webster et al. 2018). Immobile organisms, such as molluscs, were deemed to be the invertebrates most at risk from seismic impacts.

4.1.2.1 Effects of Sound on Marine Invertebrates

Effects of anthropogenic sounds on marine invertebrates are varied, ranging from no overt reactions to behavioral/physiological responses, injuries, or mortalities (Aguilar de Soto 2016; Edmonds et al. 2016; Carroll et al. 2017; Weilgart 2017b; Elliott et al. 2019). The available information suggests that invertebrates, particularly crustaceans, may be relatively resilient to airgun sounds (Day et al. 2016a,b).

Fields et al. (2019) conducted laboratory experiments to study effects of exposure to airgun sound on the mortality, predator escape response, and gene expression of the copepod *Calanus finmarchicus* and concluded that the airgun sound had limited effects on the mortality and escape responses of copepods exposed within 10 m of the airgun source but no measurable impact beyond that distance. McCauley et al. (2017) conducted a 2-day study to examine the potential effects of sound exposure of a 150 in^3 airgun on zooplankton off the coast of Tasmania; they concluded that exposure to airgun sound decreased zooplankton abundance compared to control samples and caused a two- to three-fold increase in adult and larval zooplankton mortality. They observed impacts on the zooplankton as far as 1.2 km from the exposure location – a much greater impact range than previously thought; however, there was no consistent decline in the proportion of dead zooplankton as distance increased and received levels decreased. The conclusions by McCauley et al. (2017) were based on a relatively small number of zooplankton samples, and more replication is required to increase confidence in the study findings.

Richardson et al. (2017) presented results of a modeling exercise intended to investigate the impact of exposure to airgun sound on zooplankton over a much larger temporal and spatial scale than that employed by McCauley et al. (2017). The exercise modeled a hypothetical survey over an area 80 km by 36 km during a 35-day period. Richardson et al. (2017) postulated that the decrease in zooplankton abundance observed by McCauley et al. (2017) could have been due to active avoidance behavior by larger zooplankton. The modeling results did indicate that there would be substantial impact on the zooplankton populations at a local spatial scale but not at a large spatial scale; zooplankton biomass recovery within the exposure area and out to 15 km occurred 3 days after completion of the seismic survey.

Fewtrell and McCauley (2012) exposed captive squid (*Sepioteuthis australis*) to pulses from a single airgun; the received sound levels ranged from 120–184 dB re 1 dB re 1 μPa$^2 \cdot$s SEL. Increases in alarm responses were seen at SELs >147–151 dB re 1 μPa$^2 \cdot$s; the squid were seen to discharge ink or change their swimming pattern or vertical position in the water column. Solé et al. (2013a,b) exposed four cephalopod species held in tanks to low-frequency (50–400 Hz) sinusoidal wave sweeps (with a 1-s sweep period for 2 h) with received levels of 157 ± 5 dB re 1 μPa and peak levels up to 175 dB re 1 μPa. Besides exhibiting startle responses, all four species examined received damage to the statocyst, which is the organ responsible for equilibrium and movement. The animals also showed stressed behavior, decreased activity, and loss of muscle tone (Solé et al. 2013a). To examine the contribution from near-field particle motion from the tank walls on the study, Solé et al. (2017) exposed common cuttlefish (*Sepia officinalis*) in cages in their natural habitat to 1/3 octave bands with frequencies centered at 315 Hz and 400 Hz and levels ranging from 139–141 re 1 μPa^2. The study animals still incurred acoustic trauma and injury to statocysts, despite not being held in confined tanks with walls.

When New Zealand scallop (*Pecten novaezelandiae*) larvae were exposed to recorded seismic pulses, significant developmental delays were reported, and 46% of the larvae exhibited body abnormalities; it was suggested that the malformations could be attributable to cumulative exposure (Aguilar de Soto et al. 2013). Their experiment used larvae enclosed in 60-mL flasks suspended in a 2-m diameter by 1.3-m water depth tank and exposed to a playback of seismic sound at a distance of 5–10 cm.

There have been several *in situ* studies that have examined the effects of seismic surveys on scallops. Although most of these studies showed no short-term mortality in scallops (Parry et al. 2002; Harrington et al. 2010; Przeslawski et al. 2016, 2018), one study (Day et al. 2016a,b, 2017) did show adverse effects including an increase in mortality rates. Przeslawski et al. (2016, 2018) studied the potential impacts of an industrial seismic survey on commercial (*Pecten fumatus*) and doughboy (*Mimachlamys asperrima*) scallops. *In situ* monitoring of scallops took place in the Gippsland Basin, Australia, using dredging, and autonomous underwater vehicle deployment before the seismic survey, as well as two, and ten months after the survey. The airgun array used in the study was a single 2530 in^3 array made up of 16 airguns operating at 2000 psi with a maximum SEL of 146 dB re 1 $\mu Pa^2 \cdot s$ at 51 m depth. Overall, there was little to no detectable impact of the seismic survey on scallop health as measured by scallop shell size, adductor muscle diameter, gonad size, or gonad stage (Przeslawski et al. 2016). No scallop mortality related to airgun sounds was detected two or ten months after the seismic survey (Przeslawski et al. 2016, 2018).

Day et al. (2016a,b, 2017) exposed scallops (*P. fumatus*) and egg-bearing female spiny lobsters (*Jasus edwardsi*) at a location 10–12 m below the surface to airgun sounds. The airgun source was started ~1–1.5 km from the study subjects and passed over the animals; thus, the scallops and lobsters were exposed to airgun sounds as close as 5–8 m away and up to 1.5 km from the source. Three different airgun configurations were used in the field: 45 in^3, 150 in^3 (low pressure), and 150 in^3 (high pressure), each with maximum peak-to-peak source levels of 191–213 dB re 1 µPa; maximum cumulative SEL source levels were 189–199 dB re 1 $\mu Pa^2 \cdot s$. Exposure to seismic sound was found to significantly increase mortality in the scallops, especially over a chronic time scale (i.e., months post-exposure), although not beyond naturally occurring rates of mortality (Day et al. 2017). Non-lethal effects were also recorded, including changes in reflex behavior time, other behavioral patterns, haemolymph chemistry, and apparent damage to statocysts (Day et al. 2016b, 2017). However, the scallops were reared in suspended lantern nets rather than their natural environment, which can result in higher mortality rates compared to benthic populations (Yu et al. 2010). The female lobsters were maintained until the eggs hatched; no significant differences were found in the quality or quantity of larvae for control versus exposed subjects, indicating that the embryonic development of spiny lobster was not adversely affected by airgun sounds (Day et al. 2016a,b). No mortalities were reported for either control or exposed lobsters (Day et al. 2016a,b). When Day et al. (2019) exposed rock lobster to the equivalent of a full-scale commercial seismic survey passing within 100–500 m, lobsters exhibited impaired righting and damage to the sensory hairs of the statocyst.

Fitzgibbon et al. (2017) also examined the impact of airgun exposure on spiny lobster through a companion study to the Day et al. (2016a,b, 2017) studies; the same study site, experimental treatment methodologies, and airgun exposures were used. The objectives of the study were to examine the haemolymph biochemistry and nutritional condition of groups of lobsters over a period of up to 365 days post-airgun exposure. Overall, no mortalities were observed across both the experimental and control groups; however, lobster total haemocyte count decreased by 23–60% for all lobster groups up to 120 days post-airgun exposure in the experimental group when compared to the control group. A lower haemocyte count increases the risk of disease through a lower immunological response. The only other haemolyph parameter that was significantly affected by airgun exposure was the Brix index of haemolymph at 120 and 365 days post-airgun exposure in one of the experiments involving egg-laden females. Other studies conducted in the field have shown no effects on Dungeness crab larvae or snow crab embryos to seismic sounds (Pearson et al. 1994; DFO 2004b; Morris et al. 2018).

Payne et al. (2015) undertook two pilot studies which (i) examined the effects of a seismic airgun recording in the laboratory on lobster (*Homerus americanus*) mortality, gross pathology, histopathology, serum biochemistry, and feeding; and (ii) examined prolonged or delayed effects of seismic air gun pulses in the laboratory on lobster mortality, gross pathology, histopathology, and serum biochemistry. For experiment (i), lobsters were exposed to peak-to-peak and root-mean-squared received sound levels of 180 dB re 1 µPa and 171 dB re 1 μPa_{rms} respectively. Overall there was no mortality, loss of appendages, or other signs of gross pathology observed in exposed lobster. No differences were observed in haemolymph, feeding, ovary histopathology, or glycogen accumulation in the heptapancreas. The only observed differences were greater degrees of tubular vacuolation and tubular dilation in the hepatopancreas of the exposed lobsters. For experiment (ii), lobsters were exposed to 20 airgun shots per day for five successive days in a laboratory setting. The peak-to-peak and root-mean-squared received sound levels ranged from ~176–200 dB re 1 µPa and 148–172 dB re 1 μPa_{rms}, respectively. The lobsters were returned to their aquaria and examined after six months. No differences in mortality, gross pathology, loss of appendages, hepatopancreas/ovary histopathology or glycogen accumulation in the hepatopancreas were observed between exposed and control lobsters. The only observed difference was a slight statistically significant difference for calcium-protein concentration in the haemolymph, with lobsters in the exposed group having a lower concentration than the control group.

Celi et al. (2013) exposed captive red swamp crayfish (*Procambarus clarkia*) to linear sweeps with a frequency range of 0.1–25 kHz and a peak amplitude of 148 dB re 1 μPa_{rms} at 12 kHz for 30 min. They found that the noise exposure caused changes in the haemato-immunological parameters (indicating stress) and reduced agonistic behaviors. Wale et al. (2013a,b) showed increased oxygen consumption and effects on feeding and righting behavior of shore crabs when exposed to ship sound playbacks.

Leite et al. (2016) reported observing a dead giant squid (*Architeuthis dux*) while undertaking marine mammal observation work aboard a seismic vessel conducting a seismic survey in offshore Brazil. The seismic vessel was operating 48-airgun array with a total volume of 5085 in^3. As no further information on the squid could be obtained, it is unknown whether the airgun sounds played a factor in the death of the squid.

Heyward et al. (2018) monitored corals *in situ* before and after exposure to a 3-D seismic survey; the maximum SEL and $SPL_{0\text{-}pk}$ were 204 dB re 1 $\mu Pa^2 \cdot s$ and 226 dB re 1 µPa. No macroscopic effects on soft tissues or the skeleton were noted days or months after the survey.

4.1.2.2 Effects of Sound on Fish

Popper et al. (2019a) recently reviewed the hearing ability of fishes, and potential impacts of exposure to airgun sound on marine fishes have been reviewed by Popper (2009), Popper and Hastings (2009a,b), Fay and Popper (2012), Weilgart (2017b), Hawkins and Popper (2018), Popper et al. (2019b), and Slabbekoorn et al. (2019); they include pathological, physiological, and behavioral effects. Radford et al. (2014) and Putland et al. (2017) noted that masking of key environmental sounds or social signals could also be a potential negative effect from sound. Popper et al. (2014) presented guidelines for seismic sound level thresholds related to potential effects on fish. The effect types discussed include mortality, mortal injury, recoverable injury, temporary threshold shift, masking, and behavioral effects. Seismic sound level thresholds were discussed in relation to fish without swim bladders, fish with swim bladders, and fish eggs and larvae. Hawkins and Popper (2017) cautioned that particle motion as well as sound pressure should be considered when assessing the effects of underwater sound on fishes.

Bruce et al. (2018) studied the potential behavioral impacts of a seismic survey in the Gippsland Basin, Australia, on three shark species: tiger flathead (*Neoplatycephalus richardsoni*), gummy shark (*Mustelus antarcticus*), and swellshark (*Cephaloscylum laticeps*). Sharks were captured and tagged with acoustic tags before the survey and monitored for movement via acoustic telemetry within the seismic area. The energy source used in the study was a 2530 in^3 array consisting of 16 airguns with a maximum SEL of 146 dB re 1 $\mu Pa^2 \cdot s$ at 51 m depth. Flathead and gummy sharks were observed to move in and around the acoustic receivers while the airguns in the survey were active; however, most sharks left the study area within 2 days of being tagged. The authors of the study did not attribute this behavior to avoidance, possibly because the study area was relatively small. Overall, there was little conclusive evidence of the seismic survey impacting shark behavior, though flathead shark did show increases in swim speed that was regarded by the authors as a startle response to the airguns operating within the area.

Peña et al. (2013) used an omnidirectional fisheries sonar to determine the effects of a 3-D seismic survey off Vesterålen, northern Norway, on feeding herring (*Clupea harengus*). They reported that herring schools did not react to the seismic survey; no significant changes were detected in swimming speed, swim direction, or school size when the drifting seismic vessel approached the fish from a distance of 27 km to 2 km over a 6-h period. Peña et al. (2013) attributed the lack of response to strong motivation for feeding, the slow approach of the seismic vessel, and an increased tolerance to airgun sounds.

Miller and Cripps (2013) used underwater visual census to examine the effect of a seismic survey on a shallow-water coral reef fish community in Australia. The census took place at six sites on the reef before and after the survey. When the census data collected during the seismic program were combined with historical data, the analyses showed that the seismic survey had no significant effect on the overall abundance or species richness of reef fish. This was in part attributed to the design of the seismic survey (e.g., ≥400 m buffer zone around reef), which reduced the impacts of seismic sounds on the fish communities by exposing them to relatively low SELs (<187 dB re 1 $\mu Pa^2 \cdot s$).

Fewtrell and McCauley (2012) exposed pink snapper (*Pagrus auratus*) and trevally (*Pseudocaranx dentex*) to pulses from a single airgun; the received sound levels ranged from 120–184 dB re 1 dB re 1 $\mu Pa^2 \cdot s$ SEL. Increases in alarm responses were seen in the fish at SELs >147–151 dB re 1 $\mu Pa^2 \cdot s$; the fish swam faster and formed more cohesive groups in response to the airgun sounds.

Hastings and Miksis-Olds (2012) measured the hearing sensitivity of caged reef fish following exposure to a seismic survey in Australia. When the auditory evoked potentials (AEP) were examined for fish that had been in cages as close as 45 m from the pass of the seismic vessel and at water depth of 5 m, there was no evidence of TTS in any of the fish examined, even though the cumulative SELs had reached 190 dB re 1 $\mu Pa^2 \cdot s$.

Davidsen et al. (2019) outfitted Atlantic cod and saithe with acoustic transmitters to monitor their behaviors (i.e., swimming speed, movement in water column) in response to exposure to seismic airgun sound. The study was conducted in Norway using a large sea cage with a 30 m diameter and 25 m depth. Both sound pressure and particle motion were measured within the sea cage. An airgun firing every 10 s was towed toward the sea cage from an initial distance of 6.7 km from the cage to a minimum distance of 100 m from the cage. The SEL_{cum} ranged from 172–175 dB re 1 $\mu Pa^2 \cdot s$. Both the cod and saithe changed swimming depth and horizontal position more frequently during exposure to the sound. The saithe became more dispersed in response to elevated sound levels. Both species exhibited behavioral habituation to the repeated exposures to sound.

Radford et al. (2016) conducted experiments examining how repeated exposures of different sounds to European seabass (*Dicentrarchus labrax*) can reduce the fishes' response to that sound. They exposed post-larval seabass to playback recordings of seismic survey sound (single strike SEL 144 dB re 1 $\mu Pa^2 \cdot s$) in large indoor tanks containing underwater speakers. Their findings indicated that short-term exposure of seismic sound increased the ventilation rate (i.e., opercular beat rate [OBR]) of seabass that were not previously exposed to seismic relative to seabass in controlled, ambient sound conditions. Fish that were reared in tanks that were repeatedly exposed to seismic sound over a 12-week period exhibited a reduced OBR response to that sound type, but fish exposed over the same time period to pile-driving noise displayed a reduced response to both seismic and pile-driving noise. An increased ventilation rate is indicative of greater stress in seabass; however, there was no evidence of mortality or effects on growth of the seabass throughout the 12-week study period.

Popper et al. (2016) conducted a study that examined the effects of exposure to seismic airgun sound on caged pallid sturgeon (*Scaphirhynchus albus*) and paddlefish (*Polyodon spathula*); the maximum received peak SPL in this study was 224 dB re 1 µPa. Results of the study indicated no mortality, either during or seven days after exposure, and no statistical differences in effects on body tissues between exposed and control fish.

Andrews et al. (2014) conducted functional genomic studies on the inner ear of Atlantic salmon (*Salmo salar*) that had been exposed to seismic airgun sound. The airguns had a maximum SPL of ~145 dB re 1 $\mu Pa^2/Hz$ and the fish were exposed to 50 discharges per trial. The results provided evidence that fish exposed to seismic sound either increased or decreased their expressions of different genes, demonstrating that seismic sound can affect fish on a genetic level.

Sierra-Flores et al. (2015) examined broadcast sound as a short-term stressor in Atlantic cod (*Gadus morhua*) using cortisol as a biomarker. An underwater loudspeaker emitted SPLs ranging from 104–110 dB re 1 μPa_{rms}. Plasma cortisol levels of fish increased rapidly with sound exposure, returning to baseline levels 20–40 min post-exposure. A second experiment examined the effects of long-term sound exposure on Atlantic cod spawning performance. Tanks were stocked with male and female cod and exposed daily to six noise events, each lasting one hour. The noise exposure had a total SPL of 133 dB re 1 µPa. Cod eggs were collected daily and measured for egg quality parameters as well as egg cortisol content. Total egg volume, floating fraction, egg diameter and egg weight did not appear to be negatively affected by sound exposure. However, fertilization rate and viable egg productivity were reduced by 40% and 50%, respectively, compared with the control group. Mean egg cortisol content was found to be 34% greater in the exposed group as compared to the control group. Elevated cortisol levels inhibit reproductive physiology for males and can result in a greater frequency of larval deformities for spawning females.

4.1.2.3 Effects of Sound on Fisheries

Handegard et al. (2013) examined different exposure metrics to explain the disturbance of seismic surveys on fish. They applied metrics to two experiments in Norwegian waters, during which fish distribution and fisheries were affected by airguns. Even though the disturbance for one experiment was greater, the other appeared to have the stronger SEL, based on a relatively complex propagation model. Handegard et al. (2013) recommended that simple sound propagation models should be avoided and that the use of sound energy metrics like SEL to interpret disturbance effects should be done with caution. In this case, the simplest model (exposures per area) best explained the disturbance effect.

Hovem et al. (2012) used a model to predict the effects of airgun sounds on fish populations. Modeled SELs were compared with empirical data and were then compared with startle response levels for cod. This work suggested that in the future, particular acoustic-biological models could be useful in designing and planning seismic surveys to minimize disturbance to fishing. Their preliminary analyses indicated that seismic surveys should occur at a distance of 5–10 km from fishing areas, in order to minimize potential effects on fishing.

In their introduction, Løkkeborg et al. (2012) described three studies in the 1990s that showed effects on fisheries. Results of a study off Norway in 2009 indicated that fishes reacted to airgun sound based on observed changes in catch rates during seismic shooting; gillnet catches increased during the seismic shooting, likely a result of increased movement of exposed fish, whereas longline catches decreased overall (Løkkeborg et al. 2012).

Streever et al. (2016) completed a Before-After/Control-Impact (BACI) study in the nearshore waters of Prudhoe Bay, Alaska in 2014 which compared fish catch rates during times with and without seismic activity. The air gun arrays used in the geophysical survey had sound pressure levels of 237 dB re 1$\mu Pa_{0\text{-}p}$, 243 dB re 1µPa_{p-p}, and 218 dB re 1µPa_{rms}. Received SPL_{max} ranged from 107–144 dB re 1 µPa, and received SEL_{cum} ranged from 111–141 dB re 1µPa^2-s for air gun pulses measured by sound recorders at four fyke net locations. They determined that fyke nets closest to air gun activities showed decreases in catch per unit effort (CPUE) while nets further away from the air gun source showed increases in CPUE.

Bruce et al. (2018) studied the potential impacts of an industrial seismic survey in the Gippsland Basin, Australia, on catches in the Danish seine and gillnet fishing sectors for 15 fish species. Catch data were examined from three years before the seismic survey to six months after completion of the survey in an area 13,000 km^2. Overall, there was little evidence of consistent adverse impacts of the seismic survey on catch rates. Six of the 15 species were found to have increased catch rates.

Paxton et al. (2017) examined the effects of seismic sounds on the distribution and behavior of fish on a temperate reef during a seismic survey conducted in the Atlantic Ocean on the inner continental shelf of North Carolina. Hydrophones were set up near the seismic vessel path to measure SPLs, and a video camera was set up to observe fish abundances and behaviors. Received SPLs were estimated at ~202–230 dB re 1 µPa. Overall abundance of fish was lower when undergoing seismic activity as opposed to days when no seismic occurred. Only one fish was observed to exhibit a startle response to the airgun shots. The authors claim that although the study was based on limited data, it contributes evidence that normal fish use of reef ecosystems is reduced when they are impacted by seismic sounds.

Morris et al. (2018) conducted a two-year (2015–2016) BACI study examining the effects of 2-D seismic exploration on catch rates of snow crab (*Chionoecetes opilio*) along the eastern continental slope (Lilly Canyon and Carson Canyon) of the Grand Banks of Newfoundland, Canada. The airgun array used was operated from a commercial seismic exploration vessel; it had a total volume of 4880 in^3, horizontal zero-to-peak SPL of 251 dB re 1 µPa, and SEL of 229 dB re 1 µPa^2·s. The closest approach of the survey vessel to the treatment site in 2015 (year 1 of the study) was 1465 m during 5 days of seismic operations; in 2016 (year 2), the vessel passed within 100 m of the treatment site but the exposure lasted only 2 h. Overall, the findings indicated that the sound from the commercial seismic survey did not significantly reduce snow crab catch rates during days or weeks following exposure. Morris et al. (2018) attributed the natural temporal and spatial variations in the marine environment as a greater influence on observed differences in catch rates between control and experimental sites than exposure to seismic survey sounds.

4.1.2.4 Conclusions for Invertebrates, Fish, Fisheries, EFH, and HAPC

The newly available information does not affect the outcome of the effects assessment as presented in the PEIS. The PEIS concluded that there could be changes in behavior and other non-lethal, short-term, temporary impacts, and injurious or mortal impacts on a small number of individuals within a few meters of a high-energy acoustic source, but that there would be no significant impacts of NSF-funded marine seismic research on populations. The PEIS also concluded that seismic surveys could cause temporary, localized reduced fish catch to some species, but that effects on fisheries would not be significant.

Interactions between the proposed surveys and fishing operations in the study area are expected to be limited. Two possible conflicts in general are R/V *Langseth*'s streamer entangling with fishing gear and the temporary displacement of fishers from the survey area. Fishing activities could occur within the proposed survey area; a safe distance would need to be kept from R/V *Langseth* and the towed seismic equipment. Conflicts would be avoided through communication with the fishing community during the surveys. PSOs would also watch for any impacts the acoustic sources may have on fish during the survey.

Given the proposed activities, impacts would not be anticipated to be significant or likely to adversely affect (including ESA-listed) marine invertebrates, marine fish (Table 12), and their fisheries, including commercial, recreational, and subsistence fisheries. In decades of seismic surveys carried out

TABLE 12. ESA determination for DPSs or ESUs of fish species expected to be encountered during the proposed surveys in the Northeast Pacific Ocean during summer 2021.

	ESA Determination		
Species	**No Effect**	**May Affect – Not Likely to Adversely Affect**	**May Affect – Likely to Adversely Affect**
Steelhead Trout (Various DPSs)		√	
Chinook Salmon (Various ESUs)		√	
Chum Salmon (Various ESUs)		√	
Coho Salmon (Various ESUs)		√	
Sockeye Salmon (Various ESUs)		√	
Green Sturgeon (Southern DPS)		√	

by R/V *Langseth* and its predecessor, R/V *Ewing*, PSOs and other crew members have not observed any seismic sound-related fish or invertebrate injuries or mortality. In addition, no adverse effects on EFH or HAPCare expected given the short-term nature of the study (~36 days) and minimal bottom disturbance.

4.1.3 Direct Effects on Seabirds and Their Significance

The underwater hearing of seabirds (including loons, scaups, gannets, and ducks) has recently been investigated, and the peak hearing sensitivity was found to be between 1500 and 3000 Hz (Crowell 2016). The best sensitivity of underwater hearing for great cormorants was found to be at 2 kHz, with a hearing threshold of 71 dB re 1 μPa_{rms} (Hansen et al. 2017). Great cormorants were also found to respond to underwater sounds and may have special adaptations for hearing underwater (Johansen et al. 2016; Hansen et al. 2017). African penguins (*Spheniscus demersus*) outfitted with GPS loggers showed strong avoidance of preferred foraging areas and had to forage further away and increase their foraging effort when a seismic survey was occurring within 100 km of the breeding colony (Pichegru et al. 2017). However, the birds resumed their normal behaviors when seismic operations concluded.

Potential effects of seismic sound and other aspects of seismic operations (collisions, entanglement, and ingestion) on seabirds are discussed in § 3.5.4 of the PEIS. The PEIS concluded that there could be transitory disturbance, but that there would be no significant impacts of NSF-funded marine seismic research on seabirds or their populations. The acoustic source would be powered or shut down in the event an ESA-listed seabird was observed diving or foraging within the designated EZ. Given the proposed activities, impacts would not be anticipated to be significant or likely to adversely affect ESA-listed seabirds (Table 13). In decades of seismic surveys carried out by R/V *Langseth* and its predecessor, the R/V *Ewing*, PSOs and other crew members have seen no seismic sound-related seabird injuries or mortality.

TABLE 13. ESA determination for seabird species expected to be encountered during the proposed surveys in the Northeast Pacific Ocean during summer 2021.

	ESA Determination		
Species	**No Effect**	**May Affect – Not Likely to Adversely Affect**	**May Affect – Likely to Adversely Affect**
Short-tailed Albatross		√	
Hawaiian Petrel	√		

4.1.4 Indirect Effects on Marine Mammals, Sea Turtles, Seabirds and Fish and Their Significance

The proposed seismic operations would not result in any permanent impact on habitats used by marine mammals, sea turtles, seabirds, or fish or to the food sources they use. The main impact issue associated with the proposed activity would be temporarily elevated anthropogenic sound levels and the associated direct effects on these species, as discussed above.

During the proposed seismic surveys, only a small fraction of the available habitat would be ensonified at any given time. Disturbance to fish species and invertebrates would be short-term, and fish would return to their pre-disturbance behavior once the seismic activity ceased. Thus, the proposed surveys would have little impact on the abilities of marine mammals or sea turtles to feed in the area where seismic work is planned. No significant indirect impacts on marine mammals, sea turtles, seabirds, or fish would be expected.

4.1.5 Direct Effects on Cultural Resources and Their Significance

The coast and nearshore areas are of cultural importance to indigenous peoples for fishing, hunting, gathering, and ceremonial purposes. As noted above in Section 4.1.2.4, impacts would not be anticipated to be significant or likely to adversely affect marine invertebrates, marine fish, and their fisheries, including subsistence fisheries. Interactions between the proposed surveys and fishing/hunting operations in the study area are expected to be limited. Although fishing/hunting would not be precluded in the survey area, a safe distance would need to be kept from R/V *Langseth* and the towed seismic equipment. Conflicts would be avoided through communication with subsistence fishers during the surveys. Considering the limited time that the planned seismic surveys would take place close to shore relative to the year-round, widespread nature of subsistence hunting, the proposed project is not expected to have any significant impacts to the availability of Steller sea lions, harbor seals, or sea otters for subsistence harvest.

Additionally, there are numerous shipwrecks along the coast of Southeast Alaska and B.C. However, the proposed activities are of short duration (~36 days), and most of the shipwrecks (and SCUBA dive sites) are in shallower water outside of the project area. Conflicts would be avoided through communication with dive operators during the surveys. Furthermore, OBSs would be deployed to avoid shipwrecks and would only cause minimal seafloor disturbances. Therefore, no adverse impacts to cultural resources are anticipated.

4.1.6 Cumulative Effects

Cumulative effects refer to the impacts on the environment that result from a combination of past, existing, and reasonably foreseeable projects and human activities. Cumulative effects can result from multiple causes, multiple effects, effects of activities in more than one locale, and recurring events. Human activities, when conducted separately or in combination with other activities, could affect marine animals in the study area. However, understanding cumulative effects is complex because of the animals' extensive habitat ranges, and the difficulty in monitoring populations and determining the level of impacts that may result from certain activities.

According to Nowacek et al. (2015), cumulative impacts have a high potential of disturbing marine mammals. Wright and Kyhn (2014) proposed practical management steps to limit cumulative impacts, including minimizing exposure by reducing exposure rates and levels. The results of the cumulative impacts analysis in the PEIS indicated that there would not be any significant cumulative effects to marine resources from the proposed NSF-funded marine seismic research, including the combined use of airguns with MBES, SBP, and acoustic pingers. However, the PEIS also stated that, "A more detailed, cruise-specific cumulative effects analysis would be conducted at the time of the preparation of the cruise-specific EAs, allowing for the identification of other potential activities in the areas of the proposed seismic surveys that may result in cumulative impacts to environmental resources." Here we focus on activities (e.g., research, vessel traffic, and fisheries) that could impact animals specifically in the proposed survey area. However, the combination of the proposed surveys with the existing operations in the region would be expected to produce only a negligible increase in overall disturbance effects on marine mammals.

4.1.6.1 Past and Future Research Activities

L-DEO conducted seismic surveys in the GOA, including Southeast Alaska, during 2004 and 2008. DFO and the Canadian Groundfish Research and Conservation Society (CGRCS) conduct regular surveys in B.C. to provide fishery independent abundance indices of all demersal fish species available to bottom trawling along the B.C. coast (DFO 2018c). A large-scale survey of marine megafauna off the coast of B.C. was undertaken by DFO during July to September 2018, as well as expeditions to offshore seamounts during July 2018 and July 2019 (DFO 2019g).

As noted previously, an onshore research effort by Canadian collaborators would complement the proposed R/V *Langseth* activities. The proposed onshore component would vastly expand upon the marine-based dataset, providing a more complete geophysical dataset for the region. Other research activities may have been conducted in the past or may be conducted in the study area in the future; however, we are not aware of any research activities, in addition to those described here, that are planned to occur in the proposed project area during summer 2021.

4.1.6.2 Naval Activities

The U.S. Navy currently conducts training exercises in Alaska. The Southeast Alaska Acoustic Measurement Facility is (SEAFAC) is located in Western Behm Canal, just north of the study area. The offshore components include the Underway Measurement Site and the Static Site (DoN 2015). Arrays of bottom-moored hydrophones measure vessels underway and at rest at these two sites, respectively. The acoustic signature of various vessels (e.g., submarines, NOAA vessels, cruise ships) is recorded when sonar is not in operation. The sensors are passive and mid-frequency active sonar is not used at this range. Active acoustic sources used within the range include those for communication, range calibration, and position information.

In the GOA, the Navy conducts training in its Temporary Maritime Activities Area (TMAA). The TMAA encompasses 145,482 km^2 of sea surface and subsurface areas as well as the overlying airspace (DoN 2011). The TMAA is located south of Prince William Sound and east of Kodiak Island, and 44 km south of the Kenai Peninsula (DoN 2011), and is not located near the survey area off Southeast Alaska. During Navy operations in 2021, marine mammals and sea turtles within the TMAA could be exposed to sounds from training exercises, including mid- and high-frequency sonars and impulsive detonations. The main impact associated with naval operations is the addition of underwater noise to oceanic ambient noise levels. The proposed seismic survey area is located far to the east of the TMAA; thus there is no geographic overlap with the TMAA exercises.

4.1.6.3 Vessel Traffic

Larger ports located near the proposed survey area include Ketchikan, AK, and Prince Rupert, B.C. Vessel traffic in the proposed survey area would consist mainly of commercial fishing and cargo vessels. Based on the data available through the Automate Mutual-Assistance Vessel Rescue (AMVER) system managed by the U.S. Coast Guard (USCG), most of the shipping lanes that intersect the survey area had 4 or fewer vessels travelling along them on a monthly basis during July–August 2019 (USCG 2019). Less than 10 vessels occurred within the proposed survey area when live vessel traffic information (MarineTraffic 2019) was accessed on 8 November 2019; vessels included fishing vessels, cargo vessels, and tugs. However, in the summer months, passenger vessels and cruise ships would also be expected to occur in the survey area.

Starting 1 September 2020, a trial Voluntary Shipping Protection Zone has been in effect off the Daawxuusda west coast off Haida Gwaii. The zone aims to keep large vessels far enough offshore to ensure adequate response time and prevent accidents. According to Haida Nation (2020), "Vessels 500 gross tonnage or greater are being asked to observe a minimum of 50 nautical miles off the Daawxuusda. Exceptions apply to large cruise ships, which are asked to observe a minimum distance of 12 nautical miles from shore, and vessels transiting between Pacific Northwest ports (Washington, BC and Alaska), which are asked to observe a minimum distance of 25 nautical miles from shore. Tugs and barges (including pushing and towing alongside), and fishing vessels are fully exempt. Laden oil tankers already adhere to the Voluntary Tanker Exclusion Zone, established in 1985, traveling at least 73 nautical miles offshore of Haida Gwaii."

The Alaska Marine Highway System (AMHS) provides year-round service to over 30 communities in Alaska, as well as Bellingham, WA, and Prince Rupert, B.C. Prince Rupert, Ketchikan, and Metlakatla are some of the ports serviced by AMHS. AMHS currently operates eleven vessels, with seven of those operating in Southeast Alaska. The busiest months in Southeast Alaska are June and July; in 2015 in Southeast Alaska, the AMHS carried a total of 223,000 passengers and 65,133 vehicles (AMHS 2015).

The total transit time by R/V *Langseth* (~36 days) would be minimal relative to the number of other vessels operating in the proposed survey area during summer 2021. Thus, the combination of R/V *Langseth*'s operations with the existing shipping operations is expected to produce only a negligible increase in overall ship disturbance effects on marine mammals.

4.1.6.4 Fisheries Interactions

The commercial fisheries in the region are described in § III. The primary contributions of fishing to potential cumulative impacts on marine mammals and sea turtles involve direct and indirect removal of prey items, sound produced during fishing activities, and potential entanglement (Reeves et al. 2003).

***Marine mammals*.—**Entanglement in fishing gear can lead to serious injury or mortality of some marine mammals. However, according to Lewison et al. (2014), there was no reported bycatch within the proposed survey area off B.C. and Southeast Alaska. Section 118 of the MMPA requires all commercial fisheries to be placed in one of three categories based on the level of incidental take of marine mammals relative to the Potential Biological Removal (PBR) for each marine mammal stock. Category I, II, and III fisheries are those for which the combined take is ≥50%, 1%–50%, and <1%, respectively, of PBR for a particular stock. In 2018, all groundfish fisheries in the GOA were listed as Category III fisheries, except for sablefish longline fishery, which is Category II because of sperm whale bycatch (NOAA 2018). Additionally, some salmon drift and set gillnet fisheries are listed in Category II.

The highest annual mortality rate of any cetacean in Alaska attributable to commercial fisheries is the harbor porpoise. In the most recent stock assessment, harbor porpoises of the Southeast stock had a minimum total annual mortality rate of 34 animals; the annual mortality rate for the GOA was 72 animals. (Muto et al. 2020). Incidental takes of Dall's porpoise are also high, with a minimum mean of 37 animals taken annually (Muto et al. 2020). The highest minimum mean annual mortality rate for baleen whales in Alaska fisheries was reported for the humpback whale (Central Pacific stock) at ~6 whales. A photographic study in Southeast Alaska showed that at least 2 of 28 humpback whales seen in both 2003 and 2004 had new entanglement scars in 2004 (Neilson et al. 2009). Of a total of 180 individuals seen during both years, at least 52% and up to 78% showed some kind of scarring from fishing gear entanglement (Neilson et al. 2009). The minimum mean annual mortality rate for sperm whales in Alaska fisheries is 4.4 animals; small numbers of fin and killer whales also succumb to commercial fisheries annually (Muto et al. 2020).

Of the pinniped species, the highest incidental mean annual mortality rates attributable to commercial fisheries have been reported for the Western Stock of Steller sea lions (35) and the Prince William Sound stock of harbor seals (24) (Muto et al. 2020). The annual mortality rate for the Eastern Stock of Steller sea lions was 14, and the northern fur seal had an annual mean mortality rate of 2.4; there were no reported mortalities for harbor seals in Southeast Alaska (Muto et al. 2020). Raum-Suryan et al. (2009) reported that Steller sea lions get entangled in and ingest fishing gear; packing and rubber bands were the most common neck entanglements, followed by rope, nets, and monofilament line. Ingested fishing gear consisted mainly of salmon fishery flashers, longline gear, hook and line, spinners/spoons, and bait hooks (Raum-Suryan et al. 2009). The incidence of entanglement was determined to be 0.26%.

Canada's Pacific groundfish bottom trawl fishery operates off the B.C. coast; during 1996–2006 the following marine mammals were caught and discarded: Steller sea lions (50 incidents), northern fur seals (1 incident), California sea lions (3), harbor seals (16), northern elephant seal (1), eared seals and walruses (6), other pinnipeds (32), Pacific white-sided dolphins (5), common dolphins (1), and unidentified porpoises and dolphins (8) (Driscoll et al. 2009). Entanglement in fishing gear, and fishery-caused reduction in prey abundance, quality, and availability have been identified as threats to blue, fin, and sei whales (Gregr et al. 2006) and Pacific harbor porpoise (COSEWIC 2016a). Between 1987 and 2008, there were 40 reports of humpbacks entangled in fishing gear in B.C.; humpbacks were entangled in gear from gillnet fisheries (salmon, herring roe), trap fisheries (crab, prawn, sablefish), groundfish long-line fisheries, and seine fisheries (Ford et al. 2009). Inshore fisheries in B.C. are also known to bycatch Pacific white-sided dolphins, harbor porpoises, and Dall's porpoises (Stacey et al. 1997; Williams et al. 2008).

Sea turtles.—Lewison et al. (2014) and Roe et al. (2014) reported no bycatch in the proposed survey area. However, Lewison et al. (2004) estimated that 30,000 to 75,000 loggerheads are taken as bycatch in longlines in 2000 in the Pacific; although the estimate for leatherbacks was lower (20,000 to 40,000). Entanglement of sea turtles in seismic gear is also a concern; there have been reports of turtles being trapped and killed between the gaps in tail-buoys offshore of West Africa (Weir 2007). The probability of entanglements would be a function of turtle density in the study area, which is expected to be low. Towing of hydrophone streamers or other equipment is not expected to significantly interfere with sea turtle movements, including migration, unless they were to become entrapped as indicated above.

***Seabirds*.—**Entanglement in fishing gear and hooking can also lead to mortality of seabirds. Lewison et al. (2014) reported low bycatch in gillnet and longline fisheries off Southeast Alaska and B.C. Krieger et al. (2019) reported an annual average bycatch of 6492 seabirds in Alaska groundfish and halibut fisheries between 2010 and 2018; in 2018, most records were of northern fulmars (3290), followed by gulls (782), shearwaters (780), and albatrosses (643). For 2010, there were 15 short-tailed albatross bycatch records, there were 5 in 2011, and 11 in 2014; other years had zero bycatch (Krieger et al. 2019). Bycatch of marbled murrelet in Alaska gillnet fisheries may be substantial, on the order of hundreds of birds annually and was listed as the second most important human cause for this species' decline in its 2006 Alaska status review (Piatt et al. 2007). Smith and Morgan (2005) estimated that 12,085 seabirds were bycaught annually in the commercial gillnet fishery in B.C. between 1995 and 2001, of which 95% succumbed.

4.1.6.5 Whaling and Sealing

Marine mammals are legally hunted in Alaskan waters by coastal Alaska Natives. In the GOA, the only marine mammals that are currently hunted are Steller sea lions, harbor seals, and sea otters. These species are an important subsistence resource for Alaska Natives from Southeast Alaska to the Aleutian Islands. There are numerous communities along the shores of the GOA that participate in subsistence hunting, including Juneau, Ketchikan, Sitka, and Yakutat in Southeast Alaska (Wolfe et al. 2013). For 2006–2010, the average subsistence takes of northern sea otters was 447 animals for the Southeast Alaska Stock (Muto et al. 2020). Raymond et al. (2019) reported 1449 animals were harvested in 2013. Although sea otters are harvested year-round in Southeast Alaska, there is decreased harvest effort during May–August. According to Muto et al. (2020), the annual subsistence take of Steller sea lions from the eastern stock was 11, and for northern fur seals it was ~387 individuals. Approximately 625 harbor seals were taken annually in southeast Alaska from 2004–2008, but no harvest was reported for 2014 or 2017 (Muto et al. 2020). The seal harvest throughout Southeast Alaska is generally highest during spring and fall, but can occur any time of the year (Wolfe et al. 2013). In Canada, various First Nations harvest seals and sea lions.

4.1.6.6 Tourism

Tourism employed almost 40,000 people in Alaska in 2014–2015, representing 9% of employment and 5% of labor income statewide, with visitor spending $1.94 billion (McDowell Group 2016). Over two million people visited Alaska during that time, with almost half as cruise ship passengers. Wildlife viewing and day cruises were the activities most commonly reported by tourists visiting Southeast Alaska; sportfishing was also reported (McDowell Group 2017). Whalewatching occurs out of several ports in Southeast Alaska, including Juneau, Gustavus, and Point Adolphus in Icy Straits; the peak season is May through September (Whale Watching Alaska 2019). Whalewatch operations also occur in B.C. waters, including Haida Gwaii. Recreational fishing is the largest tourism-related activity in Haida Gwaii, with 14,000 people visiting fishing lodges per year, with 100,000 angler days in 2010 (MaPP 2015). Gwaii Haanas receives 2000 tourists/year) (MaPP 2015).

4.1.7 Unavoidable Impacts

Unavoidable impacts to the species of marine mammals and turtles occurring in the proposed survey area would be limited to short-term, localized changes in behavior of individuals. For marine mammals, some of the changes in behavior may be considered to fall within the MMPA definition of "Level B Harassment" (behavioral disturbance; no serious injury or mortality). TTS, if it occurs, would be limited to a few individuals, is a temporary phenomenon that does not involve injury, and is unlikely to have long term consequences for the few individuals involved. No long-term or significant impacts would be expected on any of these individual marine mammals or turtles, or on the populations to which they belong; Although Level A takes would not be anticipated, as previously noted, NSF follows the NOAA *Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing* to estimate potential Level A takes. Effects on recruitment or survival would be expected to be (at most) negligible.

4.1.8 Coordination with Other Agencies and Processes

This Final EA was prepared by LGL on behalf of L-DEO and NSF pursuant to NEPA and Executive Order 12114. Potential impacts to marine mammals, endangered species, and critical habitat were also assessed in the document; therefore, it was used to support the ESA Section 7 consultation process with NMFS and USFWS and other regulatory processes, such as the EFH. The Draft EA was also used as supporting documentation for an IHA application submitted by L-DEO, on behalf of itself, NSF, University of New Mexico, and Western Washington University, to NMFS and USFWS, under the U.S. MMPA, for "taking by harassment" (disturbance) of small numbers of marine mammals, for the proposed seismic surveys. The document was also used in support of the Request for Review pursuant to the Canadian Fisheries Act.

NSF posted the Draft EA on the NSF website for a 30-day public comment period from 7 February 2020 to 7 March 2020 and sent notices to potential interested parties. NSF also sent letters to Alaskan tribal contacts to provide notification of the Proposed Action and NSF's related environmental compliance review, including the availability of the Draft EA, and also to provide an opportunity to consult. No comments or responses were received in response to the NSF outreach efforts. NSF coordinated with NMFS and USFWS to complete the Final EA prior to issuance of IHAs and Biological Opinion/ITS to accommodate NMFS' need to adopt NSF's Final EA as part of the NMFS NEPA process associated with issuing authorizations. NSF had enhanced coordination with NMFS and USFWS throughout the IHA and ESA consultation processes to facilitate this streamlined approach. NSF, the researchers, and L-DEO coordinated with the Navy and fishers in advance of operations to help reduce space-use conflicts and/or security matters. Due to their involvement with the Proposed Action, the U.S. Geological Survey agreed to be a Cooperating Agency.

(a) Endangered Species Act (ESA)

The Draft EA was used during the ESA Section 7 consultation process with NMFS and USFWS. On 4 December 2019, NSF submitted a letter of concurrence request to USFWS that the proposed activity may affect but was not likely to adversely affect the ***endangered*** short-tailed albatross and Hawaiian petrel. After discussions with USFWS, it was decided the Hawaiian petrel would be unlikely to be encountered during the survey. NSF modified its determination to no effects for Hawaiian petrel. On 8 April 2021, USFWS provided a Letter of Concurrence (Appendix E) that the proposed activity “may affect” but was not likely to “adversely affect” the short-tailed albatross. Mitigation measures for ESA-listed seabirds would include power downs, and if necessary, shut downs for diving or foraging seabirds within the EZ, as well as downward-pointing deck lighting, drawing curtains at night, and bird-scaring streamer lines.

On 3 December 2019, NSF submitted a formal ESA Section 7 consultation request, including the Draft EA, to NMFS for the proposed activity. NSF and NMFS held bi-weekly meetings to discuss the ESA consultation. Based on this enhanced coordination, NSF anticipates that a Biological Opinion and ITS will be issued for the proposed activity. As part of its decision-making process for the Proposed Action, NSF will take into consideration the Biological Opinion and ITS issued by NMFS and the results of the entire environmental review process.

(b) Marine Mammal Protection Act (MMPA)

The Draft EA was also used as supporting documentation for an IHA application submitted on 3 December 2019 by L-DEO on behalf of itself, NSF, and the researchers, to NMFS, under the U.S. MMPA, for “taking by harassment” (disturbance) of small numbers of marine mammals during the proposed seismic survey. NSF and NMFS held bi-weekly meetings to discuss the IHA application. On 4 June 2021, NMFS issued in the Federal Register a notice of intent to issue an IHA for the survey and a 30-day public comment period. An IHA application was also submitted on 19 December 2019 by LDEO on behalf of itself, NSF, and the researchers, to USFWS. On 9 June 2021, USFWS issued in the Federal Register a notice of intent to issue an IHA for the survey and a 30-day public comment period (Appendix F). NMFS and USFWS will consider and respond to any public comments received during that process as required per the MMPA.

As previously noted, NSF had enhanced coordination with NMFS and USFWS during the IHA application processes. Based on this enhanced coordination, NSF anticipates that IHAs will be issued for the proposed activity. As part of its decision-making process for the Proposed Action, NSF will take into consideration the IHAs issued by NMFS, USFWS, and the results of the entire environmental review process.

(e) Essential Fish Habitat (EFH) and Habit Areas of Particular Concern

EFH and HAPCs were identified to occur within the proposed survey area. Although NSF anticipated no significant impacts to EFH or HAPC, as the Proposed Action may affect EFH, in accordance with the Magnuson-Stevens Fishery Conservation and Management Act, NSF requested consultation with NMFS on 4 December 2019 and again on 29 March 2021 (resubmitted due to deferred survey status). On 17 January 2020, and again on 2 June 2021, NMFS concurred with NSF's determination that proposed activities may affect but would have no adverse effects on EFH or HAPC from the Proposed Action (Appendix G).

(f) Canadian Department of Fisheries and Oceans

An application for a Species at Risk permit application per the SARA was submitted on 22 December 2019. After discussion with DFO staff, the SARA application was revised and resubmitted along with a Canadian Fisheries Act Request for Review on 18 December 2020. After consultation with DFO, some adjustments to transect lines and their associated 160-dB ensonified area were made. We anticipate DFO will issue a Letter of Advice for this project with measures to follow to avoid causing the death of fish (including marine mammals) and/or harmful alteration, disruption, or destruction of fish habitat, or causing prohibited effects to SARA species, any part of their critical habitat or the residences of their individuals.

The most stringent measures presented in either the DFO letter or the IHA to be issued by NMFS would be implemented within the Canadian EEZ. In addition, L-DEO and NSF would comply with DFO's "Statement of Canadian Practice with respect to the Mitigation of Seismic Sound in the Marine Environment" as much as practicable and where these measures are more stringent than others required by DFO or NMFS.

4.2 No Action Alternative

An alternative to conducting the proposed activity is the "No Action" Alternative, i.e., do not issue an IHA and do not conduct the operations. If the research were not conducted, the "No Action" alternative would result in no disturbance to marine mammals or sea turtles attributable to the proposed activity; however, valuable data about the marine environment would be lost. Research that would contribute to the characterization of the crustal and uppermost mantle velocity structure, fault zone architecture and rheology, and seismicity of the QCF, and the comprehensive assessment of geohazards for the Pacific Northwest, such as earthquake, tsunami, and submarine landslide hazards, would not be collected. The No Action Alternative would not meet the purpose and need for the proposed activity.

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VI LITERATURE CITED

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List of Appendices

Appendix B: **CETACEAN, PINNIPED, AND SEA TURTLE DENSITIES AND TAKE CALCULATIONS**

APPENDIX C: SEA OTTER DENSITIES AND TAKE CALCULATIONS

APPENDIX D: ENSONIFIED AREAS FOR TAKE CALCULATIONS FOR CETACEANS, PINNIPEDS, AND SEA TURTLES

APPENDIX E: USFWS ESA LOC

APPENDIX F: UFWS ESA OTTER FED REG

APPENDIX G: EFH

APPENDIX A: DETERMINATION OF MITIGATION ZONES

APPENDIX A: DETERMINATION OF MITIGATION ZONES

During the planning phase, mitigation zones for the proposed marine seismic survey were calculated based on both modeling by L-DEO for the Level A and Level B (160 dB re 1µPa_{rms}) thresholds and using empirical measurements from Crone et al. (2014) from the Cascadia Margin. Received sound levels have been predicted by L-DEO's model (Diebold et al. 2010, provided as Appendix H in the PEIS) as a function of distance from the 36-airgun array and for a single 1900LL 40-in^3 airgun, which would be used during power downs for sea turtles and ESA-listed diving seabirds; all models used a 12-m tow depth. The L-DEO modeling approach uses ray tracing for the direct wave traveling from the array to the receiver and its associated source ghost (reflection at the air-water interface in the vicinity of the array), in a constant-velocity half-space (infinite homogeneous ocean layer, unbounded by a seafloor). In addition, propagation measurements of pulses from the 36-airgun array at a tow depth of 6 m have been reported in deep water (~1600 m), intermediate water depth on the slope (~600–1100 m), and shallow water (~50 m) in the Gulf of Mexico (GoM) in 2007–2008 (Tolstoy et al. 2009; Diebold et al. 2010).

Typically, for deep and intermediate-water cases, the field measurements cannot be used readily to derive mitigation radii, as at those GoM sites the calibration hydrophone was located at a roughly constant depth of 350–500 m, which may not intersect all the sound pressure level (SPL) isopleths at their widest point from the sea surface down to the maximum relevant water depth for marine mammals of ~2000 m (Costa and Williams 1999). Figures 2 and 3 in Appendix H of the PEIS show how the values along the maximum SPL line that connects the points where the isopleths attain their maximum width (providing the maximum distance associated with each sound level) may differ from values obtained along a constant depth line. 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 mitigation model—constructed from the maximum SPL through the entire water column at varying distances from the airgun array—is the most relevant. The L-DEO modeling results are summarized 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 for the same array tow depth are in good agreement (Fig. 12 and 14 in Appendix H of the PEIS). Consequently, isopleths falling within this domain can be predicted reliably by the L-DEO 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 (Fig. 11, 12, and 16 in Appendix H of the PEIS). Aside from local topography effects, the region around the critical distance (~5 km in Fig. 11 and 12, and ~4 km in Fig. 16 in Appendix H of the PEIS) is where the observed levels rise closest to the mitigation model curve. However, the observed sound levels are found to fall almost entirely below the mitigation model curve (Fig. 11, 12, and 16 in Appendix H of the PEIS). Thus, analysis of the GoM calibration measurements demonstrates that although simple, the L-DEO model is a robust tool for conservatively estimating mitigation radii. In shallow water (<100 m), the depth of the calibration hydrophone (18 m) used during the GoM calibration survey was appropriate to sample the maximum sound level in the water column, and the field measurements reported in Table 1 of Tolstoy et al. (2009) can be scaled for the single airgun at a tow depth of 6 m to derive mitigation radii.

L-DEO collected a multichannel seismic (MCS) data set from R/V *Langseth* on an 8 km streamer in 2012 on the shelf of the Cascadia Margin in water up to 200 m deep that allowed Crone et al. (2014) to analyze the hydrophone streamer (>1100 individual shots). These empirical data were then analyzed to determine in situ sound levels for shallow and upper intermediate water depths to provide mitigation radii.

This analysis is summarized in the Addendum at the end of this Appendix. Similarly, data collected by Crone et al. (2017) during a survey off New Jersey in 2014 and 2015 confirmed that *in situ* measurements and estimates of the 160- and 180-dB distances collected by R/V *Langseth* hydrophone streamer were 2–3 times smaller than the predicted operational mitigation radii. In fact, five separate comparisons conducted of the L-DEO model with *in situ* received levels[3] have confirmed that the L-DEO model generated conservative threshold distances, resulting in significantly larger mitigation zones than required by National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS).

The proposed surveys would acquire data with the 36-airgun array at a maximum tow depth of 12 m. For deep water (>1000 m), we use the deep-water radii obtained from L-DEO model results down to a maximum water depth of 2000 m (Fig. A-1; Table A-1). The radii for the shallow and intermediate water depths are taken from the empirical data from Crone et al. (2014) and corrected for tow depth (ie., multiplied by 1.15; see Addendum). Similarly, 175 dB_{RMS} distances have been determined using the same methodology and are provided in Table A-1.

Measurements have not been reported for the single 40-in^3 airgun. L-DEO model results are used to determine the 160-dB_{rms} radius for the 40-in^3 airgun at a 9-m tow depth in deep water (Fig. A-2). For intermediate-water depths, a correction factor of 1.5 was applied to the deep-water model results. For shallow water, a scaling of the GoM field measurements (Fig. A-3) obtained for the 36-airgun array was used. The radii for intermediate water depths (100–1000 m) are derived from the deep-water ones by applying a correction factor (multiplication) of 1.5, such that observed levels at very near offsets fall below the corrected mitigation curve (Fig. 16 in Appendix H of the PEIS). The shallow-water radii are obtained by scaling the empirically derived measurements from the GoM calibration survey to account for the differences in tow depth between the calibration survey (6 m) and the proposed survey (12 m); whereas the shallow water in the GoM may not exactly replicate the shallow water environment at the proposed survey site, it has been shown to serve as a good and very conservative proxy (Crone et al. 2014). A simple scaling factor is calculated from the ratios of the isopleths determined by the deep-water L-DEO model, which are essentially a measure of the energy radiated by the source array.

The 150-dB SEL level corresponds to a deep-water radius of 431 m for the 40-in^3 airgun at 12-m tow depth (Fig. A-2) and 7244 for the 36-airgun array at 6-m tow depth (Fig. A-3), yielding a scaling factor of 0.0595. Similarly, the 165-dB SEL level corresponds to a deep-water radius of 77 m for the 40-in^3 airgun at 12-m tow depth (Fig. A-2) and 1284 m for the 36-airgun array at 6-m tow depth (Fig. A-3), yielding a scaling factor of 0.060. The 185-dB SEL level corresponds to a deep-water radius of 7.5 m for the 40-in^3 airgun at 12-m tow depth (Fig. A-2) and 126.3 m for the 36-airgun array at 6-m tow depth (Fig. A-3), yielding a scaling factor of 0.0594. Measured 160- and 175-dB re 1µPa_{rms} distances in shallow water for the 36-airgun array towed at 6-m depth were 17.5 km and 2.8 km, respectively, based on a 95th percentile fit (Tolstoy et al. 2009). Multiplying by the scaling factors to account for the difference in array sizes and tow depths yields distances of 1041 m and 170 m, respectively.

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[3] L-DEO surveys off the Yucatán Peninsula in 2004 (Barton et al. 2006; Diebold et al. 2006), in the Gulf of Mexico in 2008 (Tolstoy et al. 2009; Diebold et al. 2010), off Washington and Oregon in 2012 (Crone et al. 2014), and off New Jersey in 2014 and 2015 (Crone et al. 2017).

TABLE A-3. Level B. Predicted distances to which sound levels ≥160-dB and ≥175-dB re 1 μPa_{rms} could be received during the proposed surveys in the Northeast Pacific Ocean. The 160-dB criterion applies to all hearing groups of marine mammals and the 175-dB criterion applies to sea turtles.

Source and Volume	Tow Depth (m)	Water Depth (m)	Predicted distances (in m) to the 160-dB Received Sound Level	Predicted distances (in m) to the 175-dB Received Sound Level
Single Bolt airgun, 40 in^3	12	>1000 m	431[1]	77[1]*
		100–1000 m	647[2]	116[2]
		<100 m	1,041[3]	170[3]
4 strings, 36 airguns, 6600 in^3	12	>1000 m	6,733[1]	1,864[1]
		100–1000 m	9,468[4]	2,542[4]
		<100 m	12,650[4]	3,924[4]

[1] Distance is based on L-DEO model results.
[2] Distance is based on L-DEO 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).
* An EZ of 100 m would be used as the shut-down distance for sea turtles in all water depths.

In July 2016, NMFS released technical guidance for assessing the effects of anthropogenic sound on marine mammal hearing (NMFS 2016, 2018). The guidance established new thresholds for permanent threshold shift (PTS) onset or Level A Harassment (injury), for marine mammal species. The new noise exposure criteria for marine mammals account for the newly-available scientific data on temporary threshold shifts (TTS), the expected offset between TTS and PTS thresholds, differences in the acoustic frequencies to which different marine mammal groups are sensitive, and other relevant factors, as summarized by Finneran (2016). For impulsive sources, onset of PTS was assumed to be 15 dB or 6 dB higher when considering SEL_{cum} and SPL_{flat}, respectively. The new guidance incorporates marine mammal auditory weighting functions (Fig. A-4) and dual metrics of cumulative sound exposure level (SEL_{cum} over 24 hours) and peak sound pressure levels (SPL_{flat}). Different thresholds are provided for the various hearing groups, including low-frequency (LF) cetaceans (e.g., baleen whales), mid-frequency (MF) cetaceans (e.g., most delphinids), high-frequency (HF) cetaceans (e.g., porpoise and *Kogia* spp.), phocids underwater (PW), and otariids/sea otters underwater (OW). The largest distance of the dual criteria (SEL_{cum} or Peak SPL_{flat}) was used to calculate takes and Level A threshold distances. The dual criteria for sea turtles (DoN 2017) were also used here. The NMFS guidance did not alter the current threshold, 160 dB re 1μPa_{rms}, for Level B harassment (behavior). Southall et al. (2019) provided updated scientific recommendations regarding noise exposure criteria which are similar to those presented by NMFS (2016, 2018), but include all marine mammals (including sirenians), and a re-classification of hearing groups.

The SEL_{cum} for the *Langseth* array is derived from calculating the modified farfield signature. The farfield signature is often used as a theoretical representation of the source level. To compute the farfield signature, the source level is estimated at a large distance directly below the array (e.g., 9 km), and this level is back projected mathematically to a notional distance of 1 m from the array's geometrical center. However, it has been recognized that the source level from the theoretical farfield signature is never physically achieved at the source when the source is an array of multiple airguns separated in space (Tolstoy et al. 2009).

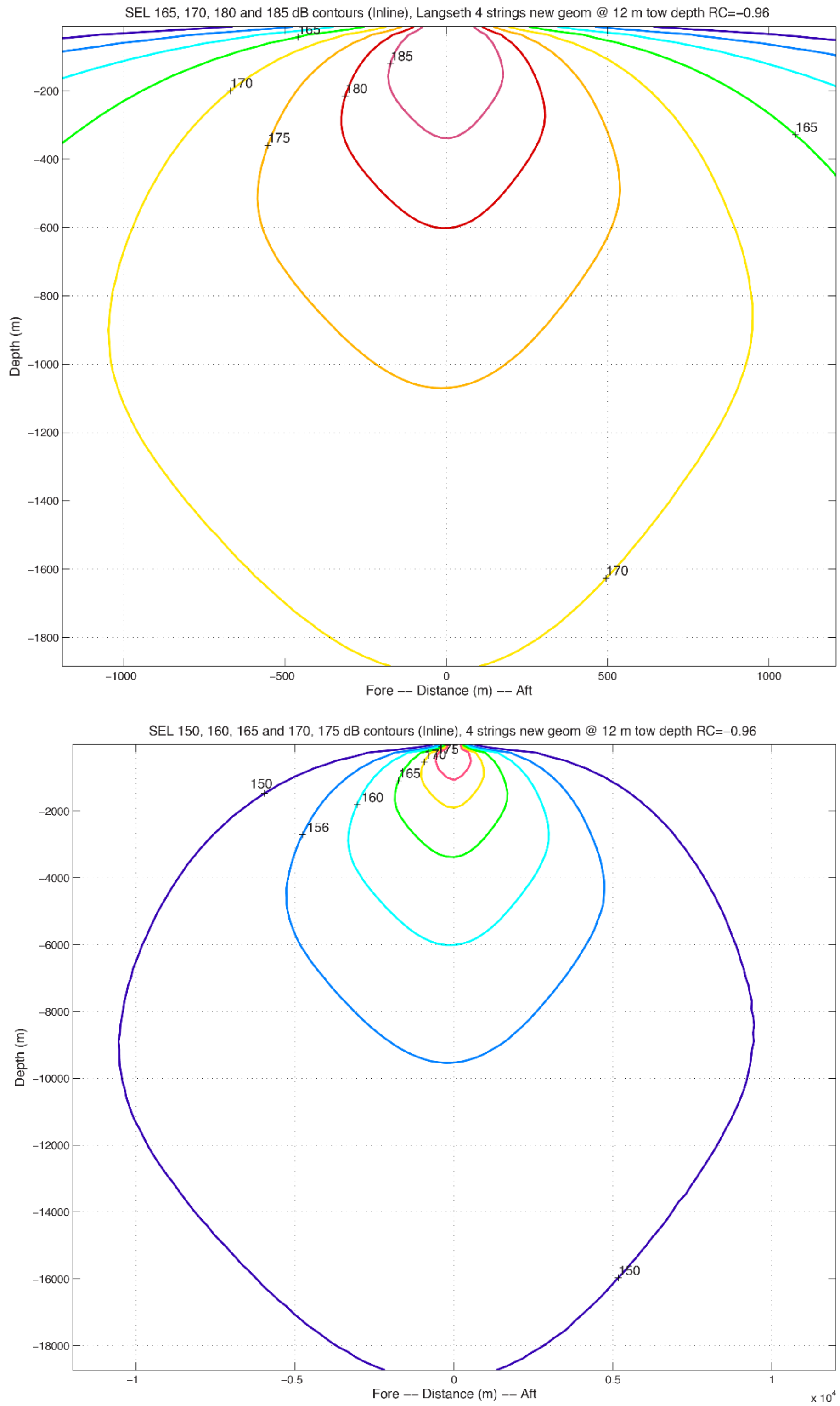

FIGURE A-1. Modeled deep-water received sound exposure levels (SELs) from the 36-airgun array at a 12-m tow depth planned for use during the proposed surveys in the Northeast Pacific Ocean. Received rms levels (SPLs) are expected to be ~10 dB higher. For example, the radius to the 150-dB SEL isopleth is a proxy for the 160-dB rms isopleth. The upper plot is a zoomed-in version of the lower plot.

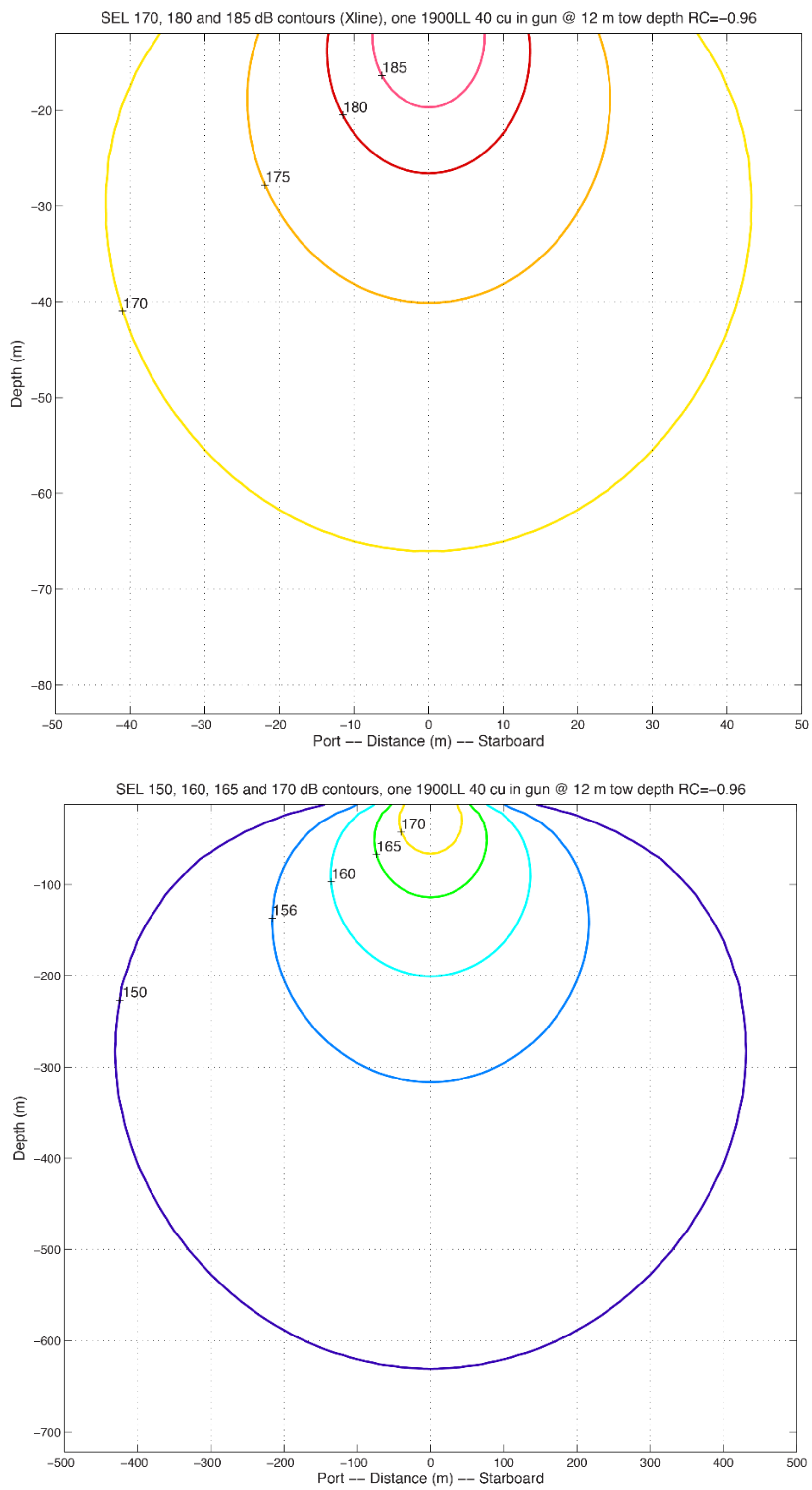

FIGURE A-2. Modeled deep-water received SELs from a single 40-in³ airgun towed at a 12-m depth, which is planned for use as a mitigation airgun during the proposed surveys in the Northeast Pacific Ocean. Received rms levels (SPLs) are expected to be ~10 dB higher. For example, the radius to the 150-dB SEL isopleth is a proxy for the 160-dB rms isopleth. The upper plot is a zoomed-in version of the lower plot.

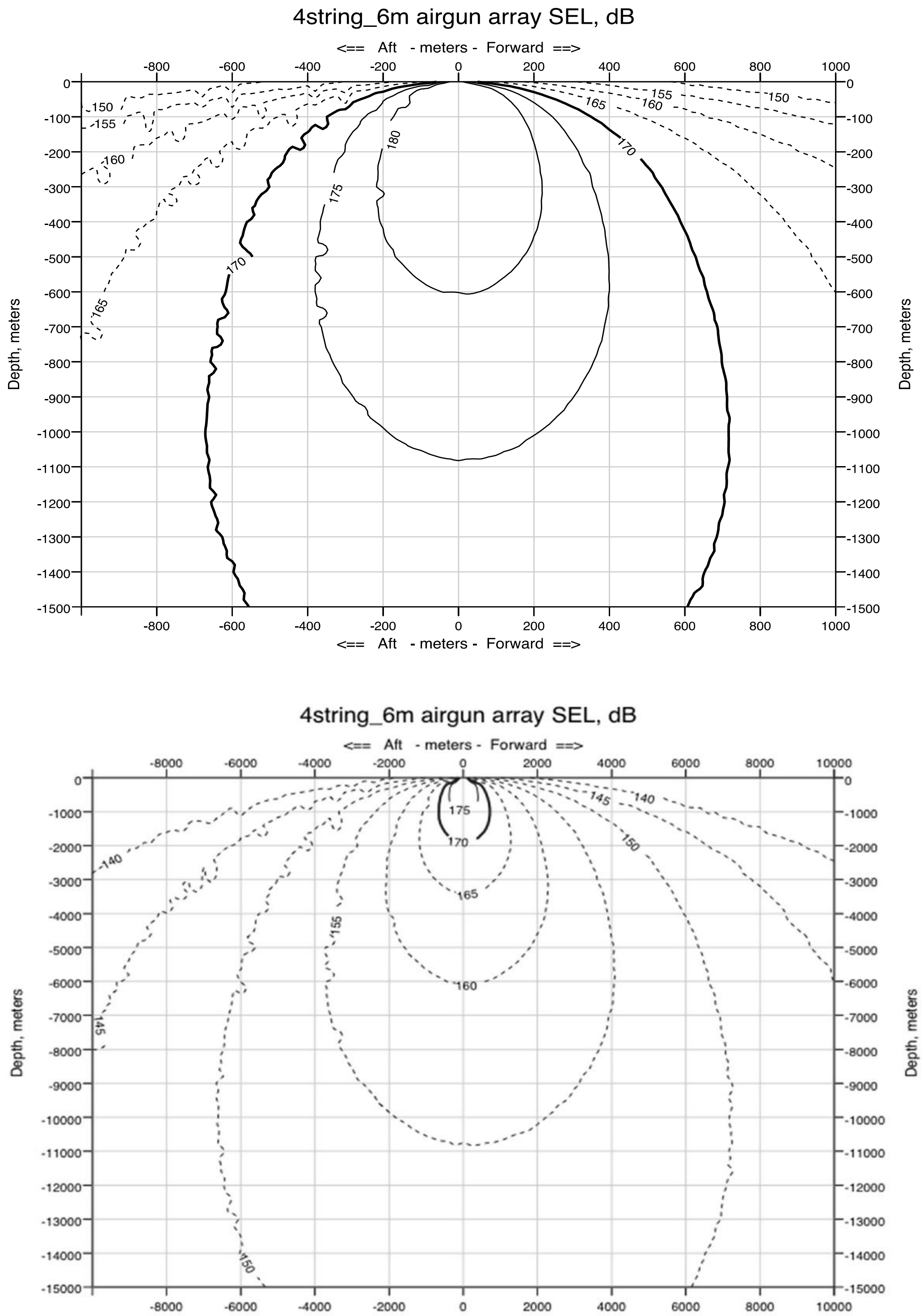

Figure A-3. Modeled deep-water received sound exposure levels (SELs) from the 36-airgun array at a 6-m tow depth used during the GoM calibration survey. Received rms levels (SPLs) are expected to be ~10 dB higher. For example, the radius to the 150 dB SEL isopleth is a proxy for the 160-dB rms isopleth. The upper plot is a zoomed-in version of the lower plot.

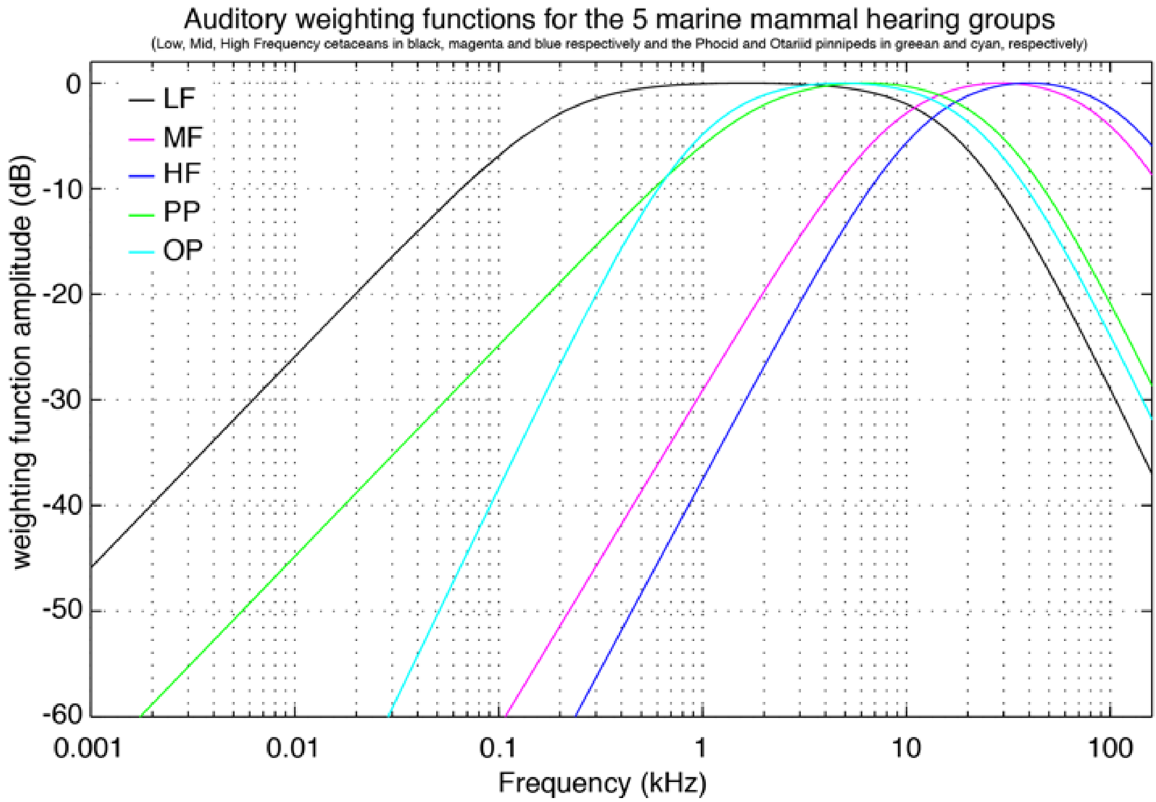

FIGURE A-4. Auditory weighting functions for five marine mammal hearing groups from the NMFS Technical Guidance.

Near the source (at short ranges, distances <1 km), the pulses of sound pressure from each individual airgun in the source array do not stack constructively as they do for the theoretical farfield signature. The pulses from the different airguns spread out in time such that the source levels observed or modeled are the result of the summation of pulses from a few airguns, not the full array (Tolstoy et al. 2009). At larger distances, away from the source array center, sound pressure of all the airguns in the array stack coherently, but not within one time sample, resulting in smaller source levels (a few dB) than the source level derived from the farfield signature. Because the farfield signature does not take into account the large array effect near the source and is calculated as a point source, the farfield signature is not an appropriate measure of the sound source level for large arrays.

To estimate SEL_{cum} and Peak SPL, we used the acoustic modeling developed at L-DEO (same as used for Level B takes) with a small grid step in both the inline and depth directions. The propagation modeling takes into account all airgun interactions at short distances from the source including interactions between subarrays which we do using the NUCLEUS software to estimate the notional signature and the MATLAB software to calculate the pressure signal at each mesh point of a grid.

PTS onset acoustic thresholds estimated in the NMFS User Spreadsheet rely on overriding the default values and calculating individual adjustment factors (dB) based on the modified farfield and by using the difference between levels with and without weighting functions for each of the five categories of hearing groups. The new adjustment factors in the spreadsheet allow for the calculation of SEL_{cum} isopleths in the spreadsheet and account for the accumulation (Safe Distance Methodology) using the source characteristics (source velocity and duty) after Sivle et al. (2014). A source velocity of 2.2 m/s and a 1/Repetition rate of 23.1 s were used as inputs to the NMFS User Spreadsheet for calculating the distances to the SEL_{cum} PTS thresholds (Level A) for the 36-airgun array and the single 40-in^3 mitigation airgun.

For the LF cetaceans, we estimated an adjustment value by computing the distance from the geometrical center of the source to where the 183 dB SEL_{cum} isopleth is the largest. We first ran the modeling for a single shot without applying any weighting function; we then ran the modeling for a single shot with the LF cetacean weighting function applied to the full spectrum. The difference between these values provides an adjustment factor and assumes a propagation of $20\log_{10}$(Radial distance). The radial distances are used to calculate the modified farfield values, whereas the radius is the vertical projection to the sea surface and distance from the source laterally, which is used for mitigation purposes.

However, for MF and HF cetaceans, and OW and PW pinnipeds, the modeling for a single shot with the weighted function applied leads to 0-m isopleths; the adjustment factors thus cannot be derived the same way as for LF cetaceans. Hence, for MF and HF cetaceans, and OW and PW pinnipeds, the difference between weighted and unweighted spectral source levels at each frequency up to 3 kHz was integrated to actually calculate these adjustment factors in dB. These calculations also account for the accumulation (Safe Distance Methodology) using the source characteristics (duty cycle and speed) after Sivle et al. (2014).

For the 36-airgun array, the results for single shot SEL source level modeling are shown in Table A-2. The weighting function calculations, thresholds for SEL_{cum}, and the distances to the PTS thresholds for the 36-airgun array are shown in Table A-3. Figure A-5 shows the impact of weighting functions by hearing group. Figures A-6–A-8 show the modeled received sound levels for single shot SEL without applying auditory weighting functions for various hearing groups. Figure A-9 shows the modeled received sound levels for single shot SEL with weighting for LF cetaceans.

TABLE A-2. Results for modified farfield SEL source level modeling for the 36-airgun array with and without applying weighting functions to the five marine mammal hearing groups and sea turtles. The modified farfield signature is estimated using the distance from the source array geometrical center to where the SEL_{cum} threshold is the largest. A propagation of 20 $\log_{10}$ (Radial distance) is used to estimate the modified farfield SEL.

SEL_{cum} Threshold	**183**	**185**	**155**	**185**	**203**	**204***
Radial Distance (m) (no weighting	315.5691	246.4678	8033.2	246.4678	28.4413	25.1030
Modified Farfield SEL	232.9819	232.8352	233.0978	232.8352	232.0790	231.9945
Radial Distance (m) (with weighting function)	71.3752	N.A.	N.A.	N.A.	N.A.	N.A.
Adjustment (dB)	-12.91	N.A.	N.A.	N.A.	N.A.	N.A.

* Sea turtles. N.A. means not applicable or not available.

TABLE A-3. Results for modified farfield SEL source level modeling for the 36-airgun array with weighting function calculations for the SEL_{cum} criteria, as well as resulting isopleths to thresholds for hearing groups.

STEP 1: GENERAL PROJECT INFORMATION

PROJECT TITLE	
PROJECT/SOURCE INFORMATION Please include any assumptions	source : 4 string 36 element 6600 cuin of the R/V Langseth at a 12m towed depth. Shot interval of 50 m. Source velocity of 4.2 knots
PROJECT CONTACT	

STEP 2: WEIGHTING FACTOR ADJUSTMENT — Specify if relying on source-specific WFA, alternative weighting/dB adjustment, or if using default value

Weighting Factor Adjustment (kHz)[¥]	NA	Override WFA: Using LDEO modeling

[¥] Broadband: 95% frequency contour percentile (kHz) OR Narrowband: frequency (kHz); For appropriate default WFA: See INTRODUCTION tab

† If a user relies on alternative weighting/dB adjustment rather than relying upon the WFA (source-specific or default), they may override the Adjustment (dB) (row 62), and enter the new value directly. However, they must provide additional support and documentation supporting this modification.

* BROADBAND Sources: Cannot use WFA higher than maximum applicable frequency (See GRAY tab for more information on WFA applicable frequencies)

STEP 3: SOURCE-SPECIFIC INFORMATION

NOTE: Choose either F1 OR F2 method to calculate isopleths (not required to fill in sage boxes for both) — NOTE: LDEO modeling relies on Method F2

F2: ALTERNATIVE METHOD† TO CALCULATE PK and SEL_{cum} (SINGLE STRIKE/SHOT/PULSE EQUIVALENT)

SEL_{cum}

Source Velocity (meters/second)	2.16067	4.2 knots
1/Repetition rate^ (seconds)	23.14097016	50m/2.16067

†Methodology assumes propagation of 20 log R; Activity duration (time) independent

^Time between onset of successive pulses.

Modified farfield SEL	232.9819	232.8352	233.0978	232.8352	232.079	231.9945
Source Factor	8.58635E+21	8.30115E+21	8.81858E+21	8.30115E+21	6.97459E+21	6.84019E+21

RESULTANT ISOPLETHS*

*Impulsive sounds have dual metric thresholds (SEL_{cum} & PK). Metric producing largest isopleth should be used.

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds/Sea Otters	Sea Turtles
SEL_{cum} Threshold	183	185	155	185	203	204
PTS SEL_{cum} Isopleth to threshold (meters)	320.2	0.0	1.0	10.4	0.0	15.4

WEIGHTING FUNCTION CALCULATIONS

Weighting Function Parameters	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds/Sea Otters	Sea Turtles	
a	1	1.6	1.8	1	2	1.4	
b	2	2	2	2	2	2	
f_1	0.2	8.8	12	1.9	0.94	0.077	
f_2	19	110	140	30	25	0.44	
C	0.13	1.2	1.36	0.75	0.64	2.35	
Adjustment (dB)†	-12.91	-56.70	-66.07	-25.65	-32.62	-4.11	OVERIDE Using LDEO Modeling

†For LF cetaceans, the adjustment factor (dB) is derived by estimating the radial distance of the 183-dB isopleth without applying the weighting function and a second time with applying the weighting function. Adjustment was derived using a propagation of $20*\log_{10}$ (Radial distance) and the modified farfield signature. For MF and HF cetaceans, pinnipeds, and sea turtles, the difference between weighted–unweighted spectral source levels at each frequency was integrated to calculate adjustment factors (see spectrum levels in Figure A-5).

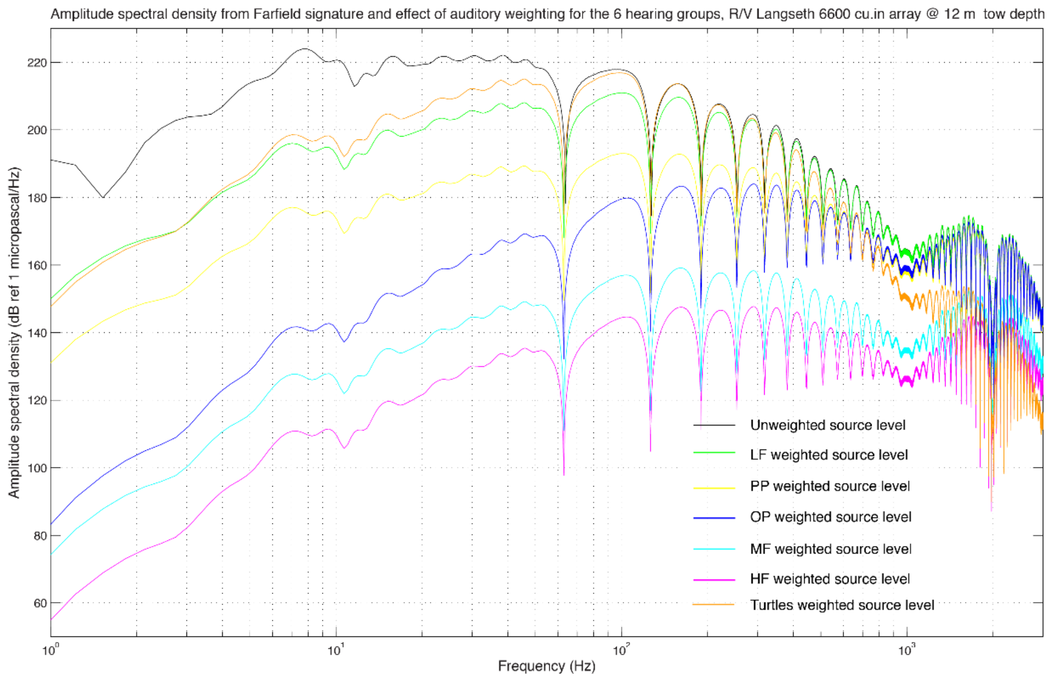

FIGURE A-5. Modeled amplitude spectral density of the 36-airgun array farfield signature. Amplitude spectral density before (black) and after (colors) applying the auditory weighting functions for LF, MF, and HF cetaceans, Phocid Pinnipeds (PP), Otariid Pinnipeds (OP), and Sea Turtles. Modeled spectral levels are used to calculate the difference between the unweighted and weighted source level at each frequency and to derive the adjustment factors for the hearing groups as inputs into the NMFS User Spreadsheet.

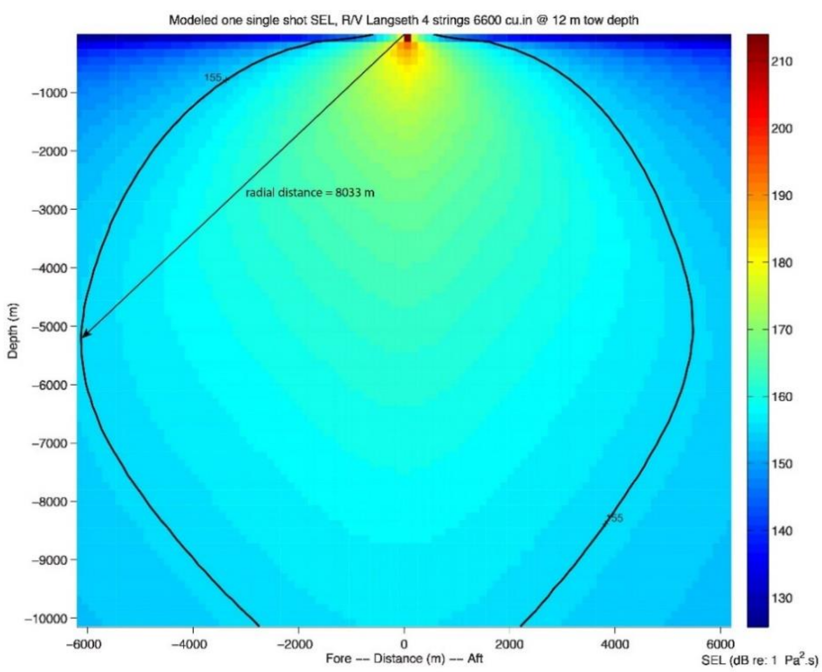

FIGURE A-6. Modeled received sound levels (SELs) in deep water from the 36-airgun array. The plot provides the radial distance from the geometrical center of the source array to the 155-dB SEL isopleth (8033 m). Radial distance allows us to determine the modified farfield SEL using a propagation of $20\log_{10}$(radial distance).

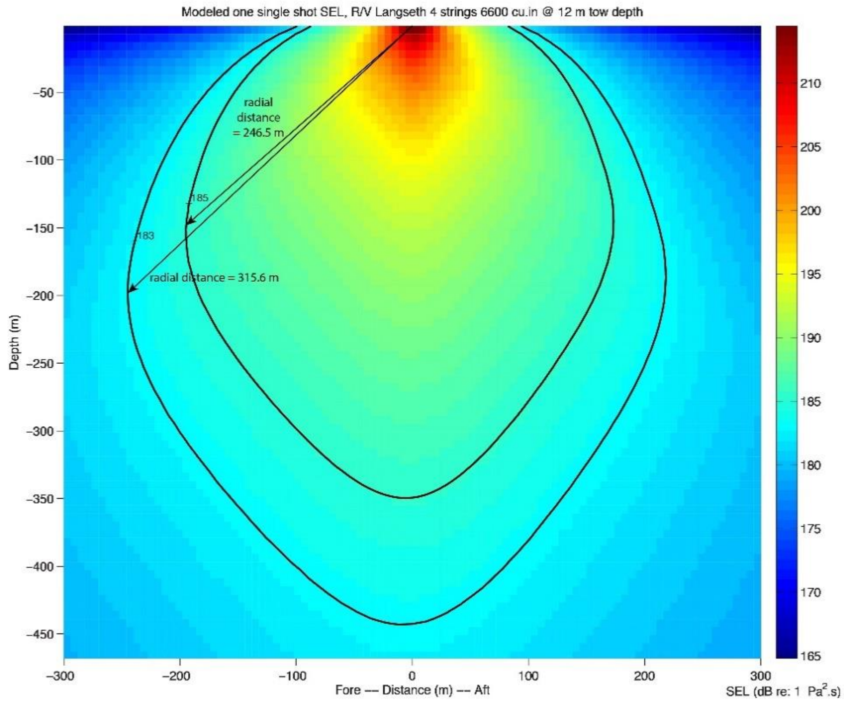

FIGURE A-7. Modeled received sound levels (SELs) in deep water from the 36-airgun array. The plot provides the radial distance from the geometrical center of the source array to the 183–185-dB SEL isopleths (315.6 and 246.5 m, respectively).

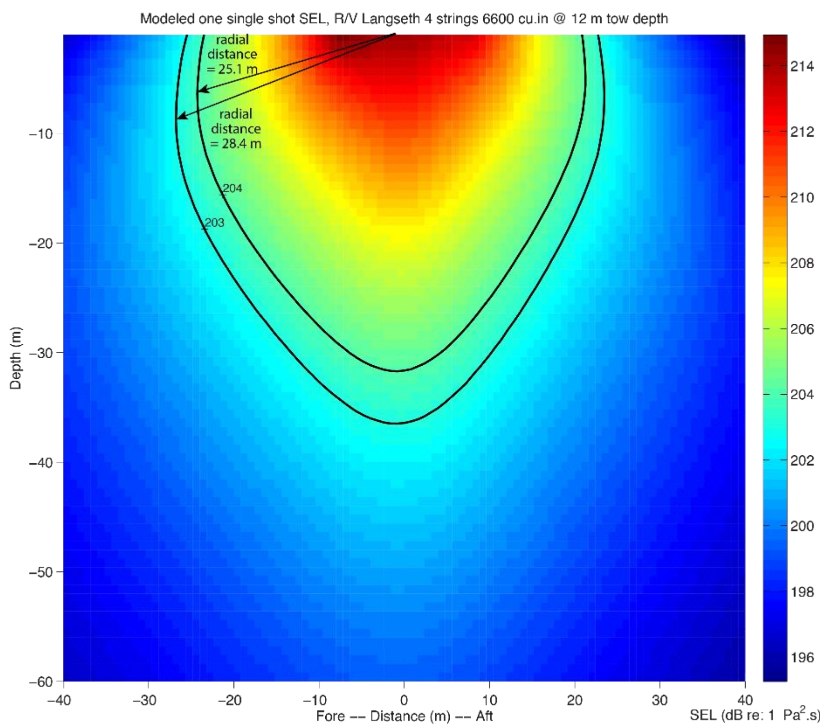

FIGURE A-8. Modeled received sound levels (SELs) in deep water from the 36-airgun array. The plot provides the radial distance from the geometrical center of the source array to the 203-dB and 204-dB SEL isopleth (28.4 m and 25.1 m, respectively).

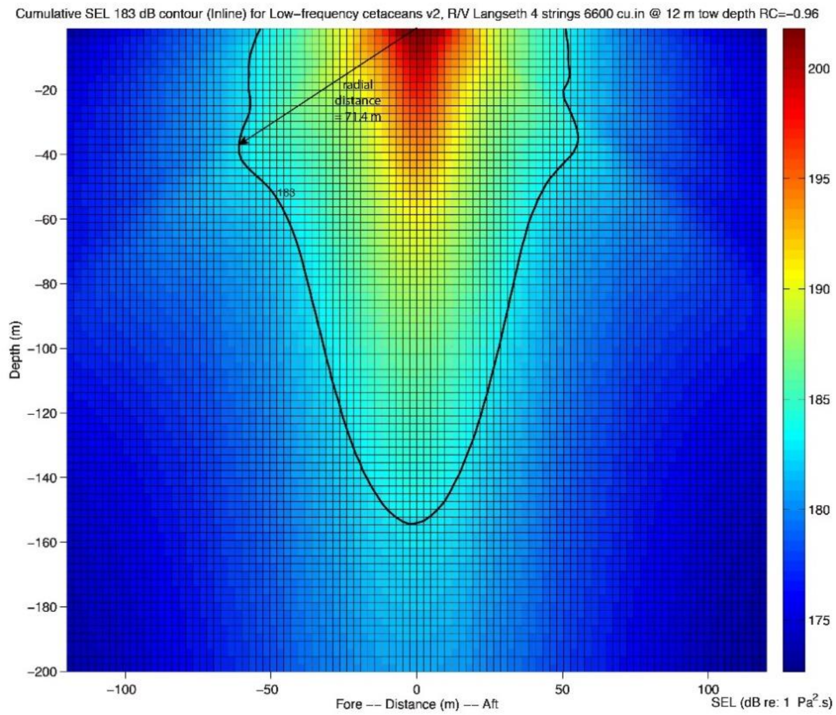

FIGURE A-9. Modeled received sound exposure levels (SELs) from the 36-airgun array at a 12-m tow depth, after applying the auditory weighting function for the LF cetaceans hearing group following the NMFS Technical Guidance. The plot provides the radial distance to the 183-dB SEL_{cum} isopleth for one shot. The difference in radial distances between Fig. A-7 and this figure (71.4 m) allows us to estimate the adjustment in dB.

The thresholds for Peak SPL_{flat} for the 36-airgun array, as well as the distances to the PTS thresholds, are shown in Table A-4. Figures A-10–A-12 show the modeled received sound levels to the Peak SPL_{flat} thresholds, for a single shot. A summary of the Level A threshold distances are shown in Table A-5.

For the single 40 in^3 mitigation airgun, the results for single shot SEL source level modeling are shown in Table A-6. The weighting function calculations, thresholds for SEL_{cum}, and the distances to the PTS thresholds for the 40 in^3 airgun are shown in Table A-7. Figure A-13 shows the impact of weighting functions by hearing group for the single mitigation airgun. Figures A-14–A-15 show the modeled received sound levels for single shot SEL without applying auditory weighting functions for various hearing groups. Figure A-16 shows the modeled received sound levels for single shot SEL with weighting for LF cetaceans. The thresholds for Peak SPL_{flat} for the 40 in^3 airgun, as well as the distances to the PTS thresholds, are shown in Table A-8. Figures A-17–A-18 show the modeled received sound levels to the Peak SPL_{flat} thresholds, for a single shot.

TABLE A-4. NMFS Level A acoustic thresholds (Peak SPL_{flat}) for impulsive sources for marine mammals and predicted distances to Level A thresholds for various marine mammal hearing groups that could be received from the 36-airgun array during the proposed surveys in the Northeast Pacific Ocean.

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds/ Sea Otters/ Sea Turtles
Peak Threshold	**219**	**230**	**202**	**218**	**232**
Radial Distance to Threshold (m)	45.00	13.57	364.67	51.59	10.62
Modified Farfield Peak SPL	252.06	252.65	253.24	252.25	252.52
PTS Peak Isopleth (Radius) to Threshold (m)	38.9	13.6	268.3	43.7	10.6

N.A. means not applicable or not available.

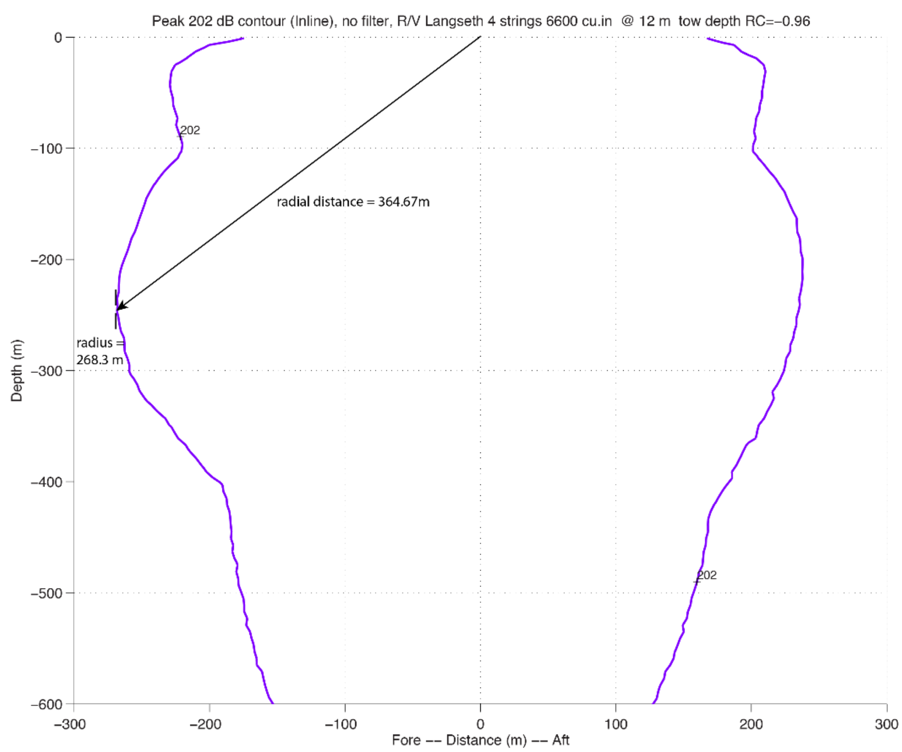

FIGURE A-10. Modeled deep-water received Peak SPL from the 36-airgun array at a 12-m tow depth. The plot provides the distance to the 202-dB Peak isopleth.

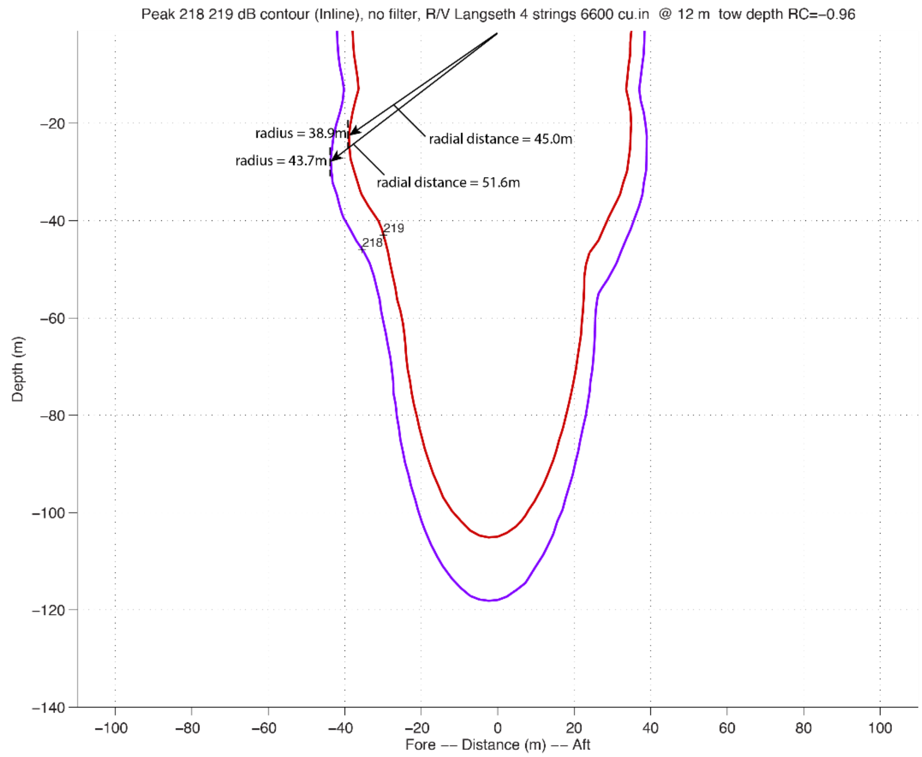

FIGURE A-11. Modeled deep-water received Peak SPL from the 36-airgun array at a 12-m tow depth. The plot provides the distances to the 218- and 219-dB Peak isopleths.

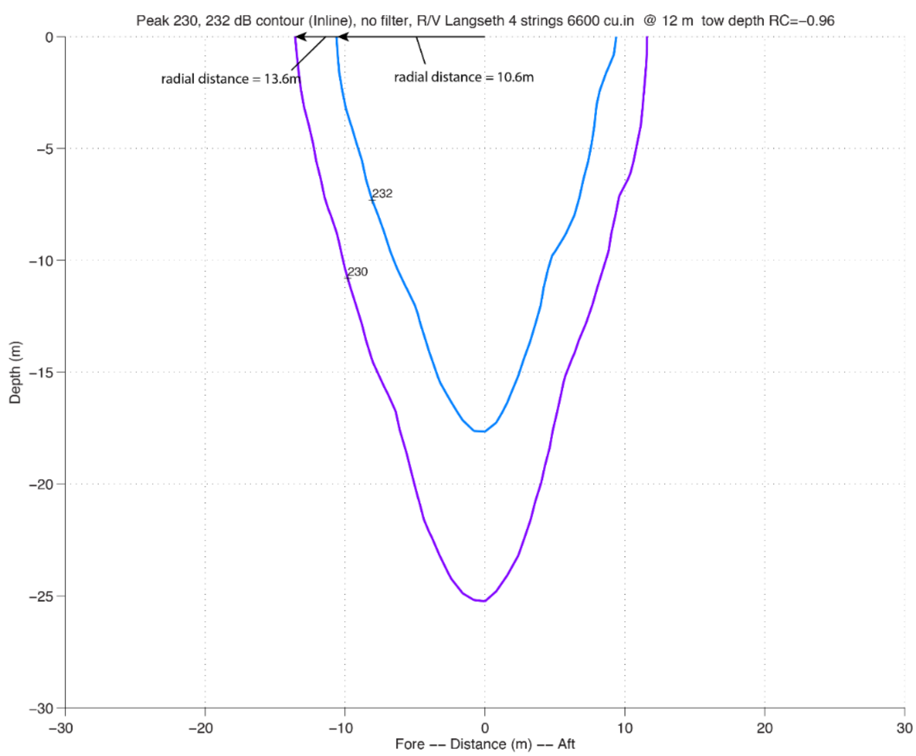

FIGURE A-12. Modeled deep-water received Peak SPL from the 36-airgun array at a 12-m tow depth. The plot provides the distances to the 230- and 232-dB Peak isopleths.

TABLE A-5. Level A threshold distances for different marine mammal hearing groups and sea turtles for the

36-airgun array. Consistent with NMFS (2016, 2018), the largest distance (in bold) of the dual criteria (SEL_{cum} or Peak SPL_{flat}) was used to calculate Level A takes and threshold distances.

	Level A Threshold Distances (m) for Various Hearing Groups					
	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds/ Sea Otters	Sea Turtles
PTS SEL_{cum}	**320.2**	0	1.0	10.4	0	**15.4**
PTS Peak	38.9	**13.6**	**268.3**	**43.7**	**10.6**	10.6

TABLE A-6. Results for modified farfield SEL source level modeling for the 40 in³ airgun with and without applying weighting function to the various hearing groups. The modified farfield signature is estimated using the distance from the source array geometrical center to where the SEL_{cum} threshold is the largest. A propagation of 20 $\log_{10}$ (Radial distance) is used to estimate the modified farfield SEL.

SEL_{cum} Threshold	**183**	**185**	**155**	**185**	**203**
Distance (m) (no weighting function)	9.9893	7.8477	294.0371	7.8477	0.9278
Modified Farfield SEL*	202.9907	202.8948	204.3680	202.8948	202.3491
Distance (m) (with weighting function)	2.3852	N.A.	N.A.	N.A.	N.A.
Adjustment (dB)	-12.44	N.A.	N.A.	N.A.	N.A.

*Propagation of 20 log R. N.A. means not applicable or not available.

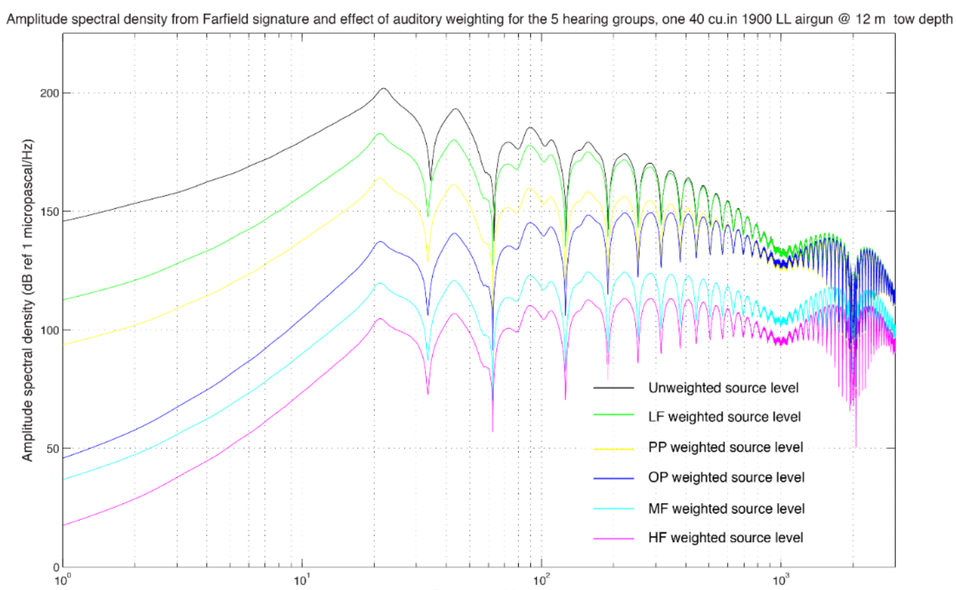

FIGURE A-13. Modeled amplitude spectral density of the 40-in³ airgun farfield signature. Amplitude spectral density before (black) and after (colors) applying the auditory weighting functions for LF, MF, and HF cetaceans, Phocid Pinnipeds (PP), and Otariid Pinnipeds (OP). Modeled spectral levels are used to calculate the difference between the unweighted and weighted source level at each frequency and to derive the adjustment factors for the hearing groups as inputs into the NMFS User Spreadsheet.

TABLE A-7. Results for modified farfield SEL source level modeling for the single 40-in^3 mitigation airgun with weighting function calculations for the SEL_{cum} criteria, as well as resulting isopleths to thresholds for various marine mammal hearing groups.

STEP 1: GENERAL PROJECT INFORMATION

PROJECT TITLE	R/V Langseth mitigation gun
PROJECT/SOURCE INFORMATION (Please include any assumptions)	one 40 cu.in 1900LL airgun @ a 12 m tow depth - speed of 4.2 knots and shot interval of 37.5 m
PROJECT CONTACT	

STEP 2: WEIGHTING FACTOR ADJUSTMENT — Specify if relying on source-specific WFA, alternative weighting/dB adjustment, or if using default value

Weighting Factor Adjustment (kHz)[¥]	NA	Override WFA: Using LDEO modeling

[¥] Broadband: 95% frequency contour percentile (kHz) OR Narrowband: frequency (kHz); For appropriate default WFA: See INTRODUCTION tab

† If a user relies on alternative weighting/dB adjustment rather than relying upon the WFA (source-specific or default), they may override the Adjustment (dB) (row 62), and enter the new value directly. However, they must provide additional support and documentation supporting this modification.

*** BROADBAND Sources: Cannot use WFA higher than maximum applicable frequency (See GRAY tab for more information on WFA applicable frequencies)**

STEP 3: SOURCE-SPECIFIC INFORMATION

NOTE: Choose either F1 OR F2 method to calculate isopleths (not required to fill in sage boxes for both) — **NOTE: LDEO modeling relies on Method F2**

F2: ALTERNATIVE METHOD† TO CALCULATE PK and SEL_{cum} (SINGLE STRIKE/SHOT/PULSE EQUIVALENT)

SEL_{cum}

Source Velocity (meters/second)	2.16067	4.2 knots
1/Repetition rate^ (seconds)	23.14097016	50/2.16067

†Methodology assumes propagation of 20 log R; Activity duration (time) independent

^Time between onset of successive pulses.

Modified farfield SEL	202.9907	202.8948	204.368	202.8948	202.3491
Source Factor	8.60376E+18	8.41586E+18	1.18146E+19	8.41586E+18	7.42213E+18

RESULTANT ISOPLETHS* — *Impulsive sounds have dual metric thresholds (SELcum & PK). Metric producing largest isopleth should be used.

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds/Sea Otters
SEL_{cum} Threshold	183	185	155	185	203
PTS SEL_{cum} Isopleth to threshold (meters)	0.4	0	0	0	0

WEIGHTING FUNCTION CALCULATIONS

Weighting Function Parameters	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds	
a	1	1.6	1.8	1	2	
b	2	2	2	2	2	
f_1	0.2	8.8	12	1.9	0.94	
f_2	19	110	140	30	25	
C	0.13	1.2	1.36	0.75	0.64	
Adjustment (dB)†	-12.44	-60.85	-70.00	-30.09	-36.69	OVERIDE Using LDEO Modeling

†For LF cetaceans, the adjustment factor (dB) is derived by estimating the radial distance of the 183-dB isopleth without applying the weighting function and a second time with applying the weighting function. Adjustment was derived using a propagation of 20*$\log_{10}$ (Radial distance) and the modified farfield signature. For MF and HF cetaceans and pinnipeds, the difference between weighted–unweighted spectral source levels at each frequency was integrated to calculate adjustment factors (see spectrum levels in Figure A-13).

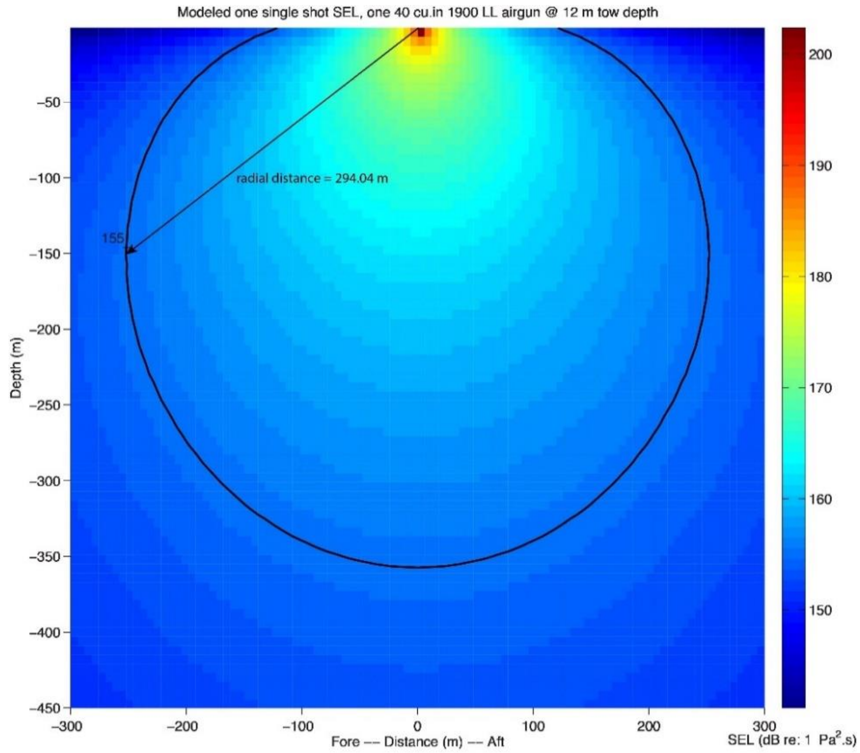

FIGURE A-14. Modeled received sound levels (SELs) in deep water from one 40-in^3 airgun at a 12-m tow depth. The plot provides the distance from the geometrical center of the source array to the 155-dB SEL isopleth (294.04 m).

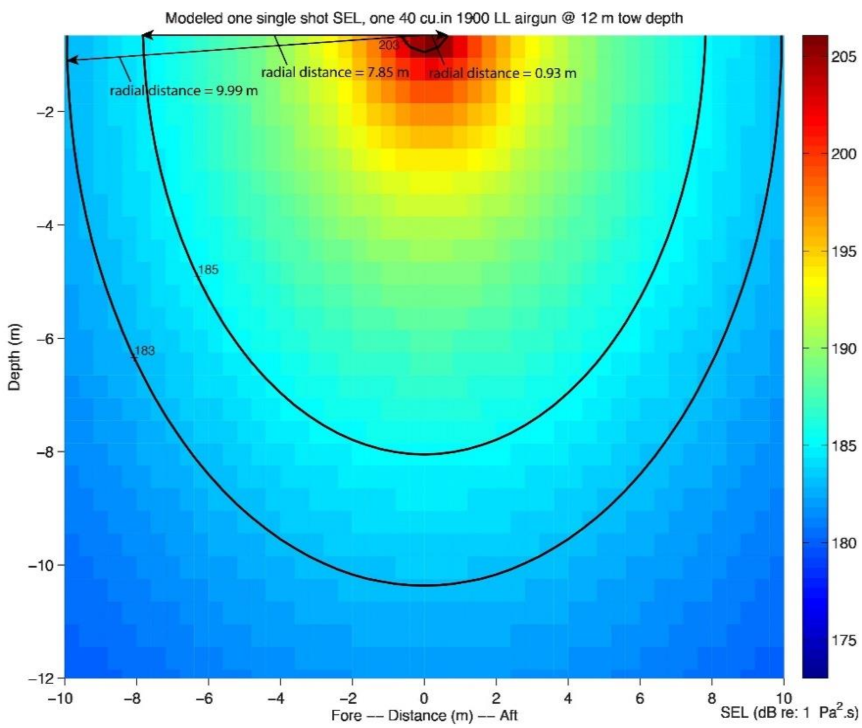

FIGURE A-15. Modeled received sound levels (SELs) in deep water from one 40-in^3 airgun at a 12-m tow depth. The plot provides the distance from the geometrical center of the source array to the 183–185 dB and 203 dB SEL isopleths.

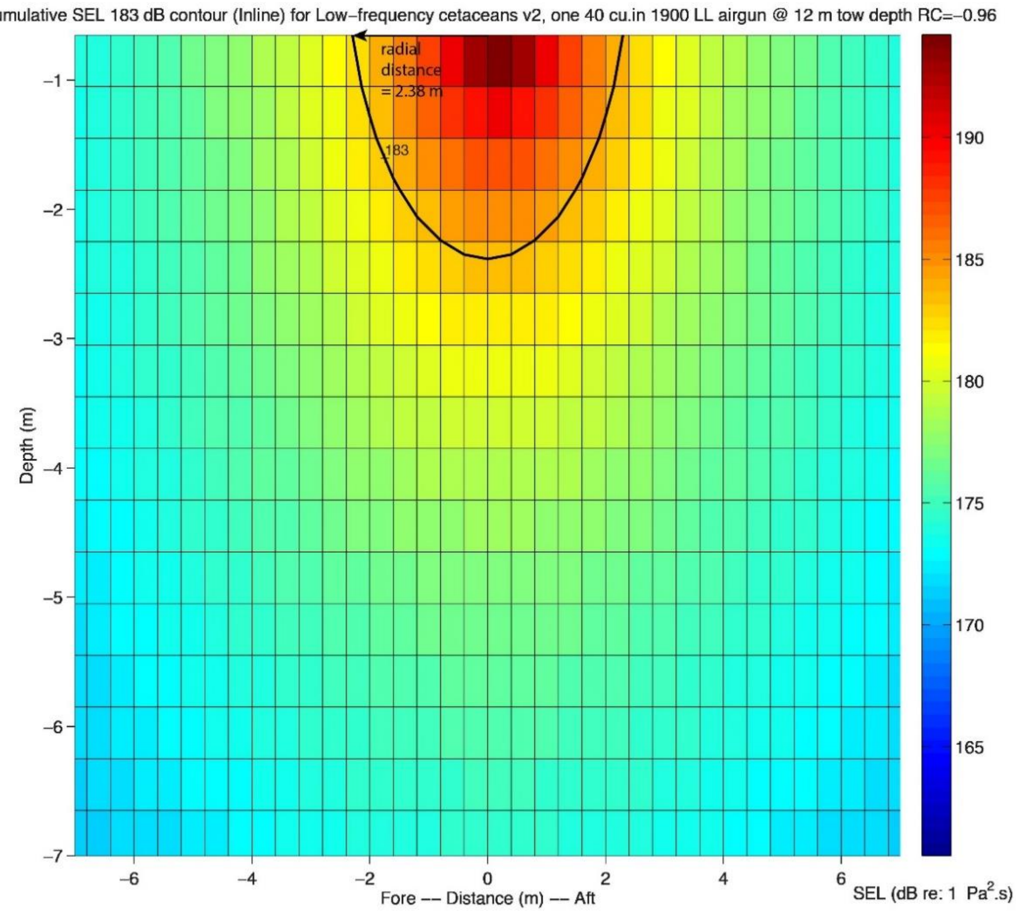

FIGURE A-16. Modeled received sound exposure levels (SELs) from one 40-in³ mitigation at a 12-m tow depth, after applying the auditory weighting function for the LF cetaceans hearing group following the NMFS Technical Guidance. The plot provides the radial distance to the 183-dB SEL_{cum} isopleth for one shot. The difference in radial distances between Fig. A-15 and this figure allows us to estimate the adjustment in dB.

TABLE A-8. NMFS Level A acoustic thresholds (Peak SPL_{flat}) for impulsive sources for marine mammals and predicted distances to Level A thresholds for various marine mammal hearing groups that could be received from the 40-in³ airgun during the proposed seismic surveys in the Northeast Pacific Ocean.

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds/ Sea Otters/ Sea Turtles
Peak Threshold	**219**	**230**	**202**	**218**	**232**
Radial Distance to Threshold (m)	1.76	N.A.	12.47	1.98	N.A.
Modified Farfield Peak	223.93	224.09	223.92	223.95	223.95
PTS Peak Isopleth (Radius) to Threshold (m)	1.76	N.A.	12.5	1.98	N.A.

N.A. means not applicable or not available.

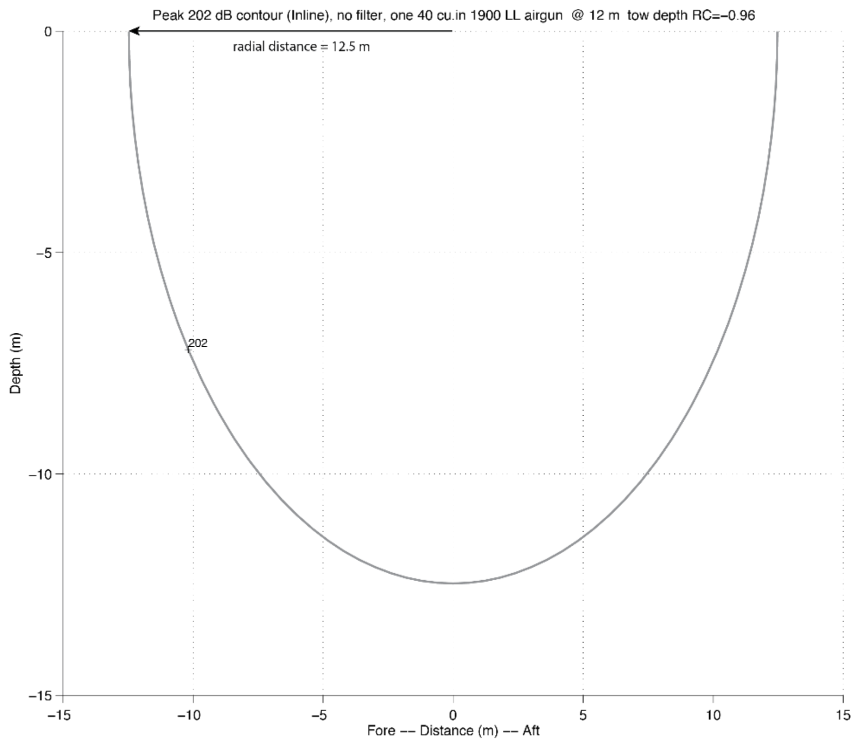

FIGURE A-17. Modeled deep-water received Peak SPL from one 40 in^3 airgun at a 12-m tow depth. The plot provides the radial distance from the source geometrical center to the 202-dB Peak isopleth.

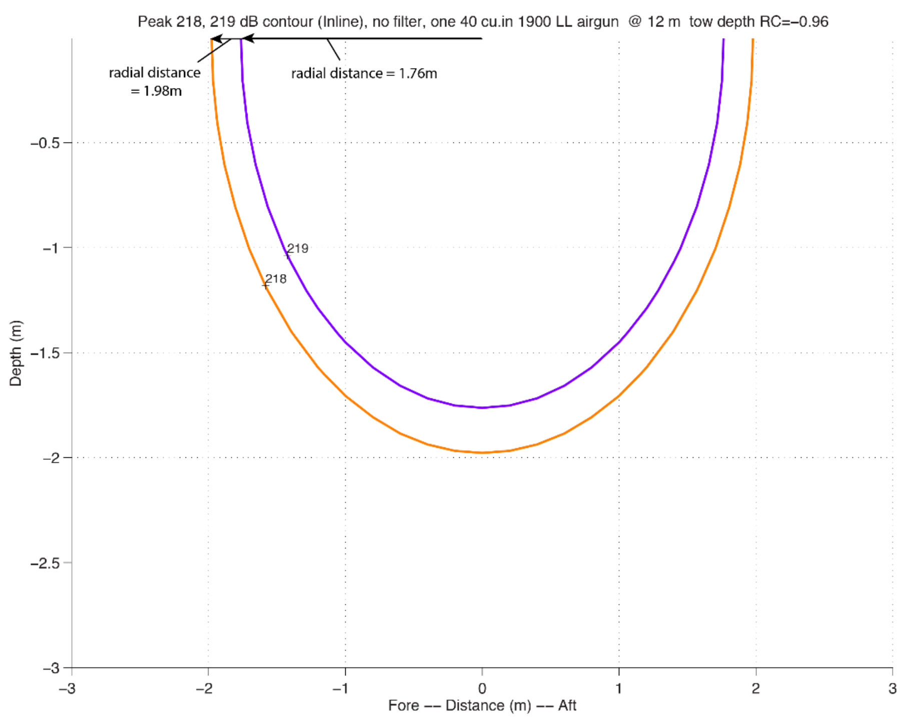

FIGURE A-18. Modeled deep-water received Peak SPL from one 40 in^3 airgun at a 12-m tow depth. The plot provides the radial distances from the source geometrical center to the 218 and 219-dB Peak isopleths.

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ADDENDUM

Using Empirical Data for Estimation of Level B Radii

Based on Crone et al. (2014; *Estimating shallow water sound power levels and mitigation radii for the R/V Marcus G. Langseth using an 8 km long MCS streamer*), empirical data collected on the Cascadia Margin in 2012 during the COAST Survey support the use of the multichannel seismic (MCS) streamer data and the use of Sound Exposure Level (SEL) as the appropriate measure to use for the prediction of mitigation radii for the proposed survey. In addition, this peer-reviewed paper showed that the method developed for this purpose is most appropriate for shallow water depths, up to ~200 m deep.

To estimate Level B (behavioral disturbance or harassment) radii in shallow and intermediate water depths, we used the received levels from MCS data collected by R/V *Langseth* during the COAST survey (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. 2004, 2009; Diebold et al. 2010).

As shown by Madsen et al. (2005), Southall et al. (2007), and Crone et al. (2014), the use of the root mean square (RMS) pressure levels to calculate received levels of an impulsive source leads to undesirable variability in levels due to the effects of signal length, potentially without significant changes in exposure level. All these studies recommend the use of SEL to establish impulsive source thresholds used for mitigation. Here we provide both the actual measured 160 dB_{RMS} and 160 dB_{SEL} to demonstrate that for determining mitigation radii in shallow water and intermediate, both would be significantly less than the modeled data for this region.

The proposed surveys would acquire data with a 4 string 6600 in^3 airgun array at a tow depth of 12 m, while the data collected in 2012 were acquired with a 4 string 6600 in^3 airgun array at a tow depth of 9 m. To account for the differences in tow depth between the COAST survey (6600 in^3 at 9 m tow depth) and the proposed survey (6600 in^3 at 12 m tow depth), we calculated a scaling factor using the deepwater modeling. The 150 dB_{SEL} corresponds to deep-water maximum radii of 10,533 m for the 6600 in^3 airguns at 12 m tow depth, and 9,149 m for the 6600 in^3 at a 9 m tow depth yielding a scaling factor of 1.15 to be applied to the shallow-water and intermediate-water 9 m tow depth results.

As the 6600 cu.in source is 18 m wide (across-line direction) and 16m long (along-line direction), this quasi-symmetric source is also able to capture azimuthal variations.

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Extracted from Crone et al. 2014 – Section 4.1

4. Discussion

4.1. RMS Versus SEL In his paper, Madsen [2005] makes a compelling argument against the use of RMS (equation (3)) for the determination of safe exposure levels and mitigation radii for marine protected species, partially on the grounds that this measure does not take into account the total acoustic energy that an animal's auditory system would experience. Madsen [2005] recommended the use of SEL as well as measures of peak pressure to establish impulsive source thresholds used for mitigation. Southall et al. [2007] came to similar conclusions.

Our work should provide further motivation for a regulatory move away from RMS power levels for marine protected species mitigation purposes. In shallow waters especially, interactions between direct, reflected, and refracted arrivals of acoustic energy from the array can result in large variations in signal length (T_{90}), and commensurate large variations in RMS without necessarily significant changes in exposure level. The use of SEL, which accounts for signal length, should be preferred for mitigation purposes in shallow water.

****

The entire 16 0dB$_{SEL}$ level data are within the length of the streamer and are well behaved throughout this depth profile. The measured sound level data in this area suggest that the 160d B$_{SEL}$ mitigation radius distance would be well defined at a maximum of 8192 m, but that the 160 dB$_{RMS}$ would be close to ~11 km (Fig. 1). For a few shots along this profile, the 160 dB$_{RMS}$ is just beyond the end of the streamer (8 km). For these shots, extrapolation was necessary. Crone et al. (2014) could only extrapolate the 160 dB$_{RMS}$ levels up to a distance of ~11 km (~133% of the length of the streamer). However, the stable 160 dB$_{SEL}$ levels across this interval would support an extrapolated value of not much more than 11 km for the 160 dB$_{RMS}$ level given that the 160 dB$_{RMS}$ and 160 dB$_{SEL}$ levels track consistently along the profile (Fig. 1).

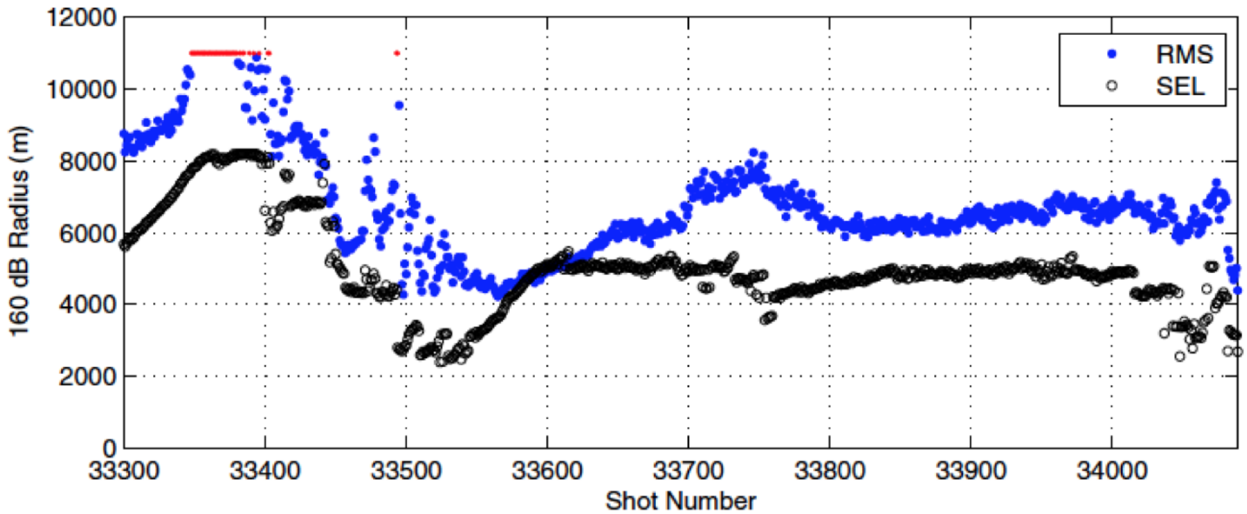

FIGURE 1. Measured radius distances to the 160 dB radii for both SEL and RMS along line A/T collected in 2012 at Cascadia with R/V *Langseth* 6600 in^3 airgun array towed at a depth of 9 m (Fig. 12 from Crone et al. 2014). This line extends across the shelf from ~50m water depth (Shot 33,300), 100m water depth (Shot # 33,675) out ~to the shelf break at 200m water depth (~Shot # 34000).

As noted in Table 2 of Crone et al. (2014), the full range of 160 dB$_{RMS}$ measured radii for intermediate waters is 4291m to 8233 m. The maximum 160 dB$_{RMS}$ measured radii, 8233 m (represented by a single shot at ~33750 from Figure 1), was selected for the 160 dB$_{RMS}$ measured radii in Table 1. Only 2 shots in water depths >100 have radii that exceed 8000 m, and there were over 1100 individual shots analyzed in the data; thus, the use of 8233 m is conservative.

Summary

The empirical data collected during the COAST Survey on Cascadia Margin and measured 160 dB$_{RMS}$ and 160 dB$_{SEL}$ values demonstrate that the modeled predictions are quite conservative by a factor of up to ~2 to 2.5 times less than modeled predictions for the Cascadia project. While we have sought to err on the conservative side for our activities, being overly conservative can dramatically overestimate potential and perceived impacts of a given activity. We understand that the 160 dB$_{RMS}$ is the current threshold, and have highlighted that here as the standard metric to be used. However, evidence from multiple publications including Crone et al. (2014) have argued that SEL is a more appropriate metric for mitigation radii calculations. However, it is important to note that use of either measured SEL or RMS metrics yields significantly smaller radii in shallow water than model predictions.

TABLE 1. Comparison of modeled mitigation radii with empirically-derived radii from the Cascadia Margin during the 2012 COAST survey for the 4-string 36 airgun array (6600 in³).

Water Depth (m)	**Proposed Project Radii using L-DEO Modeling**	**COAST project Radii using L-DEO Modeling**	**Predicted Radii for Proposed Project using Empirical Data (Crone et al. 2014). 160 dB rms measured distance proposed for current project shown in red.**			
	Distance (m) to 160-dB$_{rms}$ at 12 m tow depth	**Distance (m) to 160-dB$_{rms}$ at 9 m tow depth**	**Distance (m) to 160-dB$_{SEL}$ at 9 m tow depth (Figure 12 *in* Crone et al. 2014)**	**Distance (m) to 160-dB$_{SEL}$ with conversion factor (1.15) from 9 to 12 m tow depth**	**Distance (m) to 160 dB$_{rms}$ at 9 m tow depth (Figure 12 *in* Crone et al. 2014)**	**Distance (m) to 160 dB$_{rms}$ with conversion factor (1.15) from 9 to 12 m tow depth**
<100	25,494	20,550	8,192	9,421	11,000*	12,650
100-1000	10,100	12,200	5,487	6,300	8,233	9,468

*This value is extrapolated from end of 8-km streamer. Based on stable SEL values at same shot values. RMS extrapolated value is reasonable approximation.

When evaluating the empirical and modeled distances, all the other considerations and aspects of the airgun array still apply including:

- the airgun array is actually a distributed source and the predicted farfield level is never actually fully achieved
- the downward directionality of the airguns means that the majority of energy is directed downwards and not horizontally
- animals observed at the surface benefit from Lloyds mirror effect
- there is only one source vessel and the entire survey area is not ensonified all at one time, but rather the much smaller area around the vessel.

For these reasons, we believe the more scientifically appropriate approach for the proposed survey is to use Level B threshold distances based on the empirical data for shallow and intermediate water depths.

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APPENDIX B: CETACEAN, PINNIPED, AND SEA TURTLE DENSITIES AND TAKE CALCULATIONS

APPENDIX B: CETACEAN, PINNIPED, AND SEA TURTLE DENSITIES AND TAKE CALCULATIONS

For the proposed surveys, NMFS recommended the use of habitat-based stratified marine mammal densities developed by the U.S. Navy for assessing potential impacts of training activities in the Temporary Marine Activities Area (TMAA) of the GOA (DoN 2021) and densities for Behm Canal in Southeast Alaska (DoN 2019). A combination of these densities were used for the majority of species (see below); based on recommendations by NMFS, the GOA densities were used for offshore areas, and the Behm Canal densities were used for coastal waters, when available. In the Draft EA, densities from the GOA were based on DoN (2014); thus take estimates are different for the Final EA. In DoN (2021), densities are provided for four strata that were designed to encompass the four distinct habitats within the TMAA and greater GOA. The four strata include (1) Inshore: all waters <1000 m deep; (2) Slope: from 1000 m 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.

In our take calculations for cetaceans, the preferred densities for coastal waters (shallow and intermediate depths) were from Behm Canal; 'Offshore' densities from the GOA were used for offshore waters. Densities from the slope region in the western GOA were not deemed representative of the shallow and intermediate water depths in the proposed survey area; the slope region is much wider in the western GOA compared to southeast Alaska. If no densities were available for Behm Canal, then 'Inshore' densities were used for coastal waters (shallow and intermediate depths); 'Offshore' densities were used for offshore waters. For pinnipeds, we used densities from Behm Canal, when available, for shallow water (<100 m), 'Inshore' densities for intermediate-depth water (100–1000 m), and 'Offshore' densities for offshore waters. 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 GOA and single density values for Behm Canal were based on data from several different sources, including Navy funded line-transect surveys in the GOA, and are shown in Table B-1. Densities for harbor porpoise, northern right whale dolphin, California sea lion, and leatherback turtle were determined using alternate density sources (see below). When seasonal densities were available (e.g., as for Behm Canal for humpback, killer, and minke whales; Pacific white-sided dolphin; Steller sea lion; and harbor seal), the calculated exposures were based on summer densities, which were deemed to be most representative of the proposed survey timing. For all other species, summer densities were either not available or the same as for other seasons. There is some uncertainty related to the estimated density data and the assumptions used in their calculations.

For harbor porpoise, we used densities from Hobbs and Waite (2010) for Southeast Alaska and applied those to shallow and intermediate water depths to be conservative. These densities are more representative of the survey area compared with those from the western GOA. Densities were assumed to be zero in deep water, as reported by the DoN (2021). For northern right whale dolphins, spatially-explicit density data from the NOAA CetSound website (NOAA 2019) were used. These densities were only applied to ensonified areas in Canadian waters, as this species typically does not occur as far north as Alaska. CetMap (https://cetsound.noaa.gov/cda) provides output from habitat-based density models for cetaceans in the California Current Ecosystem (Becker et al. 2016) in the form of GIS layers; these were averaged in the shallow, intermediate, and deep water across Washington and Oregon to calculate takes in the survey area. For California sea lion, we used density data for August for the Offshore Northwest Training and Testing (NWTT) Area from DoN (2019); densities for 0–40 km from shore were applied to shallow and intermediate water depths, and the density for 0–450 km from shore was used for deep water;

the density for 40–70 km from shore was the lowest and was therefore not used. For leatherback turtles, annual densities from DoN (2019) were used to calculate takes.

All take calculations are shown in Table B-2.

TABLE B-1. Densities of marine mammals and sea turtles expected to occur in the proposed survey area.

	Shallow Water <100 m	Intermediate Water 100-1000 m	Deep Water >1000 m	Comments
LF Cetaceans				
North Pacific right whale	0.00000	0.00000	0.00003	Behm Canal (DoN 2019); deep water for GOA
Humpback whale	0.01170	0.01170	0.00100	Behm Canal (DoN 2019); deep water for GOA
Blue whale	0.00010	0.00010	0.00050	All GOA
Fin whale	0.00010	0.00010	0.01600	Behm Canal (DoN 2019); deep water for GOA
Sei whale	0.00040	0.00040	0.00040	All GOA
Minke whale	0.00080	0.00080	0.00060	Behm Canal (DoN 2019); deep water for GOA
Gray whale	0.04857	0.04857	0	All GOA
MF Cetaceans				
Sperm whale	0.00200	0.00200	0.00130	All GOA
Baird's beaked whale	0	0	0.00050	All GOA
Cuvier's beaked whale	0	0	0.00200	All GOA
Stejneger's beaked whale	0	0	0.00210	All GOA
Pacific white-sided dolphin	0.00750	0.00750	0.02000	Behm Canal (DoN 2019); deep water for GOA
Northern right-whale dolphin	0.01100	0.02763	0.03673	Cetcound (Becker et al. 2016); only for Canadian deep water (non-territorial)
Risso's dolphin	0.00001	0.00001	0.00001	All GOA
Killer whale	0.00570	0.00570	0.00200	Summer densities for transients for Behm Canal; density larger than for other stocks; deep water GOA
HF Cetaceans				
Dall's porpoise	0.12100	0.12100	0.03700	Behm Canal (DoN 2019); deep water for GOA
Harbor porpoise	0.03300	0.03300	0	Hobbs and Waite (2010)
Otariid Seals				
Northern fur seal	0.06610	0.06610	0.06610	All GOA
California sea lion	0.02880	0.02880	0.00650	CC (DoN 2019)
Steller sea lion	0.31616	0.05700	0.00000	Behm Canal (DoN 2019); int. and deep water for GOA
Phocid Seals				
Northern elephant seal	0.07790	0.07790	0.07790	All GOA
Harbor seal	0.78110	0.14070	0	Behm Canal (DoN 2019); int. and deep water for GOA
Sea Turtle				
Leatherback Turtle	0.000114	0.000114	0.000114	DoN (2019)

N.A. means not available.
CC = California Current

TABLE B-2. Take estimates (excluding takes in Canadian territorial waters) for the proposed survey area in the Northeast Pacific Ocean.

Species	Estimated Density (#/km²)			Regional Population Size	Level B 160 dB Ensonified Area (km²)			Level A Ensonified Area (km²)			Level B Takes			Level B Takes (All)	Only Level B Takes	Level A Takes	% of Pop. (Total Takes)	Requested Level A+B Take Authorization
	Shallow <100 m	Intermediate 100-1000 m	Deep >1000 m		Shallow <100 m	Intermediate 100-1000 m	Deep >1000 m	Shallow <100 m	Intermediate 100-1000 m	Deep >1000 m	Shallow <100 m	Intermediate 100-1000 m	Deep >1000 m					
LF Cetaceans																		
North Pacific right whale	0.0000	0.0000	0.00003	400	2,626	28,154	57,150	34	894	2,722	0	0	2	2	2	0	0	2
Humpback whale	0.0117	0.0117	0.0010	10,103	2,626	28,154	57,150	34	894	2,722	31	329	57	417	403	14	4.13	417
Blue whale	0.0001	0.0001	0.0005	1,496	2,626	28,154	57,150	34	894	2,722	0	3	29	32	31	1	2.12	32
Fin whale	0.0001	0.0001	0.0160	18,680	2,626	28,154	57,150	34	894	2,722	0	3	914	917	873	44	4.91	917
Sei whale	0.0004	0.0004	0.0004	519	2,626	28,154	57,150	34	894	2,722	1	11	23	35	34	1	6.78	35
Minke whale	0.0008	0.0008	0.0006	28,000	2,626	28,154	57,150	34	894	2,722	2	23	34	59	57	2	0.21	59
Gray whale	0.0486	0.0486	0.0000	26,960	2,626	28,154	57,150	34	894	2,722	128	1,367	0	1495	1450	45	5.55	1,495
MF Cetaceans																		
Sperm whale	0.0000	0.0020	0.0013	26,300	2,626	28,154	57,150	1	38	115	0	56	74	131	131	0	0.50	131
Baird's beaked whale	0.0000	0.0000	0.0005	2,697	2,626	28,154	57,150	1	38	115	0	0	29	29	29	0	1.06	29
Cuvier's beaked whale	0.0000	0.0000	0.0020	3,274	2,626	28,154	57,150	1	38	115	0	0	114	114	114	0	3.75	114
Stejneger's beaked whale	0.0000	0.0000	0.0021	3,044	2,626	28,154	57,150	1	38	115	0	0	120	120	120	0	0.45	120
Pacific white-sided dolphin	0.0075	0.0075	0.0200	26,880	2,626	28,154	57,150	1	38	115	20	211	1,143	1374	1371	3	5.11	1,374
Northern right-whale dolphin	0.0110	0.0276	0.0367	26,556	0	656	24,742	1	38	115	0	18	909	927	922	5	3.49	927
Risso's dolphin	0.0000	0.0000	0.0000	6,336	2,626	28,154	57,150	1	38	115	0	0	1	1	1	0	0.01	**22**
Killer whale[1]	0.0057	0.0057	0.0020	3,738	2,626	28,154	57,150	1	38	115	15	160	114	290	290	0	7.75	290
HF Cetaceans																		
Dall's porpoise	0.1210	0.1210	0.0370	83,400	2,626	28,154	57,150	28	748	2,280	318	3,407	2,115	5839	5661	178	7.00	5,839
Harbor porpoise	0.0330	0.0330	0.0000	11,146	2,626	28,154	57,150	28	748	2,280	87	929	0	1016	990	26	9.11	1,016
Otariid Seals																		
Northern fur seal	0.0661	0.0661	0.0661	608,143	2,626	28,154	57,150	1	29	90	174	1,861	3,778	5812	5804	8	0.96	5,812
California sea lion	0.0288	0.0288	0.0065	257,606	2,626	28,154	57,150	1	29	90	76	811	371	1258	1257	1	0.49	1,258
Steller sea lion	0.3162	0.0570	0.0000	43,201	2,626	28,154	57,150	1	29	90	830	1,605	0	2435	2433	2	5.64	2,435
Phocid Seal																		
Northern elephant seal	0.0779	0.0779	0.0779	179,000	2,626	28,154	57,150	5	122	371	205	2,193	4,452	6850	6811	39	3.83	6,850
Harbor seal	0.7811	0.1407	0.0000	13,289	2,626	28,154	57,150	5	122	371	2,051	3,961	0	6012	5992	21	45.24	6,012
Sea Turtle																		
Leatherback Turtle	0.0001140	0.0001140	0.0001140	N.A.	363.8	8,086.9	15,662.2	1.6	42.8	130.7	0	1	2	3	3	0	N.A.	3

N.A. means not available or not applicable.
[1] No takes expected for Southern Resident DPS.

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APPENDIX C: SEA OTTER DENSITIES AND TAKE CALCULATIONS

APPENDIX C: SEA OTTER DENSITIES AND TAKE CALCULATIONS

Densities for northern sea otter are based on Tinker et al. (2019), and the methodology for calculating exposures was provided by the USFWS. According to USFWS, the majority of sea otters (95%) are observed within the 40-m depth contour, although they can be found in areas with deeper water. Thus, high density sea otter habitat was delineated by the 40-m depth contour, and low-density otter habitat was delineated by the 100-m depth contour. Habitat was further divided into subregions established by Tinker et al. (2019) to incorporate demographic structure in their carrying capacity analyses. Sea otter densities for the subregions were determined using 2012 abundance estimates generated by the Bayesian hierarchical model developed by Tinker et al. (2019). Abundance estimates are traditionally generated using aerial survey data from high density (<40 m) habitat. To calculate the density of otters in low-density (40–100 m) habitat, USFWS multiplied the density of the adjacent high-density habitat by 0.05. The resulting density estimate accounts for the 5% of otters found in low-density areas.

It was assumed all sea otters exposed to underwater sound levels that meet the acoustic exposure criteria shown in Table 1 and Table 2 would experience Level B (>160 dB) or Level A (>232 dB) take, respectively. To determine the number of otters that may be exposed to these sound levels, the USFWS created spatially explicit zones of ensonification using the proposed survey transects, and determined the number of otters present in the ensonification zones using the above density information for the subgroups that comprise the Southeast Alaska stock. The zones were created using the proposed transects along the Southeast Alaskan coast and sound level isopleths for the acoustic exposure criteria. The Level A and Level B isopleths were then used to create spatially explicit ensonification zones surrounding the proposed transects using ArcGIS Pro. Using the 10.6 m Level A buffer (see Table 2), and assuming the airgun array is spread out over 24 m, a 45 m-wide buffer was created around the proposed transects to account for the Level A ensonified area on either side of the array. To determine the Level B ensonified area, points were first placed along the proposed project transects every 500 m. Bathymetry data were then used to determine ocean depth at each point along the transect. A 12.65 km buffer was placed around points in water <100 m deep, and a 9.2 km buffer was placed around points in water 100–1000 m deep (see Table 1 for isopleths). The resulting ocean depth-informed ensonification zone was then modified to account for land shadows. To do this, lines representing ensonification that radiated from each point along the proposed were clipped with a landform shapefile to identify areas where underwater sound would be absorbed by land features.

To determine the amount (km^2) of ensonified habitat in each subregion, a habitat shapefile was clipped using the Level A and Level B ensonification shapefiles in ArcGIS Pro. The area impacted in each subregion was multiplied by the estimated otter density in that region to determine the number of otters that would experience Level B (Table C-1) and Level A sound levels. The total number of takes was predicted by estimating the projected days of activity in each subregion using survey start points. In several areas, the length and direction of the proposed survey transects made it unlikely that ensonification would last only one day. In these instances, two days of disturbance were estimated. It is estimated that 49 sea otters could potentially be exposed to Level B sound levels during the proposed seismic surveys if no animals moved away from the survey vessel (Table C-1). No correction factors have been applied to account for animals at the surface of the water. Thus, the estimates are precautionary and probably overestimate the actual numbers of sea otters that could be involved. Level A takes were estimated to be zero and are therefore considered highly unlikely; otters would likely move away from a sound source before they are exposed to sound levels that could result in a Level A take. Additionally, otters spend a substantial amount of time each day on the surface of the water.

TABLE C-1. Number of sea otters estimated to be exposed to sound levels >160 dB during the proposed survey. Level B takes were calculated by multiplying the area ensonified in each subpopulation by that subpopulation's modeled sea otter density, then multiplied by the estimated number of days of ensonification (information provided by USFWS).

Sub-region	Habitat Type	Density (otters/km^2)	Ensonified Area (km^2)	Estimated Take/Day	Projected Days of Take	Estimated Total Takes
N06	High (<40 m)	0.778	4.66	4	1	4
S05	High (<40 m)	1.333	8.74	12	2	24
S12	High (<40 m)	0.1748	2.56	1	2	2
N06	Low (40-100 m)	0.034	15.69	1	1	1
S01	Low (40-100 m)	0.084	42.31	4	2	8
S05	Low (40-100 m)	0.123	31.32	4	2	8
S12	Low (40-100 m)	0.0092	47.62	1	2	2
Total			**152.90**	**27**		**49**
Current Stock Total				**25,584**		**25,584**
Percentage of Stock				**0.1%**		**0.2%**

Literature Cited

Tinker, M.T., V.A. Gill, G.G. Esslinger, J. Bodkin, M. Monk, M. Mangel, D.H. Monson, W.W. Raymond, and M.L. Kissling. 2019. Trends and carrying capacity of sea otters in Southeast Alaska. **J. Wildl. Manage.** 83(5):1073-1089.

APPENDIX D: ENSONIFIED AREAS FOR TAKE CALCULATIONS FOR CETACEANS, PINNIPEDS, AND SEA TURTLES

APPENDIX D: ENSONIFIED AREAS FOR TAKE CALCULATIONS FOR CETACEANS, PINNIPEDS, AND SEA TURTLES

Survey Zone	Criteria	Daily Ensonified Area (km^2)	Total Survey Days	25% Increase	Total Ensonified Area (km^2)	Relevant Isopleth (m)
Shallow <100 m: US	160 dB	131.3	16	1.25	2,625.6	12650
Intermediate 100-1000 m: US	160 dB	1374.9	16	1.25	27,497.7	9468
Deep >1000 m: US	160 dB	1620.4	16	1.25	32,407.1	6733
Intermediate 100-1000 m: Canada non-terr.	160 dB	47.7	11	1.25	656.4	9468
Deep >1000 m: Canada non-territorial	160 dB	1799.4	11	1.25	24,742.4	6733
Intermediate 100-1000 m: US and Canada	160 dB	1422.6	27	1.25	28,154.1	9468
Deep>1000 m: US + Canada	160 dB	3419.8	27	1.25	57,149.5	6733
Overall	**160 dB**	**4973.7**	**27**	**1.25**	**87929.2**	
All zones	LF Cetacean	210.8	27	1.25	3,649.0	320.2
All zones	MF Cetacean	8.9	27	1.25	154.7	13.6
All zones	HF Cetacean	176.6	27	1.25	3,056.4	268.3
All zones	Otariid	7.0	27	1.25	120.5	10.6
All zones	Phocid	28.7	27	1.25	497.1	43.7
All zones	Sea Turtle	10.1	27	1.25	175.1	15.4

Note: not all steps of the calculations are shown here for the PTS thresholds (e.g., ensonified areas in US vs. Canadian waters) .

APPENDIX E: USFWS ESA LOC

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United States Department of the Interior

U.S. FISH AND WILDLIFE SERVICE
Anchorage Fish and Wildlife Conservation Office
4700 BLM Road
Anchorage, Alaska 99507

In Reply Refer to:
FWS/IR11/AFWCO

April 8, 2021

Ms. Holly Smith
Environmental Compliance Officer
National Science Foundation
2415 Eisenhower Avenue
Alexandria, Virginia 22314

Subject: Marine Geophysical Survey by R/V *Marcus G. Langseth* along Queen Charlotte Fault, Northeast Pacific Ocean, 2021 (Consultation 07CAAN00-2021-I-0075)

Dear Ms. Smith:

Thank you for requesting informal consultation with the U.S. Fish and Wildlife Service (Service), pursuant to section 7 of the Endangered Species Act of 1973 (16 U.S.C. 1531 et seq., as amended; ESA), by correspondence received December 23, 2021. The National Science Foundation (NSF) proposes to conduct a high-energy marine geophysical survey along the Queen Charlotte Fault in the Northeast Pacific Ocean, within the Exclusive Economic Zones of the U.S. and Canada. The NSF has determined the proposed action may affect, but is not likely to adversely affect, the federally endangered short-tailed albatross (*Phoebastria albatrus*).

The proposed survey is funded by the NSF and would be led by Principal Investigators from the University of New Mexico and Western Washington University. The seismic survey would be conducted on the research vessel (R/V) *Marcus G. Langseth (Langseth)*, owned and operated by Columbia University's Lamont-Doherty Earth Observatory. The Canadian Coast Guard ship *John P. Tully (Tully)*, or similar vessel, will provide support during the survey. The survey would collect two dimensional (2-D) marine seismic data with an array of 36 airguns deployed from the *Langseth* as an energy source, total discharge volume of approximately 6,600 cubic inches. The *Tully* or similar vessel would deploy a 15-kilometer long hydrophone streamer and ocean bottom seismometers, comprising the receiving system for the returning acoustic signals.

The potential effects of the proposed action on ESA-listed seabirds include increased underwater anthropogenic sounds associated with operation of the airgun array, and direct collisions with the research or support vessel or components of the seismic array. The NSF has proposed the following avoidance and minimization measures to reduce potential impacts to ESA-listed seabirds:

1. The underwater noise effects of the airguns will be inherently mitigated, as they are designed to direct the majority of energy downward rather than laterally. They will be fired at 12-meter depth, below the maximum plunge-diving depth of most albatross species.

INTERIOR REGION 11 · ALASKA

2. Power down and/or shut down procedures will be initiated when ESA-listed seabirds are detected diving or foraging in designated exclusion zones. To implement this measure, the NSF will require use of dedicated protected species observers (PSOs) to maintain visual watch during all daytime airgun operations, as well as during ramp ups and the 30 minutes prior, both day and night. Bridge crew on board the *Langseth* and any support vessel will also be trained to identify short-tailed albatross and will monitor for short-tailed albatross in the absence of PSOs (including during night-time hours).
3. To reduce seabird strikes with cables, including those supporting the airgun array and those used during deployment of hydrophone streamers, the NSF will require operators to use bird-scaring streamer lines on aerial cables, configured for maximum visibility to seabirds.
4. To reduce the potential for attraction, disorientation, collision, and/or grounding of seabirds due to vessel lighting, the NSF will require deck lighting be configured to be downward-pointing, and curtains or shades to be used in cabins at night.
5. Crew will report interactions of any albatross species with any component of the seismic survey to PSOs and/or the captain, and all such interactions will be reported to the Service.

The Service agrees that the proposed avoidance and minimization measures should reduce potential effects to listed species, with all remaining effects expected to be either insignificant or discountable. Therefore, the Service concurs with the NSF's determination that proposed project activities are not likely to adversely affect listed species that fall under the Service's management authority, or their designated critical habitats. Based on your request and our response, the requirements of section 7 of the ESA have been satisfied. However, section 7 consultation must be reinitiated if:

1. New information reveals project impacts that may affect listed species or critical habitat in a manner or to an extent not previously considered.
2. This action is subsequently modified in a manner which was not considered in this assessment.
3. A new species is listed or critical habitat designated that may be affected by the proposed action.

This letter relates only to federally listed or proposed species and/or designated or proposed critical habitat under jurisdiction of the Service. It does not address species under jurisdiction of the National Marine Fisheries Service or other federal agency responsibilities, including under the Fish and Wildlife Coordination Act, Migratory Bird Treaty Act, Marine Mammal Protection Act, Clean Water Act, National Environmental Policy Act, or Bald and Golden Eagle Protection Act.

If you have any further questions regarding endangered species relative to this project, please contact Ms. Megan Boldenow at 907.271.3063 or megan_boldenow@fws.gov. Thank you for coordinating to meet our joint responsibilities under the ESA.

Sincerely,

DOUGLASS COOPER

Digitally signed by DOUGLASS COOPER
Date: 2021.04.08 09:51:01 -08'00'

Douglass M. Cooper
Branch Chief, Ecological Service

APPENDIX F: USWF OTTER FED REG

APPENDIX F: USWF OTTER FED REG

Federal Register / Vol. 86, No. 109 / Wednesday, June 9, 2021 / Notices 30613

DEPARTMENT OF THE INTERIOR

Fish and Wildlife Service

[Docket No. FWS–R7–ES–2020–0132; FXES111607MRG01–212–FF07CAMM00]

Marine Mammals; Incidental Take During Specified Activities; Proposed Incidental Harassment Authorization for Southeast Alaska Stock of Northern Sea Otters in the Queen Charlotte Fault Region, Alaska

AGENCY: Fish and Wildlife Service, Interior.

ACTION: Notice of receipt of application; proposed incidental harassment authorization; request for comments.

SUMMARY: We, the U.S. Fish and Wildlife Service, in response to a request under the Marine Mammal Protection Act of 1972, as amended, from the National Science Foundation and the Lamont-Doherty Earth Observatory, propose to authorize nonlethal, incidental take by harassment of small numbers of the Southeast Alaska stock of northern sea otters between July 1, 2021, and August 31, 2021. The applicants have requested this authorization for take that may result from high-energy seismic surveys in the Queen Charlotte Fault region of Southeast Alaska. Seismic surveys are being conducted to characterize crustal and uppermost mantle velocity structure, fault zone architecture and rheology, and seismicity in the Queen Charlotte Fault. We estimate that this project may result in the nonlethal incidental take of up to 27 northern sea otters from the Southeast Alaska stock. This proposed authorization, if finalized, will be for up to 49 takes of 27 northern sea otters by Level B harassment only. No injury or mortality is expected or will be authorized.

DATES: Comments on the proposed incidental harassment authorization and draft environmental assessment must be received by July 9, 2021.

ADDRESSES: *Document availability:* You may view this proposed authorization, the application package, supporting information, and the lists of references cited herein at *http://www.regulations.gov* under Docket No. FWS–R7–ES–2020–0132, or these documents may be requested as described under **FOR FURTHER INFORMATION CONTACT**.

Comment submission: You may submit comments on this proposed authorization by one of the following methods:

- *U.S. mail:* Public Comments Processing, Attn: Docket No. FWS–R7–ES–2020–0132, U.S. Fish and Wildlife Service, MS: PRB/3W, 5275 Leesburg Pike, Falls Church, Virginia 22041–3803.
- *Electronic submission:* Federal eRulemaking Portal at: *http://www.regulations.gov*. Follow the instructions for submitting comments to Docket No. FWS–R7–ES–2020–0132.

We will post all comments at *http://www.regulations.gov*. You may request that we withhold personal identifying information from public review; however, we cannot guarantee that we will be able to do so. See Request for Public Comments for more information.

FOR FURTHER INFORMATION CONTACT: Marine Mammals Management, U.S. Fish and Wildlife Service, MS–341, 1011 East Tudor Road, Anchorage, Alaska, 99503, by email at *R7mmmregulatory@fws.gov;* or by telephone at 1–800–362–5148. Persons who use a telecommunications device for the deaf (TDD) may call the Federal Relay Service (FRS) at 1–800–877–8339, 24 hours a day, 7 days a week.

SUPPLEMENTARY INFORMATION:

Background

Section 101(a)(5)(D) of the Marine Mammal Protection Act of 1972 (MMPA; 16 U.S.C. 1361, *et seq.*), authorizes the Secretary of the Interior (Secretary) to allow, upon request, the incidental but not intentional taking of small numbers of marine mammals of a species or population stock by U.S. citizens who engage in a specified activity (other than commercial fishing) within a specified region during a period of not more than one year. Incidental take may be authorized only if statutory and regulatory procedures are followed and the U.S. Fish and Wildlife Service (hereafter, "the Service" or "we") makes the following findings: (i) Take is of a small number of marine mammals of a species or population stock, (ii) take will have a negligible impact on the species or stock, and (iii) take will not have an unmitigable adverse impact on the availability of the species or stock for subsistence uses by coastal-dwelling Alaska Natives.

The term "take," as defined by the MMPA, means to harass, hunt, capture, or kill, or to attempt to harass, hunt, capture, or kill any marine mammal (16 U.S.C. 1362(13)). Harassment, as defined by the MMPA, means any act of pursuit, torment, or annoyance that (i) has the potential to injure a marine mammal or marine mammal stock in the wild (the MMPA defines this as "Level A harassment"), or (ii) 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 (the MMPA defines this as "Level B harassment").

The terms "negligible impact," "small numbers," and "unmitigable adverse impact" are defined in the Code of Federal Regulations at 50 CFR 18.27, the Service's regulations governing take of small numbers of marine mammals incidental to specified activities. "Negligible impact" is defined as an impact resulting from the specified activity that cannot be reasonably expected to and is not reasonably likely to adversely affect the species or stock through effects on annual rates of recruitment or survival. "Small numbers" is defined as a portion of a marine mammal species or stock whose taking would have a negligible impact on that species or stock. However, we do not rely on that definition, as it conflates the terms "small numbers" and "negligible impact," which we recognize as two separate and distinct requirements (see *Natural Res. Def. Council, Inc.* v. *Evans*, 232 F. Supp. 2d 1003, 1025 (N.D. Cal. 2003)). Instead, in our small numbers determination, we evaluate whether the number of marine mammals likely to be taken is small relative to the size of the overall population. "Unmitigable adverse impact" is defined as an impact resulting from the specified activity (1) that is likely to reduce the availability of the species to a level insufficient for a harvest to meet subsistence needs by (i) causing the marine mammals to abandon or avoid hunting areas, (ii) directly displacing subsistence users, or (iii) placing physical barriers between the marine mammals and the subsistence hunters; and (2) that cannot be sufficiently mitigated by other measures to increase the availability of marine mammals to allow subsistence needs to be met.

If the requisite findings are made, we will issue an Incidental Harassment Authorization (IHA), which sets forth the following: (i) Permissible methods of taking; (ii) other means of effecting the least practicable impact on marine mammals and their habitat, paying particular attention to rookeries, mating grounds, and areas of similar significance, and on the availability of marine mammals for taking for subsistence uses by coastal-dwelling Alaska Natives; and (iii) requirements for monitoring and reporting take.

Summary of Request

On December 2, 2019, the National Science Foundation and Lamont-Doherty Earth Observatory (hereafter

"NSF/L–DEO" or "the applicant") submitted a request to the Service's Marine Mammals Management Office (MMM) for authorization to take by Level B harassment a small number of northern sea otters (*Enhydra lutris kenyoni*, hereafter "sea otters" or "otters" unless another species is specified) from the Southeast Alaska stock. NSF/L–DEO expects that take by unintentional harassment may occur during their planned high-energy marine seismic surveys at the Queen Charlotte Fault (QCF) in the Northeast Pacific Ocean within the U.S. Exclusive Economic Zone (EEZ).

Description of Specified Activities and Geographic Region

The specified activity (the "project") consists of Lamont-Doherty Earth Observatory's (L–DEO) 2021 Marine Geophysical Surveys by the Research Vessel (R/V) *Marcus G. Langseth* (Langseth) of the QCF in the Northeast Pacific Ocean from July 1, 2021, to August 31, 2021. High-energy two-dimensional (2–D) seismic surveys will be used to characterize crustal and uppermost mantle velocity structure, fault zone architecture and rheology, and seismicity of the QCF. The 2–D seismic surveys will be conducted along transect lines within the area of 52–57° N and 131–137° W (Figure 1). Some deviation in actual transects, including order of survey operations, could be necessary due to poor data quality, inclement weather, or mechanical issues with the research vessel or equipment. The surveys are proposed to occur within the EEZs of the United States and Canada, including U.S. Federal Waters, State of Alaska Waters, and Canadian Territorial Waters ranging from 50 to 2,800 meters (m; 164 to 9,186 feet (ft)) in depth. The Service cannot and is not authorizing the incidental take of marine mammals in waters not under the jurisdiction of the United States. Therefore, the Service's calculation of estimated incidental take is limited to the specified activity occurring in United States jurisdictional waters within the stock's range. The proposed surveys are anticipated to last for 36 days, including approximately 27 days of seismic operations, approximately 2 days of transit to and from the survey area, 3 days for equipment deployment/recovery, and 4 days of contingency. The R/V *Langseth* will likely leave out of and return to the port of Ketchikan, AK, during summer 2021.

The R/V *Langseth* will tow 4 strings containing an array of 36 airguns at a depth of 12 m (39 ft), creating a discharge volume of approximately 0.11 cubic meter (m^3; 6,600 cubic inches (in^3)). The peak sound pressure 1 m (3.2 ft) from the center of the airgun array is 258.6 decibels (Tolstoy *et al.* 2009). Noise levels herein are given in decibels (dB) referenced to 1 μPa (dB re: 1 μPa) for underwater sound. All dB levels are dB_{RMS} (root-mean-squared dB level) unless otherwise noted; dB_{RMS} refers to the square root of the average of the squared sound pressure level typically measured over 1 second. Other important metrics include the sound exposure level (SEL; represented as dB re: 1 μPa^2-s), which represents the total energy contained within a pulse and considers both intensity and duration of exposure, and the peak sound pressure (also referred to as the zero-to-peak sound pressure or 0–p). Peak sound pressure is the maximum instantaneous sound pressure measurable in the water at a specified distance from the source and is represented in the same units as the dB_{RMS} sound pressure. See Richardson *et al.* (1995), Götz *et al.* (2009), Hopp *et al.* (2012), Navy (2014), for descriptions of acoustical terms and measurement units in the context of ecological impact assessment.

The seismic array produces broadband energy that ranges from a few hertz (Hz) to kilohertz (kHz). However, all but a small fraction of the energy is focused in the 10–300 Hz range (Tolstoy *et al.* 2009). The survey will also include the use of a single 655-cubic-centimeter (cm^3; 40-in^3) airgun that will be used when the full array is powered down.

The receiving system will consist of a 15-kilometer (km; 9.3-mile (mi)) hydrophone streamer and approximately 60 short-period and 28 broadband Ocean Bottom Seismometer (OBS) devices, which will be primarily deployed from a second vessel, the Canadian Coast Guard R/V *John P. Tully* (however, R/V *Langseth* may also deploy OBSs). The OBSs will be deployed at approximately 10-km (6.2-mi) intervals with 5-km (3.1 mi) spacing over the central 40 km (25 mi) of the fault zone. The OBSs have a height and diameter of 1 m (3.2 ft) and an 80-kilogram (176-pound) anchor.

Additional project details may be reviewed in the application materials available as described under **ADDRESSES** or may also be requested as described under **FOR FURTHER INFORMATION CONTACT**.

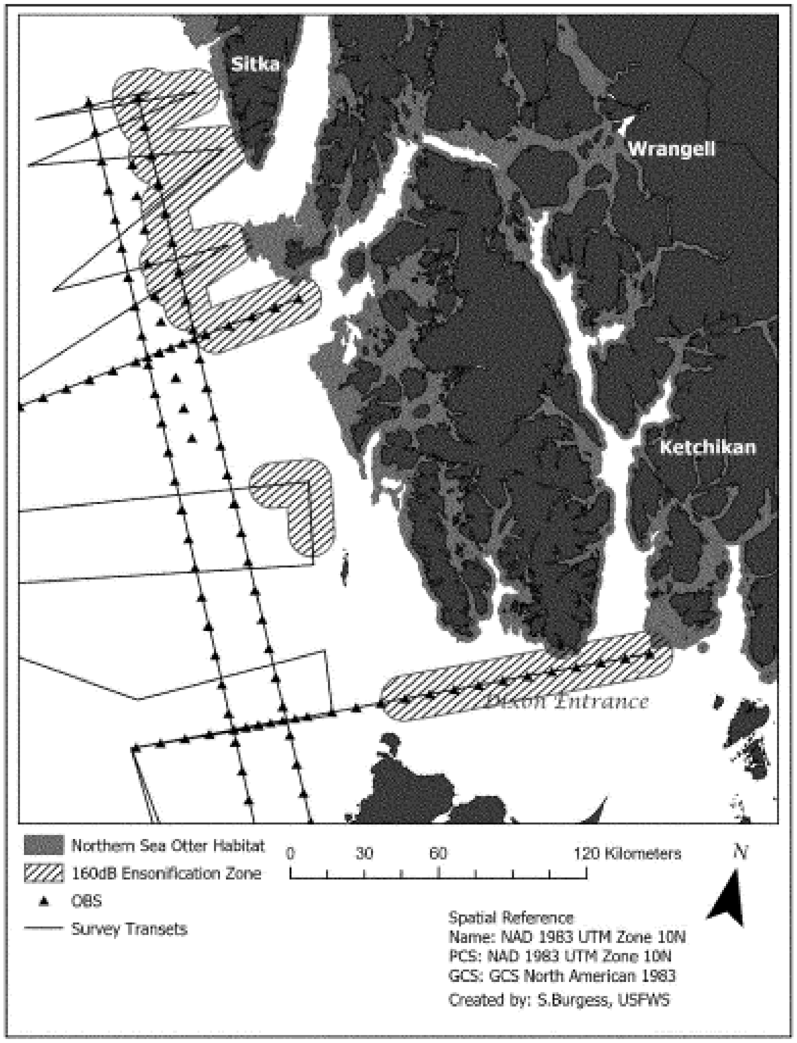

Figure 1. Specified geographic area for the National Science Foundation and Lamont-Doherty Earth Observatory seismic survey planned for summer 2021.

Description of Marine Mammals in the Specified Activity Area

The northern sea otter is the only marine mammal under the Service's jurisdiction that normally occupies the Northeast Pacific Ocean. Sea otters in Alaska are represented by three stocks. Those in the Northeast Pacific Ocean belong to the Southeast Alaska stock. Two other stocks occur in Southcentral and Southwest Alaska. Detailed information about the biology of the Southeast Alaska stock can be found in the most recent stock assessment report (USFWS 2014), which can be found at: *https://www.fws.gov/r7/fisheries/mmm/stock/Revised_April_2014_Southeast_Alaska_Sea_Otter_SAR.pdf.*

Sea otters may be distributed anywhere within the specified project area other than upland areas; however, they generally occur in shallow water near the shoreline. They are most commonly observed within the 40-m (131-ft) depth contour (USFWS 2014), although they can be found in areas with deeper water. Ocean depth is

30616 **Federal Register** / Vol. 86, No. 109 / Wednesday, June 9, 2021 / Notices

generally correlated with distance to shore, and sea otters typically remain within 1 to 2 km (0.62 to 1.24 mi) of shore (Riedman and Estes 1990). They tend to be found closer to shore during storms, but they venture farther out during good weather and calm seas (Lensink 1962; Kenyon 1969). In the 14 aerial surveys conducted from 1995 to 2012 in Southeast Alaska, 95 percent of otters were found in areas shallower than 40 m (131 ft) (Tinker *et al.* 2019). Areas important to mating for the Southeast Alaska stock include marine coastal regions containing adequate food resources within the 40-m (131-ft) depth contour.

The most recent estimate of the number of sea otters in the Southeast Alaska stock is 25,584 otters (standard error = 3,679; Tinker *et al.* 2019). The estimate was developed using a Bayesian hierarchical modeling framework based on survey and harvest count data. The survey data comprised results from 14 aerial surveys conducted in Southeast Alaska from 1995 to 2012, totaling more than 20,000 km (12,427 mi) of aerial transects. The Service conducted large-scale surveys in cooperation with the U.S. Geological Survey in 2003 and 2010 in southern Southeast Alaska (from Kake to Duke Island and Cape Chacon) and in 2002 and 2011 in northern Southeast Alaska (from Icy Point to Cape Ommaney). In these aerial surveys, transects were flown over high-density otter habitat (<40-m (131-ft) ocean depth) with a spacing of 2 km (1.2 mi) between transects and low-density otter habitat (40- to 100-m (131- to 328-ft) ocean depth) with a spacing of 8 km (5 mi) between transects.

Otter densities within the Southeast Alaska stock have been calculated for 24 subdivisions (Tinker *et al.* 2019). The density of otters in the affected subdivisions ranged from 0.175 to 1.333 otters per km². Distribution of the population during the proposed project is likely to be similar to that detected during sea otter surveys, as work will occur during the same time of the year that these surveys were conducted.

The documented home range sizes and movement patterns of sea otters illustrate the types of movements that could be seen among otters responding to the proposed activities. Sea otters are non-migratory and generally do not disperse over long distances (Garshelis and Garshelis 1984). They usually remain within a few kilometers of their established feeding grounds (Kenyon 1981). Breeding males stay for all or part of the year in a breeding territory covering up to 1 km (0.62 mi) of coastline while adult females have home ranges of approximately 8 to 16 km (5 to 10 mi), which may include one or more male territories. Juveniles move greater distances between resting and foraging areas (Lensink 1962; Kenyon 1969; Riedman and Estes 1990; Estes and Tinker 1996). Although sea otters generally remain local to an area, they are capable of long-distance travel. Otters in Alaska have shown daily movement distances greater than 3 km (1.9 mi) at speeds up to 5.5 km per hour (km/hr; 3.4 mi per hour (mi/h)) (Garshelis and Garshelis 1984).

Potential Effects of the Specified Activities

Exposure of Sea Otters to Noise

We do not expect the operations outlined in the Description of Specified Activities and Geographic Region and described in the applicant's petition to lead to take from vessel presence or anthropogenic presence. The tracklines for the vessels will not physically enter low-density or high-density sea otter habitat. Thus, we do not anticipate human–otter interactions that would lead to Level B harassment or other forms of take.

The operations have the potential to result in take of sea otters by harassment from noise. Here, we characterize "noise" as sound released into the environment from human activities that exceeds ambient levels or interferes with normal sound production or reception by sea otters. The terms "acoustic disturbance" or "acoustic harassment" are disturbances or harassment events resulting from noise exposure. Potential effects of noise exposure are likely to depend on the distance of the otter from the sound source and the level of sound the otter receives. Temporary disturbance or localized displacement reactions are the most likely to occur. No lethal take is anticipated, nor can the Service authorize lethal take through an Incidental Take Authorization. Therefore, none will be authorized.

Whether a specific noise source will affect a sea otter depends on several factors, including the distance between the animal and the sound source, the sound intensity, background noise levels, the noise frequency, the noise duration, and whether the noise is pulsed or continuous. The actual noise level perceived by individual sea otters will depend on distance to the source, whether the animal is above or below water, atmospheric and environmental conditions as well as aspects of the noise emitted.

From the discussion below, we expect the actual number of otters experiencing Level B take due to harassment by noise to be 27 or fewer. While individual otters may be taken more than once, the total number of incidental takes of sea otters is expected to be less than 49.

Sea Otter Hearing

The NSF/L–DEO's 36-airgun array will produce sound frequencies that fall within the hearing range of sea otters and will be audible to animals. Controlled sound exposure trials on southern sea otters (*E. l. nereis*) indicate that otters can hear frequencies between 125 Hz and 38 kHz with best sensitivity between 1.2 and 27 kHz (Ghoul and Reichmuth 2014). Aerial and underwater audiograms for a captive adult male southern sea otter in the presence of ambient noise suggest the sea otter's hearing was less sensitive to high-frequency (greater than 22 kHz) and low-frequency (less than 2 kHz) sound than terrestrial mustelids but was similar to that of a California sea lion (*Zalophus californianus*). However, the subject otter was still able to hear low-frequency sounds, and the detection thresholds for sounds between 0.125–1 kHz were between 116–101 dB, respectively. Dominant frequencies of southern sea otter vocalizations are between 3 and 8 kHz, with some energy extending above 60 kHz (McShane *et al.* 1995; Ghoul and Reichmuth 2012).

Exposure to high levels of sound may cause changes in behavior, masking of communications, temporary or permanent changes in hearing sensitivity, discomfort, and injury to marine mammals. Unlike other marine mammals, sea otters do not rely on sound to orient themselves, locate prey, or communicate underwater; therefore, masking of communications by anthropogenic sound is less of a concern than for other marine mammals. However, sea otters do use sound for communication in air (especially mothers and pups; McShane *et al.* 1995) and may avoid predators by monitoring underwater sound (Davis *et al.* 1987).

Thresholds have been developed for some marine mammals above which exposure is likely to cause behavioral disturbance and injuries (Southall *et al.* 2007; Finneran and Jenkins 2012; NMFS 2016). However, species-specific criteria for sea otters has not been identified. Because sea otter hearing abilities and sensitivities have not been fully evaluated, we relied on the most similar proxy to evaluate the potential effects of noise exposure.

California sea lions (otariid pinnipeds) have a frequency range of hearing most similar to that of southern sea otters (Ghoul and Reichmuth 2014) and provide the closest related proxy for which data are available. Sea otters and pinnipeds share a common mammalian aural physiology (Echteler *et al.* 1994; Solntseva 2007). Both are adapted to amphibious hearing, and both use sound in the same way (primarily for in-air communication rather than feeding).

Exposure Thresholds

The National Marine Fisheries Service (NMFS) established noise exposure criteria for identifying underwater noise levels capable of causing Level A harassment (injury) of otariid pinnipeds (NMFS 2018). Sea otter-specific criteria have not been determined. However, because of their biological similarities, we assume that NMFS' noise exposure criteria for otariid pinniped injury is a suitable surrogate for sea otter impacts. Those criteria are based on estimated levels of sound exposure capable of causing a permanent shift in sensitivity of hearing (*e.g.*, a permanent threshold shift (PTS) (NMFS 2018)). A PTS occurs when noise exposure causes hairs within the inner ear system to die.

The NMFS (2018) criteria for sound exposure incorporate two metrics of exposure: The peak level of instantaneous exposure likely to cause PTS, and the cumulative sound exposure level during a 24-hour period (SELcum). They also include weighting adjustments for the sensitivity of different species to varying frequencies. The PTS-based injury criteria were developed from theoretical extrapolation of observations of temporary threshold shifts (TTS) detected in lab settings during sound exposure trials. Studies were summarized by Finneran (2015). For otariid pinnipeds, PTS is predicted to occur at 232 dB peak or 203 dB SEL_{cum} for impulsive sound, or 219 dB SEL_{cum} for non-impulsive (continuous) sound.

The NMFS criteria for take by Level A harassment represents the best available information for predicting injury from exposure to underwater sound among pinnipeds, and in the absence of data specific to otters, we assume these criteria also represent appropriate exposure limits for Level A take of sea otters.

The NMFS (2018) criteria do not identify thresholds for avoidance of Level B take. For pinnipeds, the NMFS has adopted a 160-dB threshold for Level B take from exposure to impulse noise and a 120-dB threshold for continuous noise (NMFS 1998; HESS 1999; NMFS undated). These thresholds were developed from observations of mysticete (baleen) whales responding to airgun operations (*e.g.*, Malme *et al.* 1983a, b; Richardson *et al.* 1986, 1995) and from equating Level B take with noise levels capable of causing TTS in lab settings.

We have evaluated these thresholds and determined that the Level B threshold of 120-dB for non-impulsive noise is not applicable to sea otters. The 120-dB threshold is based on studies conducted by Malme *et al.* in the 1980s, during which gray whales (*Eschrichtius robustus*) were exposed to experimental playbacks of industrial noise. Gray whales are in the group of marine mammals believed to be most sensitive to low-frequency sounds, with an estimated audible frequency range of approximately 10 Hz to 30 kHz (Finneran 2015). During the study, conducted at St. Lawrence Island, Alaska, Malme *et al.* (1988) observed the behavioral responses of gray whales to the playback of drillship noise and concluded that "exposure to levels of 120 dB or more would probably cause avoidance of the area by more than one-half of the gray whales." Sea otters do not usually occur at St. Lawrence Island, Alaska, but similar playback studies conducted off the coast of California (Malme 1983a, 1984) included a southern sea otter monitoring component (Riedman 1983, 1984). While the 1983 and 1984 studies detected probabilities of avoidance in gray whales comparable to those reported in Malme *et al.* (1988), there was no evidence of disturbance reactions or avoidance in southern sea otters. Thus, given the different range of frequencies to which sea otters and gray whales are sensitive, the NMFS 120-dB threshold based on gray whale behavior is not appropriate for predicting sea otter behavioral responses, particularly for low-frequency sound.

Although no specific thresholds have been developed for sea otters, several alternative behavioral response thresholds have been developed for pinnipeds. Southall *et al.* (2007, 2019) assessed behavioral response studies and found considerable variability among pinnipeds. The authors determined that exposures between approximately 90 to 140 dB generally do not appear to induce strong behavioral responses in pinnipeds in water. However, they found behavioral effects, including avoidance, become more likely in the range between 120 to 160 dB, and most marine mammals showed some, albeit variable, responses to sound between 140 to 180 dB. Wood *et al.* (2012) later adapted the approach identified in Southall *et al.* (2007) to develop a probabilistic scale for marine mammal taxa at which 10 percent, 50 percent, and 90 percent of individuals exposed are assumed to produce a behavioral response. For many marine mammals, including pinnipeds, these response rates were set at sound pressure levels of 140, 160, and 180 dB, respectively.

Based on the lack of sea otter disturbance response or any other reaction to the 1980's playback studies and the absence of a clear pattern of disturbance or avoidance behaviors attributable to underwater sound levels up to about 160 dB resulting from low-frequency broadband noise, we assume 120 dB is not an appropriate behavioral response threshold for sea otters exposed to continuous underwater noise.

Thresholds based on TTS have been used as a proxy for Level B harassment (*i.e.*, 70 FR 1871, January 11, 2005; 71 FR 3260, January 20, 2006; and 73 FR 41318, July 18, 2008). Southall *et al.* (2007) derived TTS thresholds for pinnipeds based on 212 dB peak and 171 dB SEL_{cum}. Exposures resulting in TTS in pinnipeds were found to range from 152 to 174 dB (183 to 206 dB SEL) (Kastak *et al.* 2005), with a persistent TTS, if not a PTS, after 60 seconds of 184 dB SEL (Kastak *et al.* 2008). Kastelein *et al.* (2012) found small but statistically significant TTSs at approximately 170 dB SEL (136 dB, 60 minutes (min)) and 178 dB SEL (148 dB, 15 min). Finneran (2015) summarized these and other studies, and the NMFS (2018) has used the data to develop TTS threshold for otariid pinnipeds of 188 dB SEL_{cum} for impulsive sounds and 199 dB SEL_{cum} for non-impulsive sounds.

Exposure to impulsive sound levels greater than 160 dB can elicit behavioral changes in marine mammals that may lead to detrimental disruption of normal behavioral routines. Thus, using information available for other marine mammals as a surrogate and taking into consideration the best available scientific information about sea otters, the Service has set 160 dB of received underwater sound as a threshold for Level B take by disturbance for sea otters for this proposed IHA based on the work of Ghoul and Reichmuth (2012a, b), McShane *et al.* (1995), NOAA (2005), Riedman (1983), Richardson *et al.* (1995), and others. Exposure to unmitigated in-water noise levels between 125 Hz and 38 kHz that are greater than 160 dB—for both impulsive and non-impulsive sound sources—will be considered by the Service as Level B take; thresholds for potentially injurious Level A take will be 232 dB peak or 203 dB SEL for impulsive sounds and 219 dB SEL for continuous sounds (Table 1).

The area in which underwater noise in the frequency range of sea otter hearing will exceed thresholds is termed the "zone of ensonification." The ensonification zone in which noise levels exceed thresholds for Level A harassment is often referred to as the Level A harassment zone. The Level B harassment zone likewise includes areas ensonified to thresholds for Level B harassment of sea otters and extends from the sound source to the 160-dB isopleth.

TABLE 1—SUMMARY OF THRESHOLDS FOR PREDICTING LEVEL A AND LEVEL B TAKE OF NORTHERN SEA OTTERS FROM UNDERWATER SOUND EXPOSURE IN THE FREQUENCY RANGE 125 HZ–38 KHZ

Marine mammals	Injury (Level A) threshold		Disturbance (Level B) threshold
	Impulsive [1]	Non-impulsive [1]	All
Sea otters	232 dB peak; 203 dB SEL_{CUM}	219 dB SEL_{CUM} [2]	160 dB_{RMS}.

[1] Based on National Marine Fisheries Service acoustic exposure criteria for take of otariid pinnipeds (NMFS 2018).
[2] SEL_{CUM} = cumulative sound exposure level.

Evidence From Sea Otter Studies

The available studies of sea otter behavior suggest that sea otters may be more resistant to the effects of sound disturbance and human activities than other marine mammals. For example, at Soberanes Point, California, Riedman (1983) examined changes in the behavior, density, and distribution of southern sea otters that were exposed to recorded noises associated with oil and gas activity. The underwater sound sources were played at a level of 110 dB and a frequency range of 50 Hz to 20 kHz and included production platform activity, drillship, helicopter, and semi-submersible sounds. Riedman (1983) also observed the sea otters during seismic airgun shots fired at decreasing distances from the nearshore environment (50, 20, 8, 3.8, 3, 1, and 0.5 nautical miles (nm)) at a firing rate of 4 shots per minute and a maximum air volume of 4,070 in³. Riedman (1983) observed no changes in the presence, density, or behavior of sea otters as a result of underwater sounds from recordings or airguns, even at the closest distance of 0.5 nm (<1 km or 0.6 mi). However, otters did display slight reactions to airborne engine noise. Riedman (1983, 1984) also monitored the behavior of sea otters along the California coast while they were exposed to a single 1,638-cm³ (100-in³) airgun and a 67,006-cm³ (4,089-in³) airgun array. Sea otters did not respond noticeably to the single airgun, and no disturbance reactions were evident when the airgun array was as close as 0.9 km (0.6 mi).

While at the surface, turbulence from wind and waves attenuates noise more quickly than in deeper water, reducing potential noise exposure (Greene and Richardson 1988; Richardson *et al.* 1995). Additionally, turbulence at the water's surface limits the transference of sound from water to air. A sea otter with its head above water will be exposed to only a small fraction of the sound energy travelling through the water beneath it. The average time spent above the water each day resting and grooming varies between male and female sea otters and seasonally. Esslinger et al. (2014) found in the summer months (*i.e.,* the season when the proposed action will take place), female otters foraged for an average of 8.78 hours per day, while male otters foraged for an average of 7.85 hours per day. Male and female sea otters spent an average of 63 to 67 percent of their summer days at the surface resting and grooming. The amount of total time spent at the surface may help limit sea otters' exposure during noise-generating operations.

Sea otters generally show a high degree of tolerance to noise. In another study using prerecorded sounds, Davis *et al.* (1988) exposed both northern sea otters in Simpson Bay, Alaska, and southern sea otters in Morro Bay, California, to a variety of airborne and underwater sounds, including a warble tone, sea otter pup calls, killer whale calls, air horns, and an underwater noise harassment system designed to drive marine mammals away from crude oil spills. The sounds were projected at a variety of frequencies, decibel levels, and intervals. The authors noted that certain noises could cause a startle response and result in movement away from a noise source. However, the effects were limited in range (no responses were observed for otters approximately 100–200 m (328–656 ft) from the source of the stimuli), and otters stopped moving away as a result of the stimuli within hours or, at most, 3 to 4 days.

In locations that lack frequent human activity, sea otters appear to have a lower threshold for outward signs of disturbance. Sea otters in Alaska have exhibited escape behaviors in response to the presence and approach of vessels. Behaviors included diving or actively swimming away from a boat, hauled-out sea otters entering the water, and groups of sea otters disbanding and swimming in multiple different directions (Udevitz *et al.* 1995). Sea otters in Alaska have also been shown to avoid areas with heavy boat traffic but return to those same areas during seasons with less traffic (Garshelis and Garshelis 1984). In Cook Inlet, otters drifting on a tide trajectory that would have taken them within 500 m (0.3 mi) of an active offshore drilling rig tended to swim to change their angle of drift to avoid a close approach despite near-ambient noise levels from the work (BlueCrest 2013).

Individual sea otters in Southeast Alaska will likely show a range of responses to noise from NSF/L–DEO's survey equipment and vessels. Some otters will likely show startle responses, change direction of travel, diving, or premature surfacing. Sea otters reacting to survey activities may divert time and attention from biologically important behaviors, such as feeding. Some animals may abandon the survey area and return when the disturbance has ceased. Based on the observed movement patterns of wild sea otters (*i.e.,* Lensink 1962; Kenyon 1969, 1981; Garshelis and Garshelis 1984; Riedman and Estes 1990; Estes and Tinker 1996), we expect some individuals, independent juveniles, for example, will respond to NSF/L–DEO's proposed survey by dispersing to areas of suitable habitat nearby, while others, especially breeding-age adult males, will not be displaced by vessels.

Consequences of Disturbance

The reactions of wildlife to disturbance can range from short-term behavioral changes to long-term impacts that affect survival and reproduction. When disturbed by noise, animals may respond behaviorally (*e.g.,* escape response) or physiologically (*e.g.,* increased heart rate, hormonal response) (Harms *et al.* 1997; Tempel and

Gutierrez 2003). The energy expense and associated physiological effects could ultimately lead to reduced survival and reproduction (Gill and Sutherland 2000; Frid and Dill 2002). For example, South American sea lions (*Otaria byronia*) visited by tourists exhibited an increase in the state of alertness and a decrease in maternal attendance and resting time on land, thereby potentially reducing population size (Pavez *et al.* 2015). In another example, killer whales (*Orcinus orca*) that lost feeding opportunities due to boat traffic faced a substantial (18 percent) estimated decrease in energy intake (Williams *et al.* 2006). Such disturbance effects can have population-level consequences. Increased disturbance rates have been associated with a decline in abundance of bottlenose dolphins (*Tursiops* sp.; Bejder *et al.* 2006; Lusseau *et al.* 2006).

These examples illustrate direct effects on survival and reproductive success, but disturbances can also have indirect effects. Response to noise disturbance is considered a nonlethal stimulus that is similar to an antipredator response (Frid and Dill 2002). Sea otters are susceptible to predation, particularly from killer whales and eagles, and have a well-developed antipredator response to perceived threats. For example, the presence of a harbor seal (Phoca vitulina) did not appear to disturb sea otters, but they demonstrated a fear response in the presence of a California sea lion by actively looking above and beneath the water (Limbaugh 1961).

Although an increase in vigilance or a flight response is nonlethal, a tradeoff occurs between risk avoidance and energy conservation. An animal's reactions to noise disturbance may cause stress and direct an animal's energy away from fitness-enhancing activities such as feeding and mating (Frid and Dill 2002; Goudie and Jones 2004). For example, southern sea otters in areas with heavy recreational boat traffic demonstrated changes in behavioral time budgeting showing decreased time resting and changes in haul-out patterns and distribution (Benham *et al.* 2005; Maldini *et al.* 2012). Chronic stress can also lead to weakened reflexes, lowered learning responses (Welch and Welch 1970; van Polanen Petel *et al.* 2006), compromised immune function, decreased body weight, and abnormal thyroid function (Seyle 1979).

Changes in behavior resulting from anthropogenic disturbance can include increased agonistic interactions between individuals or temporary or permanent abandonment of an area (Barton *et al.* 1998). The intensity of disturbance (Cevasco *et al.* 2001), the extent of previous exposure to humans (Holcomb *et al.* 2009), the type of disturbance (Andersen *et al.* 2012), and the age or sex of the individuals (Shaughnessy *et al.* 2008; Holcomb *et al.* 2009) may influence the type and extent of response.

Effects on Habitat and Prey

Physical and biological features of habitat essential to the conservation of sea otters include the benthic invertebrates (urchins, mussels, clams, etc.) that otters eat and the shallow rocky areas and kelp beds that provide cover from predators. Important sea otter habitat in the NSF/L–DEO project area include coastal areas within the 40-m (131-ft) depth contour where high densities of otters have been detected. The MMPA allows the Service to identify avoidance and minimization measures for effecting the least practicable impact of the specified activity on important habitats. Geophysical surveys conducted by NSF/L–DEO may impact sea otters within this important habitat, however, the project is not likely to cause lasting effects to habitat.

The primary prey species for sea otters are sea urchins, abalone, clams, mussels, crabs, and squid (Tinker and Estes 1999). When preferential prey are scarce, otters will also eat kelp, turban snails (Tegula spp.), octopuses (*e.g.,* Octopus spp.), barnacles (Balanus spp.), sea stars (*e.g., Pycnopodia helianthoides),* scallops (*e.g., Patinopecten caurinus),* rock oysters (Saccostrea spp.), worms *(e.g.,* Eudistylia spp.), and chitons (*e.g.,* Mopalia spp.) (Riedman and Estes 1990). A shift to less-preferred prey species may result in more energy spent foraging or processing the prey items; however, the impacts of a change in energy expenditure is not likely seen at the population level (Newsome *et al.* 2015).

Several recent reviews and empirical studies have addressed the effects of noise on invertebrates (Carroll *et al.* 2017). Behavioral changes, such as an increase in lobster (*Homarus americanus*) feeding levels (Payne *et al.* 2007), an increase in wild-caught captive reef squid (*Sepioteuthis australis*) avoidance behavior (Fewtrell and McCauley 2012), and deeper digging by razor clams (*Sinonovacula constricta;* Peng *et al.* 2016) have been observed following experimental exposures to sound. Physical changes have also been seen in response to increased sound levels, including changes in serum biochemistry and hepatopancreatic cells in a lobster species (*H. americanus;* Payne *et al.* 2007) and long-term damage to the statocysts required for hearing in several cephalopod species (Andre *et al.* 2011; Sole *et al.* 2013).

The effects of increased sound levels on benthic invertebrate larvae have been mixed. Desoto *et al.* (2013) found impaired embryonic development in scallop (*Pecten novaezelandiae*) larvae when exposed to 160 dB. Christian *et al.* (2004) noted a reduction in the speed of egg development of bottom-dwelling crabs following exposure to noise; however, the sound level (221 dB at 2 m or 6.6 ft) was far higher than the proposed seismic array will produce.

While these studies provide evidence of deleterious effects to invertebrates as a result of increased sound levels, Carroll *et al.* (2017) caution that there is a wide disparity between results obtained in field and laboratory settings. In experimental settings, changes were observed only when animals were housed in enclosed tanks and many were exposed to prolonged bouts of continuous, pure tones. We would not expect similar results in open marine conditions. It is unlikely that noises generated by survey activities will have any lasting effect on sea otter prey given the short-term duration of sounds produced by each component of the proposed work.

Potential Impacts on Subsistence Uses

The proposed activities will occur near marine subsistence harvest areas used by Alaska Natives from the villages of Pelican, Sitka, and Port Alexander. Between 1989 and 2019, approximately 5,617 sea otters were harvested from these villages, averaging 187 per year (although numbers from 2019 are preliminary). The large majority (95 percent) were taken by hunters based in Sitka. However, harvest activity takes place in coves where the sounds produced by survey equipment will not harass sea otters.

The proposed project area will not occur in inshore waters and, therefore, will avoid significant overlap with subsistence harvest areas. NSF/L–DEO's activities will not preclude access to hunting areas or interfere in any way with individuals wishing to hunt. NSF/L–DEO will coordinate with Native villages and Tribal organizations to identify and avoid potential conflicts. If any conflicts are identified, NSF/L–DEO will develop a Plan of Cooperation (POC) specifying the particular steps necessary to minimize any effects the project may have on subsistence harvest.

Mitigation and Monitoring

If an IHA for the NSF/L–DEO project is issued, it must specify means for affecting the least practicable adverse impact on sea otters and their habitat, paying particular attention to rookeries, mating grounds, and areas of similar significance and the availability of sea otters for subsistence uses by coastal-dwelling Alaska Natives.

In evaluating what mitigation measures are appropriate to ensure the least practicable adverse impact on species or stocks and their habitat, as well as subsistence uses, we considered the manner and degree to which the successful implementation of the measures are expected to achieve this goal. We considered the nature of the potential adverse impact being mitigated (likelihood, scope, range), the likelihood that the measures will be effective if implemented, and the likelihood of effective implementation. We also considered the practicability of the measures for applicant implementation (*e.g.*, cost, impact on operations).

To reduce the potential for disturbance from acoustic stimuli associated with the activities, the applicants have proposed mitigation measures including, but not limited to, the following:

• Development of a marine mammal monitoring and mitigation plan;
• Establishment of shutdown and monitoring zones;
• Visual mitigation monitoring by designated Protected Species Observers (PSO);
• Site clearance before startup;
• Soft-start procedures;
• Shutdown procedures; and
• Vessel strike avoidance measures.

These measures are further specified under Proposed Authorization, part *B. Avoidance and Minimization*. The Service has not identified any additional mitigation or monitoring measures not already incorporated into NSF's request that are practicable and would further reduce potential impacts to sea otters and their habitat.

Estimated Incidental Take

Characterizing Take by Level B Harassment

In the previous section, we discussed the components of the project activities that have the potential to affect sea otters. Here, we describe and categorize the physiological and behavioral effects that can be expected based on documented responses to human activities observed during sea otter studies. We also discuss how these behaviors are characterized under the MMPA.

As we described in *Evidence from Sea Otter Studies*, an individual sea otter's reaction to human activity will depend on the otter's prior exposure to the activity, the potential benefit that may be realized by the individual from its current location, its physiological status, or other intrinsic factors. The location, timing, frequency, intensity, and duration of the encounter are among the external factors that will also influence the animal's response. Intermediate reactions that disrupt biologically significant behaviors are considered Level B harassment under the MMPA. The Service has identified the following sea otter behaviors as indicating possible Level B take:

• Swimming away at a fast pace on belly (*i.e.*, porpoising);
• Repeatedly raising the head vertically above the water to get a better view (spyhopping) while apparently agitated or while swimming away;
• In the case of a pup, repeatedly spyhopping while hiding behind and holding onto its mother's head;
• Abandoning prey or feeding area;
• Ceasing to nurse and/or rest (applies to dependent pups);
• Ceasing to rest (applies to independent animals);
• Ceasing to use movement corridors;
• Ceasing mating behaviors;
• Shifting/jostling/agitation in a raft so that the raft disperses;
• Sudden diving of an entire raft; or
• Flushing animals off a haulout.

This list is not meant to encompass all possible behaviors; other situations may also indicate Level B take.

Reactions capable of causing injury are characterized as Level A harassment events. The proposed action is not anticipated to result in Level A harassment due to exposure of otters to noise capable of causing PTS. However, it is also important to note that, depending on the duration and severity of the above-described Level B behaviors, such responses could constitute take by Level A harassment. For example, while a single flushing event would likely indicate Level B harassment, repeatedly flushing sea otters from a haulout may constitute Level A harassment.

Calculating Take

We assumed all animals exposed to underwater sound levels that meet the acoustic exposure criteria shown in Table 1 will experience, at a minimum, take by Level B harassment due to exposure to underwater noise. To estimate the number of otters that may be exposed to these sound levels, we worked closely with the applicant to create spatially explicit zones of ensonification around the proposed survey transects based on expected sound source levels and attenuation models. We determined the number of otters present in the ensonification zones using density information generated by Tinker *et al.* (2019) for the subgroups that comprise the Southeast Alaska stock.

Zones of Level A and Level B ensonification were created using the proposed R/V *Langseth* transects along the Southeast Alaskan coast. We developed sound level isopleths through acoustic modeling by NSF/L–DEO for deep water and an analysis of empirical data collected in a 2012 survey by the R/V *Langseth* along the Cascadia Margin in coastal Washington (Crone *et al.* 2014) for intermediate and shallow waters. The 2012 survey in Cascadia was conducted using a 4-string 0.11-m^3 (6,600-in^3) airgun array at a tow depth of 9 m (29.5 ft), while the proposed activities in Southeast Alaska will use a 0.11-m^3 (6,600-in^3) airgun array at a tow depth of 12 m (39 ft). To account for this difference, the applicant used a scaling factor (see the application available as described under ADDRESSES for details). The largest resulting Level A isopleth calculated from the NSF/L–DEO modeling (where sound levels will be greater than 232 dB peak) encompassed areas up to 10.6 m (34.7 ft) from the sound source. The Level B isopleth (where sound levels will be between 160–231 dB) was based on empirical data and encompassed areas up to 12.65 km (7.9 mi) from the sound source when the R/V *Langseth* was in shallow water (<100 m or 328 ft ocean depth) and up to 9.2 km (5.7 mi) when the vessel was in intermediate depths (100–1,000 m or 328–3,280 ft ocean depth).

The Level A and Level B isopleths were then used to create spatially explicit ensonification zones surrounding the proposed project transects using ArcGIS Pro (2018). Using the *proximity* toolset in ArcGIS Pro, we created a buffer with a 45-m (148-ft) width around the proposed project transects to account for the Level A ensonified area on either side of the 24 m-wide (79 ft-wide) airgun array. To determine the Level B ensonified area, points were first placed along the proposed project transects every 500 m (0.3 mi). We then used bathymetry data to determine ocean depth at each point along the transect. We placed a 12.65-km (7.9-mi) buffer around points in water less than 100 m (328 ft) deep, and a 9.2-km (5.7-mi) buffer around points in water 100–1,000 m (328–3,280 ft) deep. The resulting ocean depth-informed ensonification zone was then modified to remove "land shadows" (marine areas behind land features). To do this, we created lines representing ensonification that radiated from each point along the proposed project transects. Lines were then clipped with a landform shapefile to identify areas where underwater sound will be absorbed by land features.

As we described in Description of Marine Mammals in the Specified Area, sea otters are overwhelmingly observed (95 percent) within the 40-m (131-ft) depth contour, although they can be found in areas with deeper water. Thus, high-density sea otter habitat was delineated by the 40-m (131-ft) depth contour, and low-density otter habitat was between the 40-m and 100-m (131-ft to 328-ft) depth contours. Habitat was further divided into subregions established by Tinker *et al.* (2019) as densities of otters in these subregions differed. Otter densities for the affected subregions were determined using 2012 abundance estimates generated using the Bayesian hierarchical model developed by Tinker *et al.* (2019). Abundance estimates are traditionally generated using aerial survey data from high-density habitat (<40 m or 131 ft in depth). To calculate the density of otters in low-density habitat (40–100 m or 131–328 ft ocean depth), we multiplied the density of the adjacent high-density habitat by 0.05. The resulting density estimate accounts for the five percent of otters found in low-density areas.

The Level A ensonification zone did not overlap with either high- or low-density habitat areas. To determine the amount (km^2) of Level B ensonified habitat in each subregion, the high- and low-density habitat shapefiles were clipped using the Level B ensonification shapefiles in ArcGIS Pro. The area impacted in each subregion was multiplied by the estimated otter density in that region to determine the number of otters that will experience Level B sound levels (Table 2). The total number of takes was predicted by estimating the projected days of activity in each subregion using survey start points supplied by the applicant. In several areas, the length and direction of the proposed survey transects make it highly unlikely that impacts will last only one day. In these instances, we estimated two days of disturbance, and thus two takes for each otter.

TABLE 2—ESTIMATED NUMBER OF OTTERS ENSONIFIED BY SOUND LEVELS GREATER THAN 160 dB DUE TO THE PROPOSED ACTIVITIES

[Level B take was calculated by multiplying the area ensonified in each subregion by that subregion's modeled sea otter density, then multiplying by the projected days of ensonification]

Subreg.	Habitat type	Density (otters/km^2)	Area impacted (km^2)	Estimated take/day	Projected days of take	Estimated survey total takes
N06	High (<40 m)	0.778	4.66	4	1	4
S05	High (<40 m)	1.333	8.74	12	2	24
S12	High (<40 m)	0.1748	2.56	1	2	2
N06	Low (40–100 m)	0.034	15.69	1	1	1
S01	Low (40–100 m)	0.064	42.31	4	2	8
S05	Low (40–100 m)	0.123	31.32	4	2	8
S12	Low (40–100 m)	0.0092	647.62	1	2	2
Total				27		49
Current Stock Total.		25,584				
Percentage of Stock.				0.001		

Critical Assumptions

We estimate 49 takes of 27 sea otters by Level B harassment will occur due to NSF/L–DEO's proposed high-energy seismic surveys. In order to conduct this analysis and estimate the potential amount of Level B take, several critical assumptions were made.

Otter density was calculated using a Bayesian hierarchical model created by Tinker *et al.* (2019), which includes assumptions that can be found in the original publication. The most recently available density estimates and those used for our analysis were for the year 2012. Low-density otter populations exhibit a growth rate that is typically directly related to resource availability, with growth rates slowing as the populations approach carrying capacity (Estes 1990). The populations in Southeast Alaska vary in their densities and estimated carrying capacities (Tinker *et al.* 2019), making it difficult to predict current density values. Thus, we relied on 2012 density estimates to calculate projected take. One subregion within the impact area, S12, was not included in the Tinker *et al.* (2019) published densities. To calculate otter density in this subregion, we used the 2012 aerial survey data that served as the model's primary input. Thus, the S12 density estimate does not benefit from the additional information included in the Bayesian model provided by Tinker *et al.* (2019).

Estimation of ensonification zones used sound attenuation models that focused on absorption and dispersion rather than reflection and refraction. Our models assumed that points of land intercepting high-level noise will effectively attenuate sound levels above 160 dB, and sea otters in areas behind those land features (in land shadows) will be exposed to sound less than 160 dB. This assumption is adequate for this analysis given the offshore location of the survey transects.

Finally, we estimated the repeated take of a portion of the otters affected by the proposed action due to the presence of the R/V *Langseth* for more than one day. We assume, due to the proposed survey transects, start points, and speed of the R/V *Langseth*, that otters within subregions S01, S05, and S12 will be ensonified for two days each. The applicant has listed a number of potential yet unanticipated reasons the R/V *Langseth* may remain in one area for an extended period of time, including poor data quality, inclement weather, or mechanical issues with the research vessel and/or equipment. However, except for the case of a reshoot due to poor data quality, the vessel's airgun array (*i.e.*, the source of

30622 Federal Register / Vol. 86, No. 109 / Wednesday, June 9, 2021 / Notices

take) will not be operational during extended delays of operations.

We estimate 49 instances of take by Level B harassment of 27 northern sea otters from the Southeast Alaska stock due to behavioral responses or TTS associated with noise exposure. These levels represent a small proportion of the most recent stock abundance estimate for the Southeast Alaska stock. Take of 27 otters is less than one percent of the best available estimate of the current population size of 25,584 animals in the Southeast Alaska stock (Tinker *et al.* 2019) (27÷25,584=0.00105). Although an estimated 49 instances of take of 27 otters by Level B harassment are possible, most events are unlikely to have significant consequences for the health, reproduction, or survival of affected animals.

Sea otters exposed to sound project-produced sounds are likely to respond with temporary behavioral modification or displacement. Project activities could temporarily interrupt the feeding, resting, and movement of sea otters. Because activities will occur during a limited amount of time and in a localized region, the impacts associated with the project are likewise temporary and localized. The anticipated effects are primarily short-term behavioral reactions and displacement of sea otters near active operations.

Sea otters that encounter the specified activity may exert more energy than they would otherwise due to temporary cessation of feeding, increased vigilance, and retreat from the project area. We expect that affected sea otters will tolerate this exertion without measurable effects on health or reproduction. Most of the anticipated takes will be due to short-term Level B harassment in the form of TTS, startling reactions, or temporary displacement. Chronic exposure to sound levels that cause TTS may lead to PTS (which would constitute Level A injury). While more research into the relationship between chronic noise exposure and PTS is needed (Finneran 2015), it is likely that the transition from temporary effects to permanent cellular damage occurs over weeks, months, or years (Southall *et al* 2019).

With the adoption of the measures proposed in NSF/L–DEO's application and required by this proposed IHA, estimated take was reduced.

Findings

Small Numbers

For small numbers analyses, the statute and legislative history do not expressly require a specific type of numerical analysis, leaving the determination of "small" to the agency's discretion. In this case, we propose a finding that the NSF/L–DEO project may result in approximately 49 incidental takes of 27 otters from the Southeast Alaska stock. This represents less than one percent of the estimated stock. Predicted levels of take were determined based on estimated density of sea otters in the project area and an ensonification zone developed using empirical evidence from a similar geographic area and corrected for the methodology proposed by NSF/L–DEO for this project. Based on these numbers, we propose a finding that the NSF/L–DEO project will take only a small number of animals.

Negligible Impact

We propose a finding that any incidental take by harassment resulting from the proposed project cannot be reasonably expected to, and is not reasonably likely to, adversely affect the sea otter through effects on annual rates of recruitment or survival and will, therefore, have no more than a negligible impact on the Southeast Alaska stock of northern sea otters. In making this finding, we considered the best available scientific information, including: The biological and behavioral characteristics of the species, the most recent information on species distribution and abundance within the area of the specified activities, the current and expected future status of the stock (including existing and foreseeable human and natural stressors), the potential sources of disturbance caused by the project, and the potential responses of marine mammals to this disturbance. In addition, we reviewed applicant provided materials, information in our files and datasets, published reference materials, and species experts.

Sea otters are likely to respond to proposed activities with temporary behavioral modification or displacement. These reactions are unlikely to have consequences for the long-term health, reproduction, or survival of affected animals. Most animals will respond to disturbance by moving away from the source, which may cause temporary interruption of foraging, resting, or other natural behaviors. Affected animals are expected to resume normal behaviors soon after exposure with no lasting consequences. Twenty-one otters are estimated to be exposed to seismic noise for two days and thus, will have repeated exposure. However, permanent (*i.e.*, Level A) injury due to chronic sound exposure is estimated to occur at the scale of weeks, months, or years (Southall *et al.* 2019). Some animals may exhibit more severe responses typical of Level B harassment, such as fleeing, ceasing feeding, or flushing from a haul-out. These responses could have temporary, yet significant, biological impacts for affected individuals but are unlikely to result in measurable changes in survival or reproduction.

The total number of animals affected and severity of impact is not sufficient to change the current population dynamics at the stock scale. Although the specified activities may result in approximately 49 incidental takes of 27 otters from the Southeast Alaska stock, we do not expect this level of harassment to affect annual rates of recruitment or survival or result in adverse effects on the stock.

Our proposed finding of negligible impact applies to incidental take associated with the proposed activities as mitigated by the avoidance and minimization measures identified in NSF/L–DEO's mitigation and monitoring plan. These mitigation measures are designed to minimize interactions with and impacts to sea otters. These measures and the monitoring and reporting procedures are required for the validity of our finding and are a necessary component of the proposed IHA. For these reasons, we propose a finding that the 2021 NSF/L–DEO project will have a negligible impact on the Southeast Alaska stock of northern sea otters.

Impact on Subsistence

We propose a finding that NSF/L–DEO's anticipated harassment will not have an unmitigable adverse impact on the availability of the Southeast Alaska stock of northern sea otters for taking for subsistence uses. In making this finding, we considered the timing and location of the proposed activities and the timing and location of subsistence harvest activities in the area of the proposed project. We also considered the applicant's consultation with subsistence communities, proposed measures for avoiding impacts to subsistence harvest, and commitment to development of a POC, should any concerns be identified.

Required Determinations

National Environmental Policy Act (NEPA)

Per the National Environmental Policy Act (NEPA; 42 U.S.C. 4321, *et seq.*), the Service must evaluate the effects of the proposed action on the human environment. We plan to adopt

Federal Register / Vol. 86, No. 109 / Wednesday, June 9, 2021 / Notices 30623

NSF's environmental assessment (EA), as we have preliminarily concluded that, as written, the draft EA contains adequate information analyzing the effects on the human environment of issuing the IHA. NSF's EA is available at *https://www.nsf.gov/geo/oce/envcomp/*. If the Service determines that impacts from issuing the IHA would not significantly affect the human environment, we may prepare a Finding of No Significant Impact that would conclude the Service's NEPA process.

We will review all comments submitted in response to this notice as indicated above in **DATES** and **ADDRESSES** prior to concluding our NEPA process or making a final decision on the IHA.

Endangered Species Act (ESA)

Under the ESA, all Federal agencies are required to ensure the actions they authorize are not likely to jeopardize the continued existence of any threatened or endangered species or result in destruction or adverse modification of critical habitat. The proposed activities will occur entirely within the range of the Southeast Alaska stock of the northern sea otter, which is not listed as threatened or endangered under the ESA. The measures included in the proposed IHA will not affect other listed species or designated critical habitat.

Government-to-Government Coordination

It is our responsibility to communicate and work directly on a Government-to-Government basis with federally recognized Tribes in developing programs for healthy ecosystems. We are also required to consult with Alaska Native Corporations. We seek their full and meaningful participation in evaluating and addressing conservation concerns for protected species. It is our goal to remain sensitive to Alaska Native culture and to make information available to Alaska Natives. Our efforts are guided by the following policies and directives:

(1) The Native American Policy of the Service (January 20, 2016);

(2) the Alaska Native Relations Policy (currently in draft form);

(3) Executive Order 13175 (January 9, 2000);

(4) Department of the Interior Secretarial Orders 3206 (June 5, 1997), 3225 (January 19, 2001), 3317 (December 1, 2011), and 3342 (October 21, 2016); and

(5) the Department of the Interior's policies on consultation with Tribes and with Alaska Native Corporations.

We have evaluated possible effects of the proposed activities on federally recognized Alaska Native Tribes and organizations. Through the IHA process identified in the MMPA, the applicant has presented a communication process, culminating in a POC if needed, with the Native organizations and communities most likely to be affected by their work. NSF/L–DEO has engaged these groups in informational meetings. We invite continued discussion, either about the project and its impacts or about our coordination and information exchange throughout the IHA/POC process.

Proposed Authorization

We propose to authorize up to 49 incidental takes of 27 Northern sea otters from the Southeast Alaska stock. We authorize take limited to disruption of behavioral patterns that may be caused by geophysical surveys and support activities conducted by NSF/L–DEO in Southeast Alaska, from July 1 to August 31, 2021. We anticipate no take by injury or death to northern sea otters resulting from these surveys.

A. General Conditions for Issuance of the Proposed IHA

1. The taking of Northern sea otters from the Southeast Alaska stock whenever the required conditions, mitigation, monitoring, and reporting measures are not fully implemented as required by the IHA will be prohibited. Failure to follow measures specified may result in the suspension or revocation of the IHA.

2. If take exceeds the level or type identified in the proposed authorization (*e.g.*, greater than 49 incidents of incidental take of 27 otters by Level B harassment), the IHA will be invalidated and the Service will reevaluate its findings. If project activities cause unauthorized take, such as any injury due to seismic noise, acute distress, or any indication of the separation of mother from pup, NSF/L–DEO must take the following actions: (i) Cease its activities immediately (or reduce activities to the minimum level necessary to maintain safety); (ii) report the details of the incident to the Service's MMM within 48 hours; and (iii) suspend further activities until the Service has reviewed the circumstances, determined whether additional mitigation measures are necessary to avoid further unauthorized taking, and notified NSF/L–DEO that it may resume project activities.

3. All operations managers and vessel operators must receive a copy of the IHA and maintain access to it for reference at all times during project work. These personnel must understand, be fully aware of, and be capable of implementing the conditions of the IHA at all times during project work.

4. The IHA will apply to activities associated with the proposed project as described in this document and in NSF/L–DEO's amended application (LGL 2020). Changes to the proposed project without prior authorization may invalidate the IHA.

5. NSF/L–DEO's IHA application will be approved and fully incorporated into the IHA, unless exceptions are specifically noted herein or in the final IHA. The application includes:

- NSF/L–DEO's original request for an IHA, dated December 19, 2019;
- NSF/L–DEO's response to requests for additional information from the Service, dated January 22, February 19, and February 26, 2020; and
- A revised application, dated October 29, 2020.

6. Operators will allow Service personnel or the Service's designated representative to visit project work sites to monitor impacts to sea otters and subsistence uses of sea otters at any time throughout project activities so long as it is safe to do so. "Operators" are all personnel operating under the NSF/L–DEO's authority, including all contractors and subcontractors.

B. Avoidance and Minimization

7. Seismic surveys must be conducted using equipment that generates the lowest practicable levels of underwater sound within the range of frequencies audible to sea otters.

8. Vessels will not approach within 100 m (328 ft) of individual sea otters or 500 m (0.3 mi) of rafts of otters. Operators will reduce vessel speed if a sea otter approaches or surfaces within 100 m (328 ft) of a vessel.

9. Vessels may not be operated in such a way as to separate members of a group of sea otters from other members of the group.

10. All vessels must avoid areas of active or anticipated subsistence hunting for sea otters as determined through community consultations.

C. Mitigation During Seismic Activities

11. Designated trained and qualified PSOs must be employed to monitor for the presence of sea otters, initiate mitigation measures, and monitor, record, and report the effects of the activities on sea otters. NSF/L–DEO is responsible for providing training to PSOs to carry out mitigation and monitoring.

12. NSF/L–DEO must establish mitigation zones for their 2D seismic

30624 **Federal Register** / Vol. 86, No. 109 / Wednesday, June 9, 2021 / Notices

surveys, which generate underwater sound levels at or more than or 160 dB between 125 Hz and 38 kHz. Mitigation zones must include all in-water areas where work-related sound received by sea otters will match the levels and frequencies above. Mitigation zones will be designated as follows:

• Exclusion Zones (EZ) will be established with the following minimum radii: 500 m (0.3 mi) from the source for the full seismic array and 100 m (328 ft) for the single bolt airgun (655 cm^3 or 40 in^3).

• A Safety Zone (SZ) is an area larger than the EZ and will include all areas within which sea otters may be exposed to noise levels that will likely result in Level B take.

• Both the EZ and SZ will be centered on the sound source (the seismic array).

• The radius of the SZs are shown in Table 3 (as calculated based on modeling techniques described herein and in Appendix A of NSF/L–DEO's application).

TABLE 3—ESTIMATED RADIAL DISTANCES FROM THE SEISMIC SOUND SOURCE TO THE 160-dB ISOPLETH

[The area within the isopleth is designated as the Safety Zone (SZ)]

Source and volume	Water depth (m)	Predicted distances (in m) to the 160 dB received sound level
Single Bolt airgun, 40 in^3	>1,000 m	[1] 431
	100–1,000 m	[2] 647
	<100 m	[3] 1,041
	<1000 m	[1] 6,733
4 strings, 36 airguns, 6600 in^3	100–1,000m	[4] 9,468
	<100m	[4] 12,650

[1] Distance is based on L–DEO model results.
[2] Distance is based on L–DEO 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 the NSF/L–2012;DEO IHA application for details.

13. PSOs must conduct visual monitoring of the entire EZ and the visible SZ continuously during all seismic work occurring in daylight hours.

14. Prior to seismic work, a "ramp-up" procedure must be used to increase the levels of underwater sound at a gradual rate.

• A ramp-up will be used at the initial start of airgun operations and prior to restarting after any period greater than 30 minutes (min) without airgun operations, including a power-down or shutdown event.

• Visual monitoring must begin at least 30 min prior to and continue throughout ramp-up efforts.

• During geophysical work, the number and total volume of airguns will be increased incrementally until the full volume is achieved.

• The rate of ramp-up will be no more than 6 dB per 5-min period. Ramp-up will begin with the smallest gun in the array that is being used for all airgun array configurations. During the ramp-up, the applicable mitigation zones (based on type of airgun and sound levels produced) must be maintained.

• It will not be permissible to ramp-up the full array from a complete shutdown in thick fog or at other times when the outer part of the EZ is not visible.

• Ramp-up of the airguns will not be initiated if a sea otter is sighted within the EZ at any time.

• If sea otters are observed during a ramp-up effort or prior to startup, a PSO must record the observation and monitor the animal's position until it moves out of visual range. Seismic work may commence if, after a full and gradual effort to ramp up the underwater sound level, the sea otter is outside of the EZ and does not show signs of visible distress (for example, vocalizing, repeatedly spy-hopping, or fleeing).

15. The following actions must be taken in response to sea otters in mitigation zones:

• Seismic work will be shut down completely if a sea otter is observed within the 500-m (0.3-mi) EZ for the full array or the 100-m (328-ft) EZ for the 40-cui array.

• When sea otters are observed in visible distress (for example, vocalizing, repeatedly spy-hopping, or fleeing), seismic work must be immediately shut down or powered down to reduce noise exposure.

• The shutdown procedure will be accomplished within several seconds of the determination that a sea otter is in the applicable EZ or as soon as practicable considering worker safety and equipment integrity.

• Following a shutdown, seismic work will not resume until the sea otter has cleared the EZ. The animal will be considered to have cleared the EZ if it is visually observed to have left the EZ or has not been seen within the EZ for 30 minutes or longer.

• Any shutdown due to sea otters sighted within the EZ must be followed by a 30-minute all-clear period and then a standard full ramp-up.

• Any shutdown for other reasons resulting in the cessation of seismic work for a period greater than 30 minutes must also be followed by full ramp-up procedures.

16. Operators may reduce power to seismic equipment as an alternative to a shutdown to prevent a sea otter from entering the EZ. A power-down procedure involves reducing the volume of underwater sound generated. Vessel speed or course may be altered to achieve the same task.

• Whenever a sea otter is detected outside the EZ and, based on its position and motion relative to the seismic work, appears likely to enter the EZ but has not yet done so, the operator may power down to reduce high-level noise exposure.

• When a sea otter is detected in the SZ, an operator may choose to power down when practicable to reduce Level B take, but is not required to do so.

• During a power-down, the number of airguns in use will be reduced to a single mitigation airgun (airgun of small volume such as the 655-cm^3 (40-in^3) gun), such that the EZ is reduced, making the sea otters unlikely to enter the EZ.

• After a power-down, noise-generating work will not resume until the sea otter has cleared the EZ for the full airgun array. The animal will be considered to have cleared the EZ if it is visually observed to have left the EZ and has not been seen within the zone for 30 minutes.

17. Visual monitoring must continue for 30 minutes after the use of the acoustic source ceases or the sun sets, whichever is later.

D. Monitoring

18. Operators shall work with PSOs to apply mitigation measures and shall recognize the authority of PSOs up to and including stopping work, except where doing so poses a significant safety risk to vessels and personnel.

19. Duties of PSOs include watching for and identifying sea otters, recording observation details, documenting presence in any applicable monitoring zone, identifying and documenting potential harassment, and working with vessel operators to implement all appropriate mitigation measures.

20. A sufficient number of PSOs will be onboard to meet the following criteria: 100 percent monitoring coverage during all daytime periods of seismic activity; a maximum of four consecutive hours on watch per PSO; a maximum of approximately 12 hours on watch per day per PSO; and at least one observer each on the source vessel and support vessel.

21. All PSOs will complete a training course designed to familiarize individuals with monitoring and data collection procedures. A field crew leader with prior experience as a marine mammal observer will supervise the PSO team. New or inexperienced PSOs will be paired with experienced PSOs so that the quality of marine mammal observations and data recording is kept consistent. Resumes for candidate PSOs will be made available for the Service to review.

22. Observers will be provided with reticule binoculars (10×42), big-eye binoculars or spotting scopes (30×), inclinometers, and range finders. Field guides, instructional handbooks, maps and a contact list will also be made available.

E. Measures To Reduce Impacts to Subsistence Users

23. Prior to conducting the work, NSF/L–DEO will take the following steps to reduce potential effects on subsistence harvest of sea otters:

• Avoid work in areas of known sea otter subsistence harvest;
• Discuss the planned activities with subsistence stakeholders including Southeast Alaska villages and traditional councils;
• Identify and work to resolve concerns of stakeholders regarding the project's effects on subsistence hunting of sea otters; and
• If any concerns remain, develop a POC in consultation with the Service and subsistence stakeholders to address these concerns.

F. Reporting Requirements

24. NSF/L–DEO must notify the Service at least 48 hours prior to commencement of activities.

25. Reports will be submitted to the Service's MMM weekly during project activities. The reports will summarize project work and monitoring efforts.

26. A final report will be submitted to the Service's MMM within 90 days after completion of work or expiration of the IHA. It will summarize all monitoring efforts and observations, describe all project activities, and discuss any additional work yet to be done. Factors influencing visibility and detectability of marine mammals (*e.g.*, sea state, number of observers, fog, and glare) will be discussed. The report will describe changes in sea otter behavior resulting from project activities and any specific behaviors of interest. Sea otter observation records will be provided in the form of electronic database or spreadsheet files. The report will assess any effects NSF/–DEO's operations may have had on the availability of sea otters for subsistence harvest and if applicable, evaluate the effectiveness of the POC for preventing impacts to subsistence users of sea otters.

27. Injured, dead, or distressed sea otters that are not associated with project activities (*e.g.*, animals found outside the project area, previously wounded animals, or carcasses with moderate to advanced decomposition or scavenger damage) must be reported to the Service within 24 hours of discovery. Photographs, video, location information, or any other available documentation shall be provided to the Service.

28. All reports shall be submitted by email to *fw7_mmm_reports@fws.gov*.

29. NSF/L–DEO must notify the Service upon project completion or end of the work season.

Request for Public Comments

If you wish to comment on this proposed authorization, the applicability of NSF's draft EA to the proposed action, or the proposed adoption of NSF's EA, you may submit your comments by any of the methods described in **ADDRESSES**. Please identify if you are commenting on the proposed authorization, draft EA, or both, make your comments as specific as possible, confine them to issues pertinent to the proposed authorization or draft EA, and explain the reason for any changes you recommend. Where possible, your comments should reference the specific section or paragraph that you are addressing. The Service will consider all comments that are received before the close of the comment period (see **DATES**).

Comments, including names and street addresses of respondents, will become part of the administrative record for this proposal. Before including your address, telephone number, email address, or other personal identifying information in your comment, be advised that your entire comment, including your personal identifying information, may be made publicly available at any time. While you can ask us in your comments to withhold from public review your personal identifying information, we cannot guarantee that we will be able to do so.

Gregory Siekaniec,
Regional Director, Alaska Region.

[FR Doc. 2021–12134 Filed 6–8–21; 8:45 am]
BILLING CODE 4333–15–P

DEPARTMENT OF THE INTERIOR

Geological Survey

[GX21EE000101100]

Public Meeting of the National Geospatial Advisory Committee

AGENCY: U.S. Geological Survey, Interior.

ACTION: Notice of public meeting.

SUMMARY: In accordance with the Federal Advisory Committee Act of 1972, the U.S. Geological Survey (USGS) is publishing this notice to announce that a Federal Advisory Committee meeting of the National Geospatial Advisory Committee (NGAC) will take place.

DATES: The meeting will be held as a webinar on Tuesday, June 29, 2021 from 1:00 p.m. to 5:00 p.m., and on Wednesday, June 30, 2021 from 1:00 p.m. to 5:00 p.m. (Eastern Daylight Time).

ADDRESSES: The meeting will be held on-line and via teleconference. Instructions for accessing the meeting will be posted at *www.fgdc.gov/ngac*. Comments can be sent to Ms. Dionne Duncan-Hughes, Group Federal Officer by email to *gs-faca-mail@usgs.gov*.

FOR FURTHER INFORMATION CONTACT: Mr. John Mahoney, Federal Geographic Data Committee (FGDC), USGS, 909 First Avenue, Suite 800, Seattle, WA 98104; by email at *jmahoney@usgs.gov*; or by telephone at (206) 220–4621.

APPENDIX G: EFH

APPENDIX G: EFH

From: "John V. Olson - NOAA Federal" <john.v.olson@noaa.gov>
Date: Wednesday, June 2, 2021 at 1:04 PM
To: "Smith, Holly E." <hesmith@nsf.gov>
Subject: Re: [EXTERNAL] - Re: EFH Request - NSF marine geophysical survey in the Northeast Pacific Ocean, Queen Charlotte Fault

thank you Holly. The additional information was useful as we try to coordinate responses between marine mammal and EFH issues.

I have reviewed your updated EFH assessment and have no issues with the survey as documented.

John

--
John V. Olson
Fisheries Biologist, Habitat Conservation Division/Alaska Region
NOAA Fisheries | U.S. Department of Commerce
Office: (907) 271-1508
Mobile: (907) 830-5146
Teleworking 7:30-4:00
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Région du Pacifique
Gestion des ecosystems
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July 8, 2021

Your file *Votre référence*
NSF Queen Charlotte Fault Seismic Survey
Our file *Notre référence*
20-HPAC-01329

Sean Higgins
Director, Office of Marine Operations
Lamont-Doherty Earth Observatory (LDEO) of Columbia University
61 Route 9 West
Palisades, New York, USA 10964

Via email: sean@ldeo.columbia.edu

Dear Mr. Higgins:

Subject: National Science Foundation (NSF) Marine Seismic Survey of the Queen Charlotte Fault, July 12 – August 27, 2021

Fisheries and Oceans Canada (DFO) received your proposal on December 18, 2020. We understand that you propose to conduct high-energy seismic surveys from the Research Vessel (R/V) Marcus G. Langseth (Langseth) in combination with Ocean Bottom Seismometers (OBS) along the Queen Charlotte Fault in the Northeast Pacific Ocean off the west coast of Haida Gwaii during summer 2021. In particular:

- The proposed two-dimensional (2-D) seismic surveys will occur over an estimated 27 days within the Exclusive Economic Zone (EEZ) of Canada and Canadian Territorial Waters.
- The R/V Langseth will cruise at 7.8 km/h (4.2 kt) and deploy a 36-airgun towed array (12 m depth: 50, 130 or 150 m shot interval) with a total discharge volume of ~6600 in^3 in water depths ranging from 50–2800 m.
- The array will have a sound output equivalent to 250 dB RMS (root mean square) re: 1 µPa which is above the sound pressure level (160 dB RMS re: 1 µPa) that can result in the temporary threshold shift in the hearing of marine mammals.
- The receiving system will consist of a 15 km long hydrophone streamer.
- In addition to the operation of the towed array and hydrophone streamer, the R/V Langseth will operate a multibeam echosounder, a sub-bottom profiler and an acoustic Doppler current profiler continuously during the seismic survey.

We understand a number of aquatic species listed under the *Species at Risk Act* (SARA) may use the area in the vicinity of where your proposed activities are to be carried out. These listed

Canada

species include three distinct types of Killer Whales classified as threatened: Northern Resident Killer Whales, Offshore Killer Whales, and Transient Killer Whales.

Our review considered the following information:

- DFO Request for Review form dated December 16, 2020; and
- Draft *Environmental Assessment/Analysis (EA/A) of a Marine Geophysical Survey by R/V Marcus G Langseth of the Queen Charlotte Fault in the Northeast Pacific Ocean, Summer 2021* dated December 16, 2019, prepared by LGL Ltd (King City, Ontario).

Your proposal has been reviewed to determine whether it is likely to result in:

- the death of fish by means other than fishing and the harmful alteration, disruption or destruction of fish habitat which are prohibited under subsections 34.4(1) and 35(1) of the *Fisheries Act*; and
- effects to listed aquatic species at risk, any part of their critical habitat or the residences of their individuals in a manner which is prohibited under subsection 32(1), section 33 and subsection 58(1) of the *Species at Risk Act*.

The aforementioned outcomes are prohibited unless authorized under their respective legislation and regulations.

DFO's review of the information provided indicates that there are a number of both listed and non-listed aquatic SARA species that are likely to be present or in the vicinity of the proposed seismic survey, as mentioned above. As such, DFO recommends that avoidance of sensitive habitats and SARA-listed species be undertaken. However, given the nature of the proposed activities, such as the extent, location and timing of activities, avoidance measures may not always be possible. For example, using observers to avoid encounters with marine mammals may not always be effective given the limitations of observing animals during certain conditions, such as storms with Beaufort sea states > 3 and the proposed night-time operations. Killer Whales (all ecotypes: resident, transient, offshore) are known to have a strong behavioural reaction to intense mid-frequency noise and are currently facing threats to their survival and recovery from multiple factors including anthropogenic sound. Impacts on a small number of individuals can have serious population-level consequences if population numbers and /or the reproduction rate is low, as is the case of Northern Resident, Offshore and Transient Killer Whales. In addition, the activities will occur in the vicinity of designated critical habitat of Northern Resident Killer Whales. Although the generation of noise intrinsic to the survey methodology may cause a short term disruption of marine mammal communication, if individuals are present; physical injury or harm/harassment is not anticipated. Generated noise is expected to trigger avoidance behaviour by both marine mammals and fish species as the R/V Langseth moves forward along the survey tracks at slow speed (7.8 km/h or 4.2 kt).

In addition, DFO notes the following:

- Other marine mammal species, in addition to those SARA-listed species, may be found in the proposed survey area at all times of the year, and some are particularly sensitive to anthropogenic noise, such as the Sperm Whale and three species of Beaked Whales.
- Small cetacean species (i.e., dolphins and porpoises) are ubiquitous in the area of the planned activities and may be encountered at any time of the year.
- Impacts on a few individual animals of the following species may have serious

population-level consequences if population abundance is low. In this regard, the Blue Whale, Sei Whale, Killer Whale (all ecotypes), North Pacific Right Whale, and Grey Whales from the Pacific Coast Feeding Group (two new populations classified as Endangered by the Committee on the Status of Endangered Wildlife in Canada, and under consideration for listing under SARA as Endangered: Pacific Coast Feeding Group, and Western Pacific) are at greater risk of long-term negative impacts because of their low population numbers.

- Due to the specifics of sound propagation in shallow (<100 m) versus deep water (>100m) there is a considerable risk of harm to all cetaceans in shallow waters from seismic survey sources, but specifically from low frequency and mid-frequency sources of noise. There is additional risk of harm to species such as the Blue Whale and Sei Whale at medium and deeper water depths.

The submitted EA/A report describes the monitoring and mitigation measures that the proponent proposes to undertake during the seismic survey. These measures are generally consistent with current standards including those outlined in the *Statement of Canadian Practice with Respect to the Mitigation of Seismic Sound in the Marine Environment* (SCP attached). However, given that mitigation measures outlined in the SCP are intended as minimum requirements and considering the large size of the airgun array to be employed and the likely presence of SARA-listed species, it is imperative that additional mitigation measures be followed to reduce the risk to marine mammals.

Should the NSF proceed with the Queen Charlotte Fault Seismic Survey, DFO recommends that the NSF implement additional mitigation measures such that the activities will avoid or minimize impacts and adverse effects to SARA-listed individuals and populations and avoid the destruction of critical habitat. DFO also recommends implementing all reasonable alternatives to those activities that have an adverse effect.

To avoid causing the death of fish (including marine mammals) and/or the harmful alteration, disruption or destruction of fish habitat, or causing prohibited effects to aquatic species at risk, DFO recommends that the mitigation measures listed in the attached *Statement of Canadian Practice with Respect to the Mitigation of Seismic Sound in the Marine Environment* and the submitted EA/A document be implemented along with the following mitigation and avoidance measures.

The most stringent measure should be implemented where relevant:

- Conduct seismic survey activities outside of designated Northern Resident Killer Whale Critical Habitat (KWCH) with a setback that ensures that the estimated sound pressure level has diminished to ≤160 dB RMS re: 1 μPa for the shortest distance to the boundary of KWCH.
- Initiate an immediate and complete shutdown of the airgun array if a Killer Whale (all ecotypes), Northern Pacific Right Whale, whale with calf (any species) or aggregation of whales (any species) is observed.
- Initiate an immediate and complete shutdown of the airgun array if a Sperm Whale or a beaked whale (any species) is sighted within 1500 m of the airgun array.
- For other observations of marine mammals and/or turtles, initiate an immediate and complete shutdown of the airgun array if these animals are observed within an established exclusion zone with a radius of 1000 m.

- Avoid conducting seismic surveys within the following conservation areas: Gwaii Haanas National Marine Conservation Area Reserve and Haida Heritage Site, Duu Guusd Heritage Site / Conservancy, and Daawuuxusda Heritage Site / Conservancy.
- Refrain from conducting seismic surveys in waters less than 100 m in depth.
- Conduct seismic surveys in waters 100 to 200 m deep during daylight hours only, with a second vessel having two marine mammal observers on watch, positioned 5 km ahead of the R/V Langseth.
- Combine enhanced visual observations (e.g., reticle and big-eye binoculars, night vision devices and digital cameras) with non-visual detection methods (e.g., infrared technology (FLIR) and passive acoustic monitoring) to increase the likelihood of detecting marine mammals during ramp up, Beaufort sea states >3, and during night time survey operations.
- Monitor the established exclusion zone with a radius of 1000 m for 60 minutes prior to initial start-up of the airgun array or resumption of operations following a complete shutdown to allow for the detection of deep diving animals.

It remains your responsibility to remain in compliance with the *Fisheries Act* (including the *Marine Mammal Regulations*) and the *Species at Risk Act.* It is also your Duty to Notify DFO if you have caused, or are about to cause, the death of fish (including marine mammals) by means other than fishing and/or the harmful alteration, disruption or destruction of fish habitat. Such notifications should be directed to the DFO-Pacific Observe, Record and Report phone line at 1-800-465-4336 or by email at DFO.ORR-ONS.MPO@dfo-mpo.gc.ca.

The protection of Killer Whales and other cetaceans is a priority for the Government of Canada. DFO and the Canadian Coast Guard (CCG) work with various stakeholders including the Province, First Nations, academia, and private industry partners to protect Killer Whales and other marine mammals in British Columbia. Sightings of marine mammals by research vessels, such as the R/V Langseth, are typically provided to the CCG's Marine Mammal Desk at 1-833-339-1020 or via CCG radio. The Marine Mammal Desk reports whale sightings in real time and advises vessel traffic by providing enhanced situational awareness of the activities of Killer Whales and other cetaceans, such as humpback and grey whales. Sighting information is used to prevent vessel strikes, entanglements and other threats facing marine mammals.

DFO recognizes that this is a multi-vessel survey and that proposed activities may be carried out by vessels that are not under the direction of NSF personnel. To reduce impacts, DFO recommends that all relevant Queen Charlotte Fault Seismic Survey participants be made aware of and implement the avoidance and mitigation measures listed above and in the attached document. Furthermore, DFO recommends that the NSF contact other Canadian federal authorities for advice on aspects of the survey that fall outside of DFO's expertise and mandate. It remains your responsibility to meet all other federal requirements that apply to your proposal.

Please note that the advice provided in this letter will remain valid for the period of the proposed activities. If you plan to execute your proposal after September 15, 2021, we recommend that you contact the Program to ensure that the advice remains up-to-date and accurate. Furthermore, the validity of the advice is also subject to there being no change in the relevant aquatic environment, including any legal protection orders or designations, during the period of activity.

If you have any questions with the content of this letter, please contact Steven Colwell at our Nanaimo office at 250 327-4763 or by email at Steven.Colwell@dfo-mpo.gc.ca. Please refer to the file number referenced above when corresponding with the Program.

Yours sincerely,

BRotinsky

Brenda Rotinsky
Watershed Operations Regulatory Manager
Fish and Fish Habitat Protection Program

Cc: Holly Smith, NSF, Alexandria, VA USA (hesmith@nsf.gov)

Attachment: *Statement of Canadian Practice with Respect to the Mitigation of Seismic Sound in the Marine Environment*

Statement of Canadian Practice with respect to the Mitigation of Seismic Sound in the Marine Environment

MARINE SEISMIC SURVEYS IN CANADA are conducted in the Atlantic, Pacific and Arctic oceans in waters with very diverse biological, oceanographic and geomorphic characteristics. In response to public concerns over the potential impacts of seismic surveys on marine life, federal and provincial authorities responsible for the review and assessments of proposed surveys agreed to develop a national code of conduct.

DEVELOPMENT PROCESS

1. National and international peers reviewed scientific evidence of potential physical, physiological and behavioural impacts associated with seismic survey, considering the direct, indirect, chronic or cumulative nature of those impacts.

2. Technical experts reviewed and identified best mitigation practices used world wide

3. Public review of the draft Statement was completed.

OUTCOME

Conclusions were drawn using a risk-based approach that considered the likelihood of occurrence, the frequency and duration of the mitigated impact, the recovery potential and the ecological significance or severity of the impact.

THE STATEMENT DOES NOT APPLY TO ICE COVERED WATERS, TO NON-ESTUARINE PORTIONS OF RIVERS OR TO LAKES.

During the Planning Phase the Statement sets out mitigation requirements that must be met:

EXERCISING PRECAUTION, operators must minimize the unnecessary introduction of sound and design survey which:

- use the minimum energy needed
- reduce horizontal spread
- reduce the generation of unnecessary high frequency sounds.

THE PEER REVIEW PROCESS CONCLUDED THAT AT CERTAIN RECEIVED SOUND LEVELS, BEHAVIOURAL CHANGES COULD BE MANIFESTED BY SOME MARINE FISH, MARINE MAMMALS AND SEA TURTLES. THE REVIEW ALSO RECOGNIZED THAT ADDITIONAL PRECAUTION WAS CALLED FOR TO ADDRESS THE NEEDS OF MARINE SPECIES LISTED AS ENDANGERED OR THREATENED AND THAT INDIVIDUAL LEVEL IMPACTS SHOULD THEREFORE BE MITIGATED.

Surveys must therefore be designed to avoid causing:

- a significant adverse effect for an individual marine mammal or sea turtle listed as endangered or threatened in the Canadian legislation to protect species at risk;
- a significant adverse population-level effect for any other marine species;

REDUCING THE IMPACT ON POPULATION

To reduce the potential impacts of the survey and to reflect the peer review conclusion that population-level impacts could result if surveys were conducted in areas and at times when large groups of marine mammals and fish were engaged in critical biological activity, surveys must be planned to avoid:

- displacing an individual endangered or threatened marine mammal or sea turtle breeding, feeding or nursing;
- diverting an individual endangered or threatened marine mammal or sea turtle from a known migration corridor;

Surveys must also be planned to avoid:

- dispersing large groups (aggregations) of spawning fish from know spawning areas
- displacing a group of breeding, feeding or nursing marine mammals, if it is known that there are no alternate areas available or if use of those areas will result in significant adverse effects.
- diverting large groups of fish or marine mammals from known migration routes if it is known that there are no alternate routes or that using those routes will result in significant adverse effects.

REGIONAL FLEXIBILITY

The diverse biological, oceanographic, geomorphic characteristics of the Atlantic, Pacific and Arctic oceans require that regional flexibility be built into the code of conduct for seismic operations. Environmental processes and the associated regulatory reviews may require additional or modified mitigation as required to address regional specificities, chronic or cumulative effects, variations in sound propagation levels, or other region or project specific conditions.

During field operations a number of mitigative measures are required during the conduct of the seismic survey.

THESE INCLUDE THE establishment and monitoring of a *Safety Zone*, which must at a minimum be 500m as measured from the center of the air source array.

SAFETY ZONE

The Statement recognizes that in certain circumstances, an environmental assessment process may identify the need for a safety zone greater than 500m. It further specifies that for 30 minutes prior to start up, the area must be clear of whale, dolphin, porpoise or sea turtles and that a regular watch maintained during the conduct of the survey.

Recognizing that many marine species appear to avoid seismic vessels when the air sources are active, seismic operators are required to start up the air source arrays with a pulse from the lowest energy source. The remainder of the sound sources on the array must be gradually activated over a fixed period of time.

SHUT DOWN

Survey activities must be suspended if an endangered or threatened marine mammal or sea turtle or if a marine mammal or sea turtle identified by an environmental assessment process as possibly subject to population-level impacts enters the safety zone. Air sources can be gradually ramped up when the animals have left the area.

LINE CHANGES AND MAINTENANCE

To futher reduce the amount of unnecessary sound entering the marine environment, operators are required to either shut down the energy source completely or shut down all but one source when active surveying ceases for example during line changes or for maintenance reasons.

LOW VISIBILITY

Reduced visibility due to shorten light periods, fog, storm conditions may limit the ability of the marine mammal observer to watch the full extent of the Safety zone. In situations of low visibility, the Statement calls for the use of alternate monitoring measures to detect the presence of cetaceans if the survey is in an area identified as critical habitat for an endangered or threatened vocalizing cetacean, or if the survey areas has been identified as an area where a species for which significant environmental impacts have been identified by an environmental process.

It is recognized that the field of cetacean detection technology is a rapidly evolving one and that there are limitations to the current technology particularly with respect to the location and identification of the vocal signature of the cetacean. Required use of cetacean detection technology is limited to areas where operators can expect the presence of endangered or threatened cetaceans or species for which special conditions have been identified through an environmental process. Precaution is called for and operators are directed to treat all non-identified cetacean vocalizations as those of endangered, threatened or species for which concern has been identified by the environmental process and to shut down until the area until no vocalizations have been detected for a fixed period of time.

THE STATEMENT OF PRACTICE IS REVIEWED ANNUALLY BY THE GOVERNMENTS. THE REVIEW ALLOWS FOR REVISIONS TO THE REQUIREMENTS BASED UPON NEW TECHNOLOGIES, SCIENCE FINDINGS, INNOVATIVE INDUSTRY PRACTICES AND DISCUSSION WITH OTHER GOVERNMENT REGULATORS.

Statement of Canadian Practice on the Mitigation of Seismic Noise in the Marine Environment

Released for discussion purposes February 19th, 2005

Seismic surveys in the marine environment are conducted by earth scientists and geophysicists to understand the structure and movement of the earth's crust and to detect and delineate potential commercial quantities of sub-sea oil and gas resources.

The potential for environmental impacts from seismic surveys on key components of the marine ecosystems has been recognized for some time.
In order to understand the state of scientific knowledge, DFO sponsored a peer review by Canadian and international science experts. Their objective was to develop scientific conclusions and advice on the potential impacts of seismic noise on marine fish, marine invertebrates, marine zooplankton, eggs and larvae of fish and invertebrates, marine turtles and marine mammals. A copy of the peer-reviewed report, entitled "Review of Scientific Information on Impacts of Seismic Sound on Fish, Invertebrates, Marine Turtles and Marine Mammals" (Habitat Status Report 2004/002) is available at http://www.dfo-mpo.gc.ca/csas/Csas/status/2004/HSR2004_002_E.pdf.

Based on this peer-reviewed advice and an assessment by technical experts of the best available and internationally-recognized techniques to mitigate the effects of seismic noise in the marine environment, a group of federal and provincial experts in marine regulatory policy and practice developed a Statement of Canadian Practice. The Statement of Canadian Practice is intended to formalize and standardize the mitigation measures in Canada with respect to the conduct of seismic surveys in the marine environment. It will consist of minimum standards which will be given effect through existing regulatory authorities. For oil and gas seismic activities, Natural Resources Canada and Indian Affairs and Northern development, the provinces of Nova Scotia, Newfoundland and British Columbia, and their related boards, the National Energy Board, the Canada-Newfoundland Offshore Petroleum Board and the Canada-Nova Scotia Offshore Petroleum Board, will give effect to the Statement under their respective regulatory instruments. Non-oil and gas related seismic surveys will be regulated by the *Oceans Act.*

The Statement of Practice is being released by the Government of Canada and the Provinces of British Columbia, Newfoundland and Labrador, and Nova Scotia for public comment for a period of sixty days (April 19th, 2005). A copy of the Statement can be obtained electronically at ___________________________
http://www.dfo-mpo.gc.ca/oceans-habitat/oceans/im-gi/seismic-sismique/statement-enonce_e.asp

Statement of Canadian Practice with respect to the Mitigation of Seismic Sound in the Marine Environment

Background Paper

2007

Summary

Recent years have seen a heightened interest in the potential impacts of seismic surveying on the marine environment. In 2004, federal and provincial government advisors, and national and international scientific experts met to review the body of scientific knowledge that exists in this area. A review of the most effective and appropriate mitigative measures used world-wide was also conducted. These reviews led to the identification of a set of mitigation measures, which can assist in minimizing the potential adverse impacts of marine seismic activity. Federal and provincial governments have compiled these mitigation measures into the *Statement of Canadian Practice with respect to the Mitigation of Seismic Sound in the Marine Environment*. The *Statement* sets out minimum standards which will apply in Canada's non-ice covered marine waters to all seismic activities that use air source arrays. It will complement the existing environmental assessment processes, including those pursuant to settled land claims, and the existing regulatory requirements that currently govern marine seismic activities. Recognizing that the body of scientific knowledge is continually expanding, the *Statement* will be regularly reviewed. As new scientific information and improved mitigation technologies and practices emerge, these will be considered for incorporation into the *Statement*.

SOUND IN THE OCEANS is generated by a variety of natural sources, including vocalisation by marine life as well as wind and wave action, ice movements, and meteorological and oceanographic conditions.

Human activity also contributes to sound in the marine environment. Activities such as navigation, dredging, pile driving, ice breaking, whale watching and operating fishing gear each produce sound patterns with distinct characteristics. Resource exploration and production activities, including offshore drilling and marine seismic surveying, produce different types of sound. Active sonar which is used by security and defence operations produces a distinct type of sound.

There are fundamental differences between the type and intensity of sound generated by seismic air source arrays and sound associated with active sonar. These differences are mainly due to the emission of sounds of different intensity, frequency and direction of transmission.

Oceanographic characteristics such as the physiography of the sea bottom, the water depth, temperature, salinity and density differences can influence the transmission of sound as it travels through water. For example, sound levels are quickly reduced in shallow waters. In deeper waters, sound is likely to propagate further, especially where acoustic channels exist to conduct and focus sound energy.

In recent years, considerable international effort has been dedicated to a better understanding of the generation and transmission of sound in the marine environment and of the potential impacts of marine sound on life in the oceans. One area that has been of particular interest to the Canadian public is the sound associated with conducting marine seismic surveys.

SEISMIC SURVEYS use sound waves to gather information about geological structures lying beneath the surface of the earth, both on land and in the marine environment. A common purpose for conducting seismic surveys is to locate rock formations that could potentially contain hydrocarbons. Seismic surveys are also conducted by government and academic researchers for general scientific purposes, to understand the composition, structure and movement of the earth's crust.

During marine seismic surveys, compressed air is released into the water column, creating a sound energy pulse. The pulse is "focused" to concentrate the sound energy toward the ocean bottom rather than horizontally. These surveys are carried out from a ship that tows a sound source or sources, referred to as "air source arrays", and one or more cables ("streamers") that contain sound receivers and other instruments.

The sea floor and the structures beneath it are mapped by measuring the time it takes for a sound energy pulse to leave the source, penetrate the earth, reflect off a subsurface layer, and return to a sound receiver. Reflections occur at each layer where there is a measurable change in the speed at which sound is transmitted. The data retrieved from these surveys provides information on depth, position and shape of underground geological formations.

Most seismic surveys conducted in Canadian marine waters fall into the category of two-dimensional (2D) surveys or three-dimensional (3D) surveys. The objective of a 2D survey is to provide a broad picture of the geological characteristics of an area, including type and size of structures present. In conducting a 2D survey, a seismic vessel typically tows a single air source array and a single set of receivers along a set of parallel and transverse lines, spaced up to five kilometres apart, to create a grid pattern. A 3D seismic survey is conducted over a smaller area, to obtain more detailed geological information and to identify potential targets for hydrocarbon drilling. 3D surveys also create a grid pattern, but generally use two or more air source arrays and multiple sets of receivers trailed closer together.

THE POTENTIAL IMPACTS OF SEISMIC SOUND ON MARINE LIFE have been studied internationally for decades. Biological impacts on marine life from seismic surveys are generally discussed in terms of:

- physical impacts, or changes in organisms' physical state;
- physiological impacts, or changes in biological functions; and
- behavioural impacts, or changes in how organisms act.

In 2004, governments and academic researchers set out to take stock of our scientific knowledge in these areas. The process, which was led by Fisheries and Oceans Canada, culminated in a scientific peer review process involving national and international scientific experts. It considered the most current evidence of physical and physiological impacts of seismic sound on marine life, as well as potential behavioural impacts, and whether those impacts were direct, indirect, chronic or cumulative. The peer review process drew a number of conclusions using a risk-based approach that considered the likelihood of occurrence, the frequency and duration of the impact and the ecological significance or severity of the impact.[1]

In general, studies have found that for key components of the ecosystem, including invertebrates, fish, marine mammals and sea turtles, biological impacts vary from species to species and according to the proximity to the sound source arrays. Impacts are greatest within a few metres of the seismic source arrays.

Some marine mammals rely heavily on the use of underwater sounds to communicate and to echo-locate and emit and can sense different sound frequencies. There is evidence that these species hear and react to many man-made sounds including those associated with seismic surveys. The available data suggests that for a seismic sound to result in auditory impairment or other direct physical impacts for marine mammals, animals must be located within a short distance from the sound source. Most marine mammals, including most baleen whales, some odontocetes (toothed whales) and some pinnipeds (seals), generally avoid the immediate vicinity of active seismic vessels. However, some marine mammals, such as dolphins and porpoises, have been observed to swim near sources of seismic sound, with no apparent impacts.

The findings of the peer review process concluded that there was evidence that at certain received sound levels, behavioural changes can be manifested by some marine fish, marine mammals and sea turtles. If seismic surveys were to occur in areas and at times when a large enough aggregation of these marine organisms were engaged in critical biological functions the behavioural impacts might have important ecological and population-level impacts. For example the impact may be important if it results in the displacement of breeding, feeding or nursing marine mammals, dispersion of spawning aggregations of fish in their spawning areas and diversion of aggregations of marine mammals and fish from their migration routes.

While there has recently been an increased interest in sea turtles because of the endangered or threatened status of some species, relatively little is known about the sensitivity of these species to sound. Studies do indicate that sea turtles are able to detect sound frequencies similar to those generated during seismic surveys. As a measure of precaution, given the limited knowledge on the sensitivity of sea turtles to sound and given the endangered status of a number of sea turtles, it was concluded that sea turtles should have the benefit of the same mitigative measures as marine mammals.

Building on existing scientific information, the peer review process concluded that mitigation should be used where detrimental population-scale impacts were considered likely to occur, or where adverse impacts including death, harm or harassment of

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[1] The report of the peer review, *Review of Scientific Information on Impacts of Seismic Sound on Fish, Invertebrates, Marine Turtles and Marine Mammals" (Habitat Status Report 2004/002),* is available online at: http://www.dfo-mpo.gc.ca/csas/Csas/status/2004/HSR2004_002_E.pdf

individual marine mammals or turtles listed as endangered or threatened on Schedule 1 of the *Species at Risk Act* were likely to occur.

The peer review process identified a number of recognized measures for mitigating the potential impacts of seismic sound, consistent with a precautionary approach. A federal-provincial regulatory policy review further identified the most effective measures which would be appropriate for use in Canadian marine waters. Federal and provincial governments have agreed to incorporate these measures into the *Statement of Canadian Practice with respect to the Mitigation of Seismic Sound in the Marine Environment*.

The *Statement of Canadian Practice with respect to the Mitigation of Seismic Sound in the Marine Environment* specifies the mitigation requirements that must be met during the planning and conduct of marine seismic surveys, in order to minimize impacts on life in the oceans. These requirements are set out as minimum standards, which will apply in all non-ice covered marine waters in Canada. The *Statement* complements existing environmental assessment processes, including those set out in settled land claims. The current regulatory system will continue to address protection of the health and safety of offshore workers and ensure that seismic activities are respectful of interactions with other ocean users.

The *Statement* was developed by federal and provincial authorities responsible for the regulation and management of seismic surveys, including representatives from the provincial governments of Nova Scotia, Newfoundland and Labrador, British Columbia and Quebec. Federally, representation included Natural Resources Canada, Indian and Northern Affairs Canada, and Fisheries and Oceans Canada. The *Statement* was developed following a peer review process involving scientific and technical experts, acousticians, and experts in the design and effectiveness of mitigative measures. Public policy experts as well as experts from the National Energy Board, the Canada-Nova Scotia and the Canada-Newfoundland and Labrador Offshore Petroleum Boards were also consulted. Public input on the *Statement* was received during a 60-day web-based public consultation, and targeted discussions were held with representatives from the fishing and oil and gas sectors, academics and other interested parties.

The *Statement* will apply to all seismic activities in the marine environment that use air source arrays; as such it will not apply to activities conducted in ice covered waters. For seismic surveys conducted for the purpose of oil and gas exploration, the *Statement* will be administered by the existing oil and gas regulatory bodies – the National Energy Board, the Canada-Nova Scotia Offshore Petroleum Board, and the Canada-Newfoundland and Labrador Offshore Petroleum Board. For seismic surveys conducted for any other purposes, the *Statement* will be administered by Fisheries and Oceans Canada.

The *Statement* was drafted using the best available scientific information, current international best management practices and internationally recognized techniques to mitigate the impacts of seismic sound in the marine environment. However, it is recognized that the body of scientific knowledge is continually expanding. As new scientific information and improved mitigation technologies and practices emerge, these will be considered for incorporation into the *Statement*. The *Statement* will be reviewed on an annual basis, and interested parties will be consulted on any potential amendments.

The *Statement of Canadian Practice with respect to the Mitigation of Seismic Sound in the Marine Environment* sets out mitigation requirements for:

- Planning of seismic surveys;
- Establishment and monitoring of a safety zone;
- Prescribed marine mammal observation and detection measures.
- Prescribed start-up; and
- Prescribed shut-down.

The following sections briefly describe each of these areas, and the requirements contained in the *Statement*:

Planning of seismic surveys

The *Statement* requires that operators plan and design seismic survey programs according to certain conditions. As a precautionary measure and to minimize the unnecessary introduction of sound into the marine environment, surveys are to be designed to use the minimum energy needed to obtain the information sought, to reduce or baffle the horizontal spread of sound and reduce the generation of unnecessary high frequency sounds.

In order to further reduce the potential impacts of a seismic survey, there is an additional requirement to design programs which avoid areas where it is known that there are aggregations of marine mammals and marine fish at critical times in their life cycle and during critical biological functions such as spawning, breeding, feeding, nursing and migration times.

Establishment and monitoring of a safety zone

Recognizing that sound is most intense closest to the air source and that the potential impacts of seismic are greatest within short distances, the *Statement* requires that a "safety zone" be established and monitored around seismic air source arrays. As noted above, the propagation of sound and of specific frequencies varies according to many factors, including ocean depths, temperatures and salinity. This poses a challenge in establishing precise distance at which specific sound levels can be expected. Similarly, marine species respond differently to various frequencies of sound, depending on their biological characteristics, life history and their respective hearing thresholds. The use and testing of sound propagation models combined with active science research programs are increasing our understanding of potential impacts and relationships between sound levels/distance and those impacts.

The *Statement* contains a basic requirement for a minimum 500m safety zone, established around the air source array(s). Existing scientific evidence and the application of a precautionary approach revealed that beyond a 500m safety zone, sound energy from seismic activity is unlikely to cause adverse impacts on marine mammals and sea turtles, under many circumstances. However, the *Statement* recognizes that in other circumstances, environmental assessment processes may identify the need for a safety zone of greater than 500m.

As is discussed below, the *Statement* requires seismic vessels to use a qualified marine mammal observer to watch the safety zone. If a whale, dolphin, porpoise or sea turtle is seen by a marine mammal observer to be within the safety zone, the air source array must not be started up until the area is clear. Similarly if a marine mammal listed as endangered or threatened in Schedule 1 of the *Species at Risk Act* is in the area of the safety zone, no activity can begin.

Prescribed start-up

Most marine species will likely avoid a seismic vessel while survey activities are underway. Seismic operators are required to take advantage of this behaviour by using a start up technique whereby activation of the air source arrays begins with a pulse from the lowest energy source on the array. The remainder of the sound sources on the array are gradually activated over a fixed period of time. This procedure provides the time and the incentive for marine mammals and fish to leave the immediate area.

In certain circumstances, such as well site surveys and vertical seismic profiling, only one energy source is used. In this circumstance, where technically feasible, the start-up procedure should consist of a gradual increase of the intensity of the sound until it reaches the required intensity.

Prescribed shut-down

Once seismic survey activity is ongoing, if a marine mammal or a turtle listed as endangered or threatened on Schedule 1 of the *Species at Risk Act* enters the safety zone the operator must shut down and wait for them to leave. The Statement also requires shut down of the array if other marine mammals or sea turtles enter the safety zone. These species could be those identified by an environmental review process as possibly experiencing significantly-adverse population-level impacts if exposed to seismic sound.

Prescribed procedures when active surveying ceases

As a precautionary measure and to reduce the amount of unnecessary sound released into the marine environment, when active surveying ceases, operators are required to either shut down the energy source completely or shut down all but one source. Continued release of sound from a single source would serve to deter whale, dolphin, porpoises or turtles from entering the safety zone.

Prescribed marine mammal observation and detection measures

Marine mammal observer: The *Statement* requires the stationing of a qualified marine mammal observer on board seismic vessels. The marine mammal observer is required to verify that the safety zone is clear for at least 30 minutes before the seismic air source array (s) can be activated. A marine mammal observer is required to maintain a regular watch during the entire duration of the time that the air source arrays are active and that the safety zone is visible.

Use of Cetacean detection technology: Reduced visibility and storm conditions may require the use of different mitigative measures, such as Passive Acoustic Monitoring, to detect and track the sounds made by vocalizing marine mammals prior to start-up.
Passive Acoustic Monitoring uses “listening” technology to detect animals that are below the sea surface, while having no adverse environmental impacts of its own. Passive Acoustic Monitoring’s usefulness presently is limited to those species that are known to vocalize and to spend much time below the water surface (e.g., dolphins, sperm whales, northern bottlenose whales). Additional approaches to marine mammal detection (including radar, infrared detection and adaptation of fishing industry “fish finder” technologies) are currently in the research and planning stages, and will likely be available in upcoming years.

The *Statement* requires the use of cetacean detection technology under certain circumstances and conditions. If all of the following conditions exist, then PAM, or equivalent technology, must be used:

- the survey’s sound sources array has been shut down for more than 30 minutes;
- the full extent of the safety zone is not visible;
- the survey is in an area where vocalizing cetaceans such as dolphins, porpoises and whales listed as endangered or threatened in Schedule 1 of the Species at Risk Act are likely to be encountered, or if the survey is conducted in an area where species identified in an environmental assessment process as likely to be negatively impacted at a population level by seismic sound are likely to be found.

Under these conditions, if the presence of a vocalizing whale, porpoise or dolphin is detected and it cannot be identified, the operator must assume that it is a whale listed as endangered or threatened in Schedule 1 of the *Species at Risk Act*, or one identified by an environmental assessment process, and the operation must shut down and remain shut down until the operator is able to determine that the whale, dolphin or porpoise is outside the safety zone, or has not been heard for at least 30 minutes.

Additional or modified mitigative measures

In some cases, environmental assessment processes will point to regional specificities, including oceanographic, geomorphologic and biological characteristics, and regulatory reviews may require modified or additional mitigative measures to be applied. Also, variations to the mitigative measures set out in the Statement may be allowed if persons wishing to conduct seismic surveys provide an equivalent or greater level of environmental protection.

Statement of Canadian Practice with respect to the Mitigation of Seismic Sound in the Marine Environment

Context

The Statement of Canadian Practice with respect to the Mitigation of Seismic Sound in the Marine Environment specifies the mitigation requirements that must be met during the planning and conduct of marine seismic surveys, in order to minimize impacts on life in the oceans. These requirements are set out as minimum standards, which will apply in all non-ice covered marine waters in Canada. The *Statement* complements existing environmental assessment processes, including those set out in settled land claims. The current regulatory system will continue to address protection of the health and safety of offshore workers and ensure that seismic activities are respectful of interactions with other ocean users.

Definitions

Cetacean: means a whale, dolphin or porpoise.

Critical habitat: means the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in the recovery strategy or in an action plan for the species.

Marine Mammal Observer: means an individual trained to identity different species of marine mammals and turtles that may reasonably be expected to be present in the area where the seismic survey will take place.

Marine mammals: means all cetaceans and pinnipeds.

Passive Acoustic Monitoring: means a technology that may be used to detect the subsea presence of vocalizing cetaceans.

Pinniped: means a seal, sea lion or walrus.

Ramp-up: means the gradual increase in emitted sound levels from a seismic air source array by systematically turning on the full complement of an array's air sources over a period of time.

Seismic air source: means an air source that is used to generate acoustic waves in a seismic survey.

Seismic air source array(s): means one or a series of devices designed to release compressed air into the water column in order to create an acoustical energy pulse to penetrate the seafloor.

Seismic survey: means a geophysical operation that uses a seismic air source to generate acoustic waves that propagate through the earth, are reflected from or refracted along subsurface layers of the earth, and are subsequently recorded.

"Statement:" means the Statement of Canadian Practice for the Mitigation of Seismic Sound in the Marine Environment.

Whale: means a cetacean that is not a dolphin or porpoise.

Application

1. Unless otherwise provided, the mitigation measures set out in this Statement apply to all seismic surveys planned to be conducted in Canadian marine waters and which propose to use an air source array(s).

2. The mitigation measures set out in this Statement do not apply to seismic surveys conducted:
   a. on ice-covered marine waters; or
   b. in lakes or the non-estuarine portions of rivers.

Planning Seismic Surveys

Mitigation Measures

3. Each seismic survey must be planned to
   a. use the minimum amount of energy necessary to achieve operational objectives;
   b. minimize the proportion of the energy that propagates horizontally; and
   c. minimize the amount of energy at frequencies above those necessary for the purpose of the survey.
4. All seismic surveys must be planned to avoid:
   a. a significant adverse effect for an individual marine mammal or sea turtle of a species listed as endangered or threatened on Schedule 1 of the *Species at Risk Act*; and
   b. a significant adverse population-level effect for any other marine species.

5 Each seismic survey must be planned to avoid:
   a. displacing an individual marine mammal or sea turtle of a species listed as endangered or threatened on Schedule 1 of the *Species at Risk Act* from breeding, feeding or nursing;
   b. diverting an individual migrating marine mammal or sea turtle of a species listed as endangered or threatened on Schedule 1 of the *Species at Risk Act* from a known migration route or corridor;
   c. dispersing aggregations of spawning fish from a known spawning area;
   d. displacing a group of breeding, feeding or nursing marine mammals, if it is known there are no alternate areas available to those marine mammals for those activities, or that if by using those alternate areas, those marine mammals would incur significant adverse effects; and
   e. diverting aggregations of fish or groups of marine mammals from known migration routes or corridors if it is known there are no alternate migration routes or corridors, or that if by using those alternate migration routes or corridors, the group of marine mammals or aggregations of fish would incur significant adverse effects.

Safety Zone and Start-up

Mitigation Measures

6. Each seismic survey must:

   a. establish a safety zone which is a circle with a radius of at least 500 metres as measured from the centre of the air source array(s); and

   b. for all times the safety zone is visible,

      i. a qualified Marine Mammal Observer must continuously observe the safety zone for a minimum period of 30 minutes prior to the start up of the air source array(s), and

      ii. maintain a regular watch of the safety zone at all other times if the proposed seismic survey is of a power that it would meet a threshold requirement for an assessment under the *Canadian Environmental Assessment Act*, regardless of whether the Act applies.

7. If the full extent of the safety zone is visible, before starting or restarting an air source array(s) after they have been shut-down for more than 30 minutes, the following conditions and processes apply:

   a. none of the following have been observed by the Marine Mammal Observer within the safety zone for at least 30 minutes:

      i. a cetacean or sea turtle,

      ii. a marine mammal listed as endangered or threatened on Schedule 1 of the *Species at Risk Act*, or

      iii. based on the considerations set out in sub-section 4(b), any other marine mammal that has been identified in an environmental assessment process as a species for which there could be significant adverse effects; and

   b. a gradual ramp-up of the air source array(s) over a minimum of a 20 minute period beginning with the activation of a single source element of the air source array(s), preferably the smallest source element in terms of energy output and a gradual activation of additional source elements of the air source array(s) until the operating level is obtained.

Shut-down of Air Source Array(s)

Mitigation Measures

8. The air source array(s) must be shut down immediately if any of the following is observed by the Marine Mammal Observer in the safety zone:

   a. a marine mammal or sea turtle listed as endangered or threatened on Schedule 1 of the *Species at Risk Act*; or

   b. based on the considerations set out in sub-section 4(b), any other marine mammal or sea turtle that has been identified in an environmental assessment process as a species for which there could be significant adverse effects.

Line Changes and Maintenance Shut-downs

Mitigation Measures

9. When seismic surveying (data collection) ceases during line changes, for maintenance or for other operational reasons, the air source array(s) must be:
   a. shut down completely; or
   b. reduced to a single source element.

10. If the air source array(s) is reduced to a single source element as per subsection 9(b), then:
    a. visual monitoring of the safety zone as set out in section 6 and shut-down requirements as set out in section 8 must be maintained; but
    b. ramp-up procedures as set out in section 7 will not be required when seismic surveying resumes.

Operations in Low Visibility

Mitigation Measures

11. Under the conditions set out in this section, cetacean detection technology, such as Passive Acoustic Monitoring, must be used prior to ramp-up for the same time period as for visual monitoring set out in section 6. Those conditions are as follows:
    a. the full extent of the safety zone is not visible; and
    b. the seismic survey is in an area that
       i. has been identified as critical habitat for a vocalizing cetacean listed as endangered or threatened on Schedule 1 of the Species at Risk Act, or
       ii. in keeping with the considerations set out in sub-section 4(b), has been identified through an environmental assessment process as an area where a vocalising cetacean is expected to be encountered if that vocalizing cetacean has been identified through the environmental assessment process as a species for which there could be significant adverse effects.

12. If Passive Acoustic Monitoring or similar cetacean detection technology is used in accordance with the provision of section 11, unless the species can be identified by vocal signature or other recognition criteria:
    a. all non-identified cetacean vocalizations must be assumed to be those of whales named in sections 8(a) or (b); and
    b. unless it can be determined that the cetacean(s) is outside the safety zone, the ramp-up must not commence until non-identified cetacean vocalizations have not been detected for a period of at least 30 minutes.

Additional Mitigative Measures and Modifications

Mitigation Measures

13. Persons wishing to conduct seismic surveys in Canadian marine waters may be required to put in place additional or modified environmental mitigation measures, including modifications to the area of the safety zone and/or other measures as identified in the environmental assessment of the project to address:

   a. the potential for chronic or cumulative adverse environmental effects of

      i. multiple air source arrays (e.g., two vessels on one project; multiple projects), or

      ii. seismic surveys being carried out in combination with other activities adverse to marine environmental quality in the area affected by the proposed program or programs;

   b. variations in sound propagation levels within the water column, including factors such as seabed, geomorphologic, and oceanographic characteristics that affect sound propagation;

   c. sound levels from air source array(s) that are significantly lower or higher than average; and

   d. species identified in an environmental assessment process for which there is concern, including those described in sub-section 4b).

14. Variations to some or all of the measures set out in this Statement may be allowed provided the alternate mitigation or precautionary measures will achieve an equivalent or greater level of environmental protection to address the matters outlined in sections 6 through 13 inclusive. Where alternative methods or technologies are proposed, they should be evaluated as part of the environmental assessment of the project.

15. Where a single source element is used and the ramping up from an individual air source element to multiple elements is not applicable, the sound should still be introduced gradually whenever technically feasible.

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
Action Agency:	National Science Foundation, Division of Ocean Sciences and the National Oceanic Atmospheric Administration National Marine Fisheries Service, Office of Protected Resources, Permits and Conservation Division
Publisher:	Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce
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TABLE OF CONTENTS

Page

LIST OF TABLES

Page

LIST OF FIGURES

Page

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.

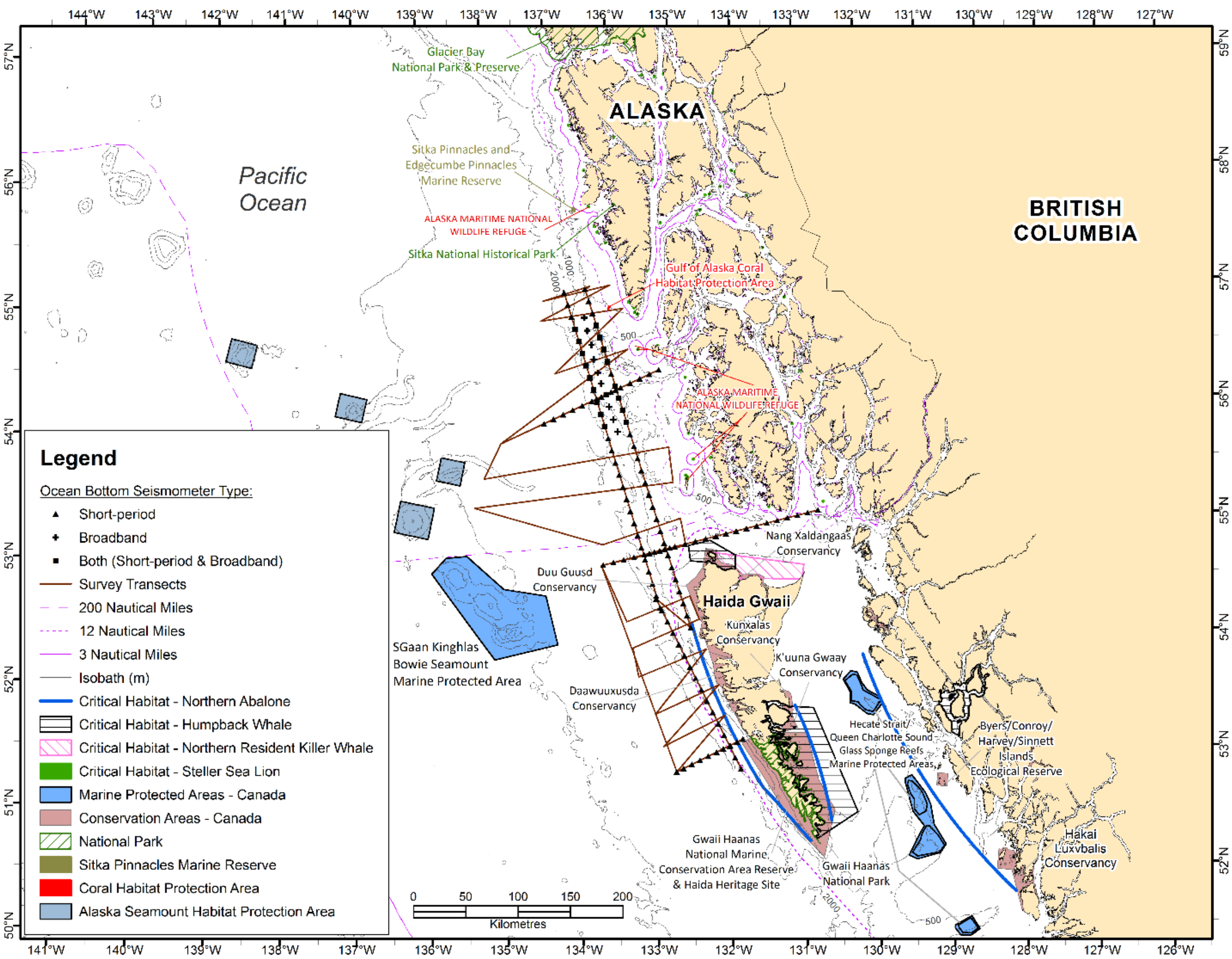

Figure 1. Location of the proposed seismic surveys in the Northeast Pacific Ocean off the coasts of Southeast Alaska and northern British Columbia.

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).

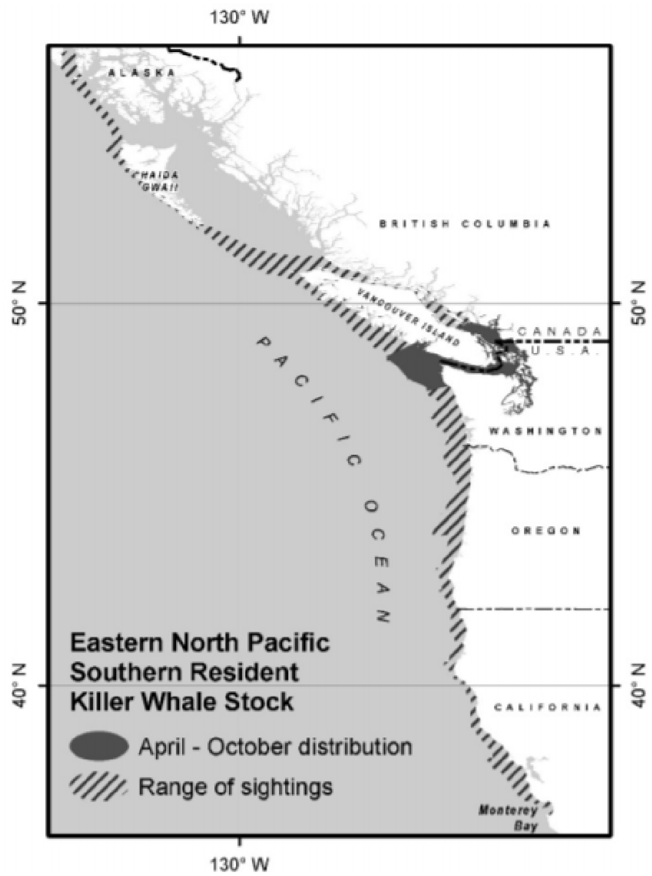

Figure 2. Approximate April - October distribution of the Eastern North Pacific Southern Resident killer whale stock (shaded area) and range of sightings (diagonal lines) (Carretta et al. 2020a).

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).

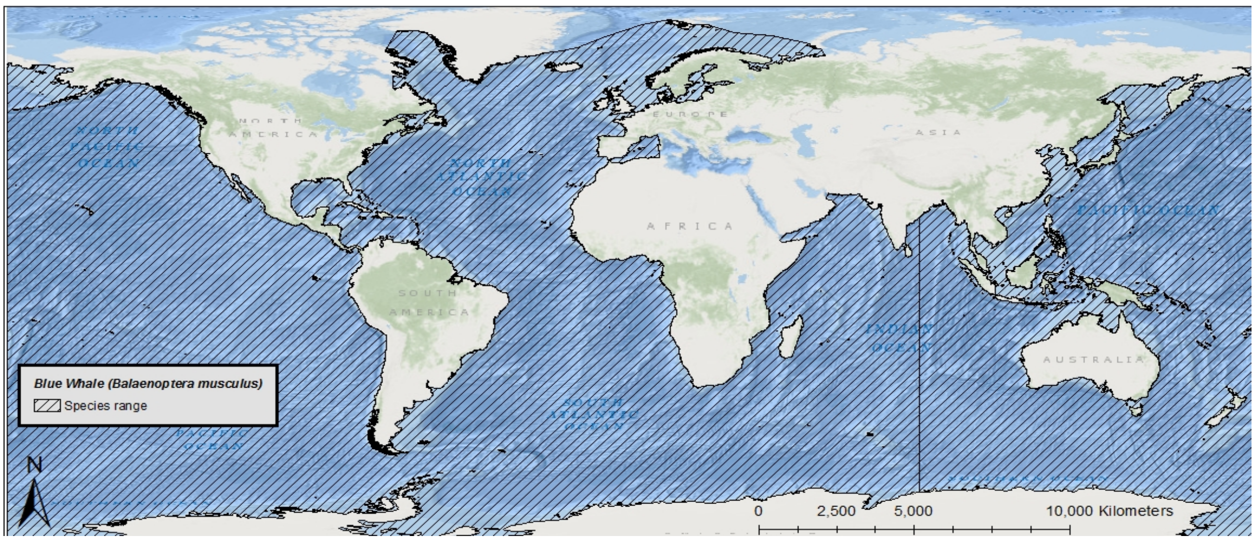

Figure 3. Map identifying the range of the endangered blue whale.

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.

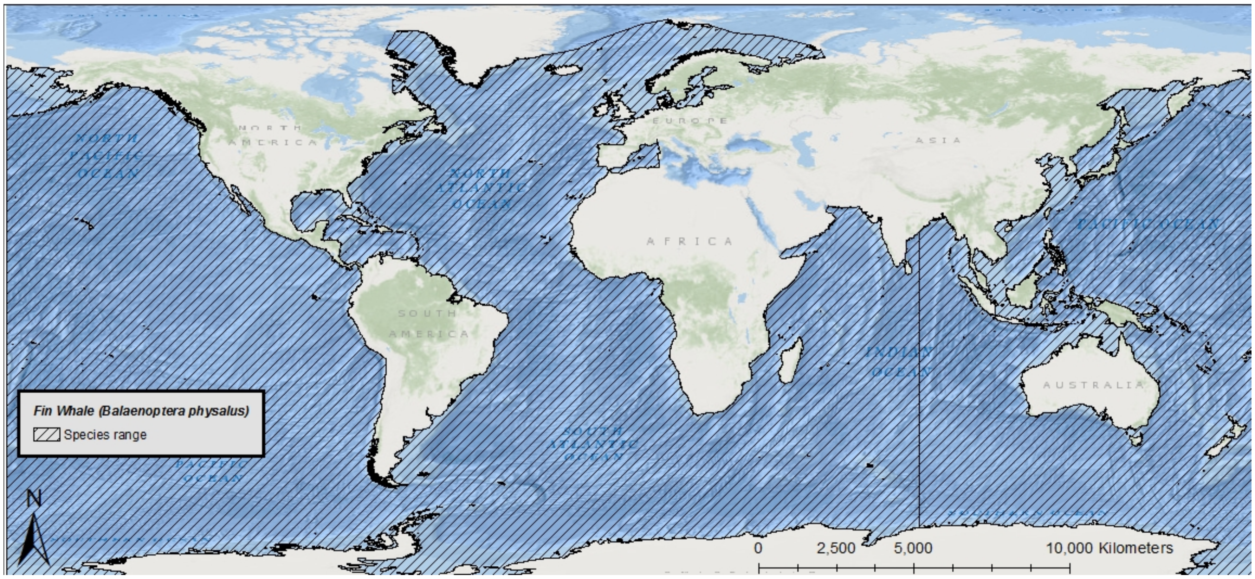

Figure 4. Map identifying the range of the endangered fin whale

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.

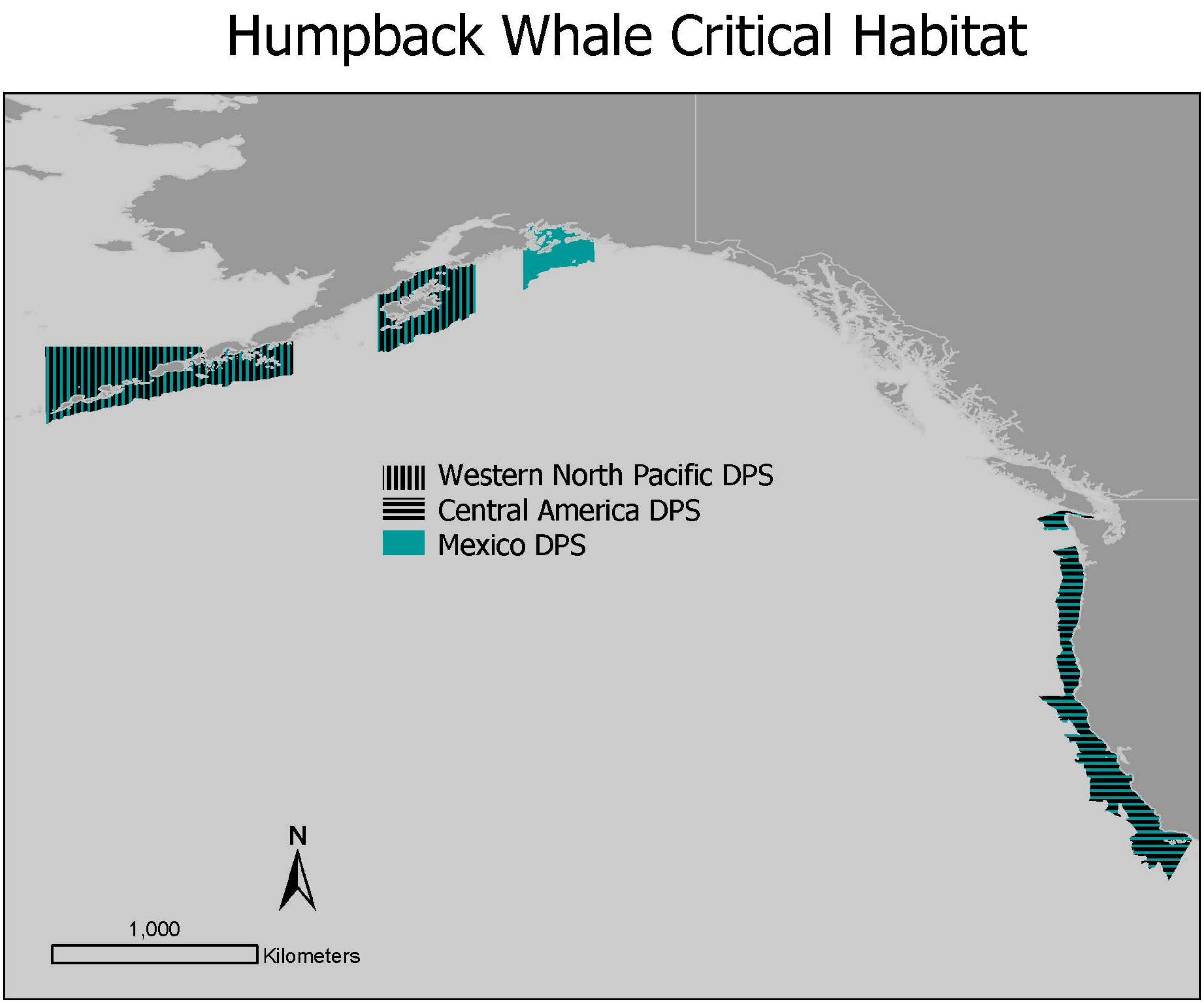

Figure 5. Designated critical habitat for the humpback whales.

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.

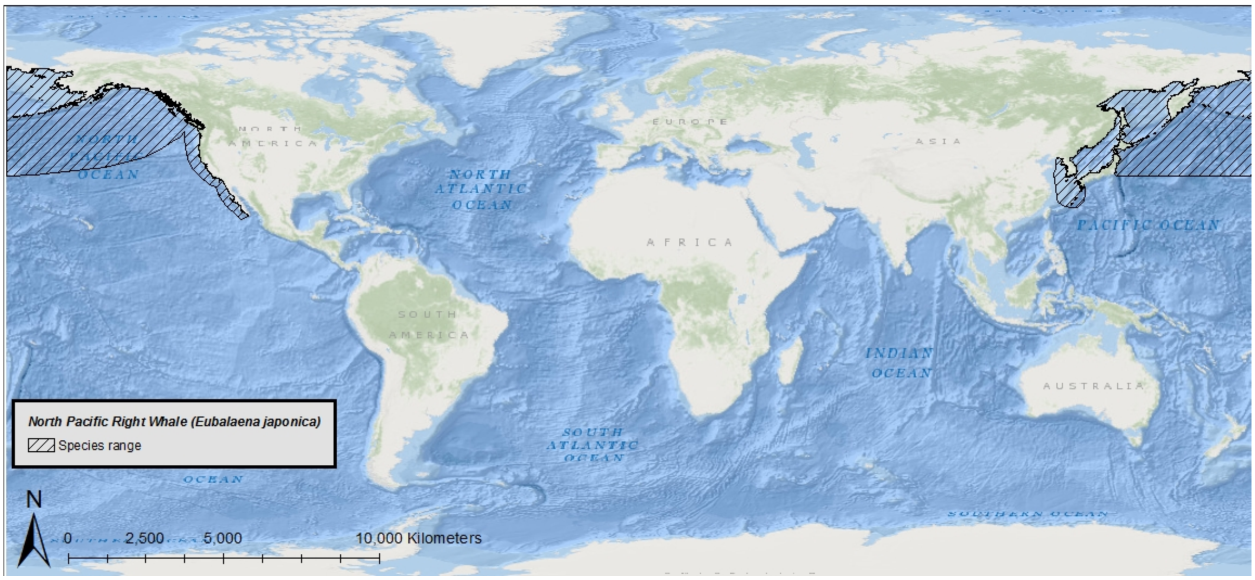

Figure 6. Map identifying the range of the endangered North Pacific right whale.

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.

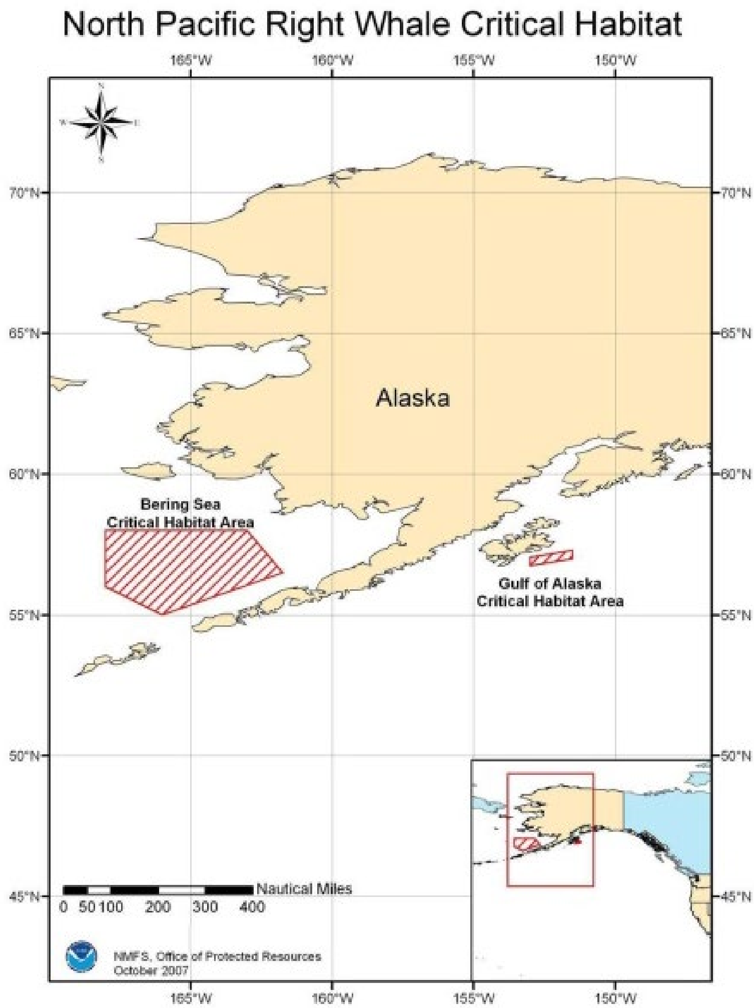

Figure 7. Map identifying designated critical habitat for the North Pacific right whale in the Southeast Bering Sea and south of Kodiak Island in the Gulf of Alaska.

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).

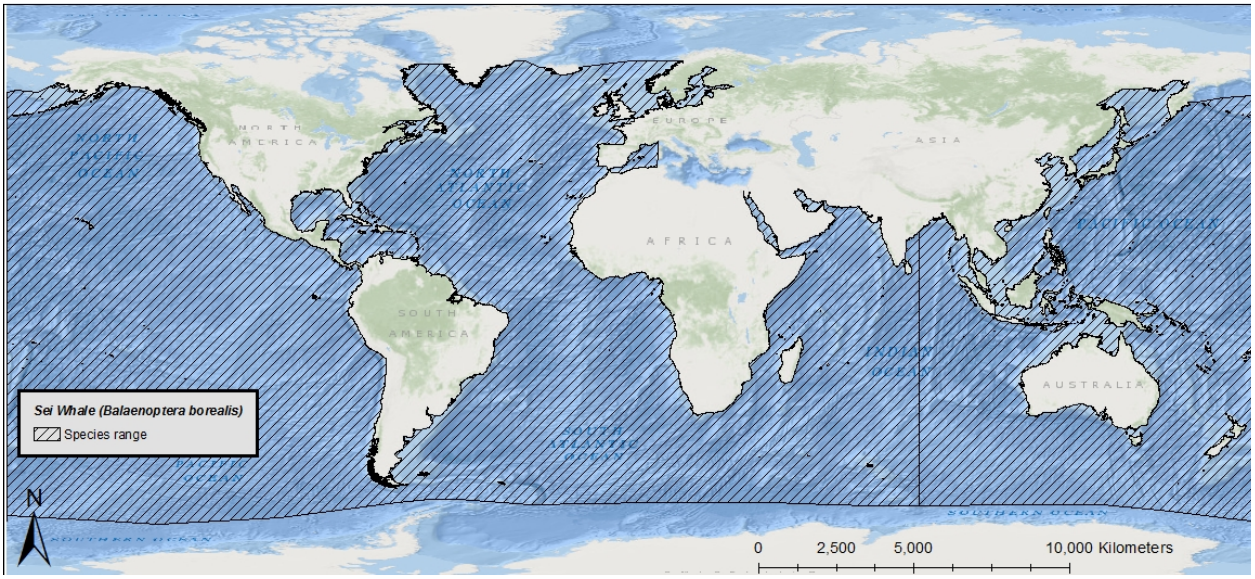

Figure 8. Map identifying the range of the endangered sei whale.

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).

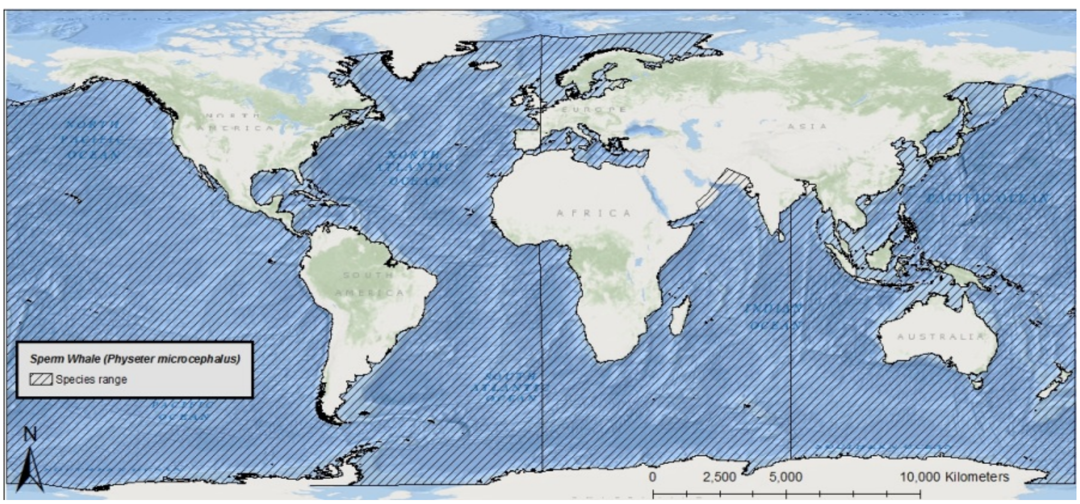

Figure 9. Map identifying the range of the endangered sperm whale.

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).

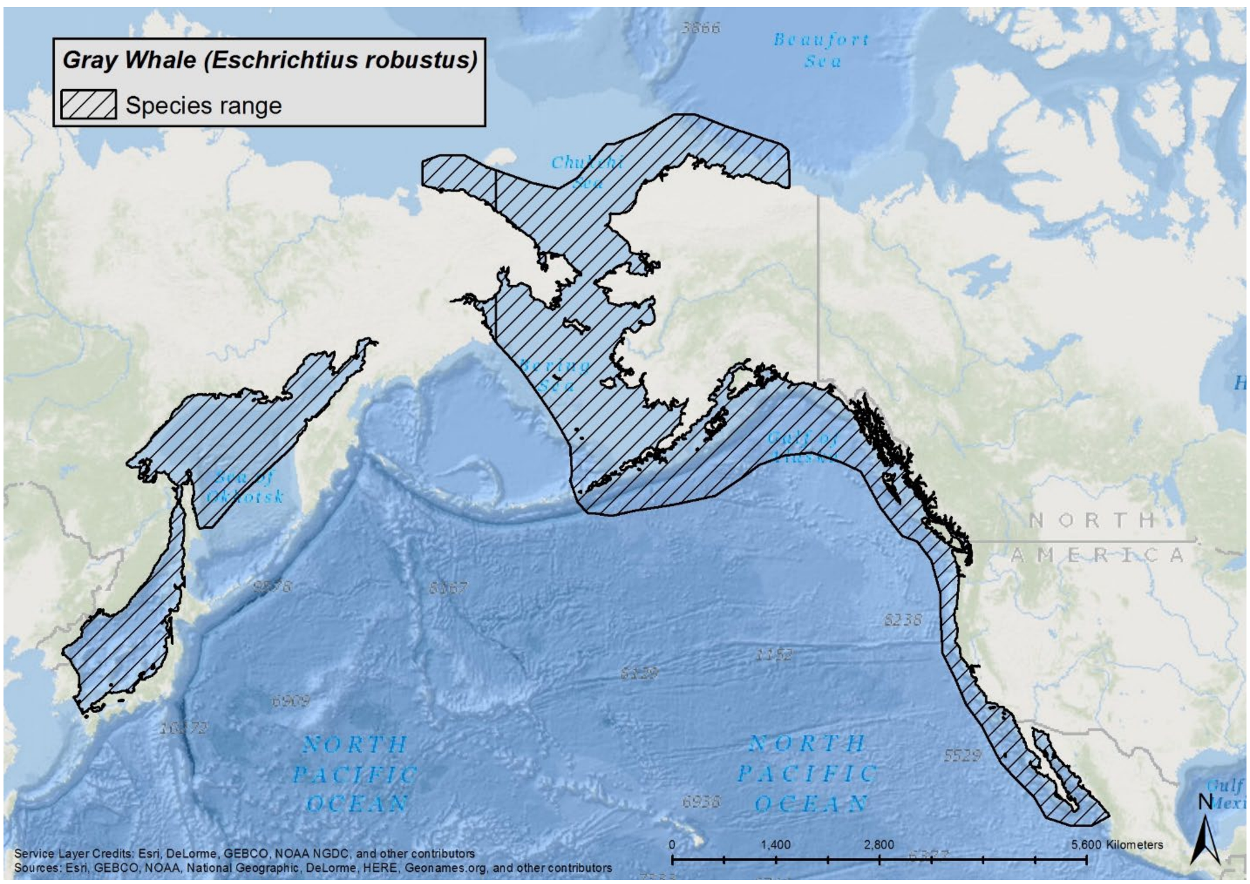

Figure 10. Map identifying the range of the gray whale.

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).

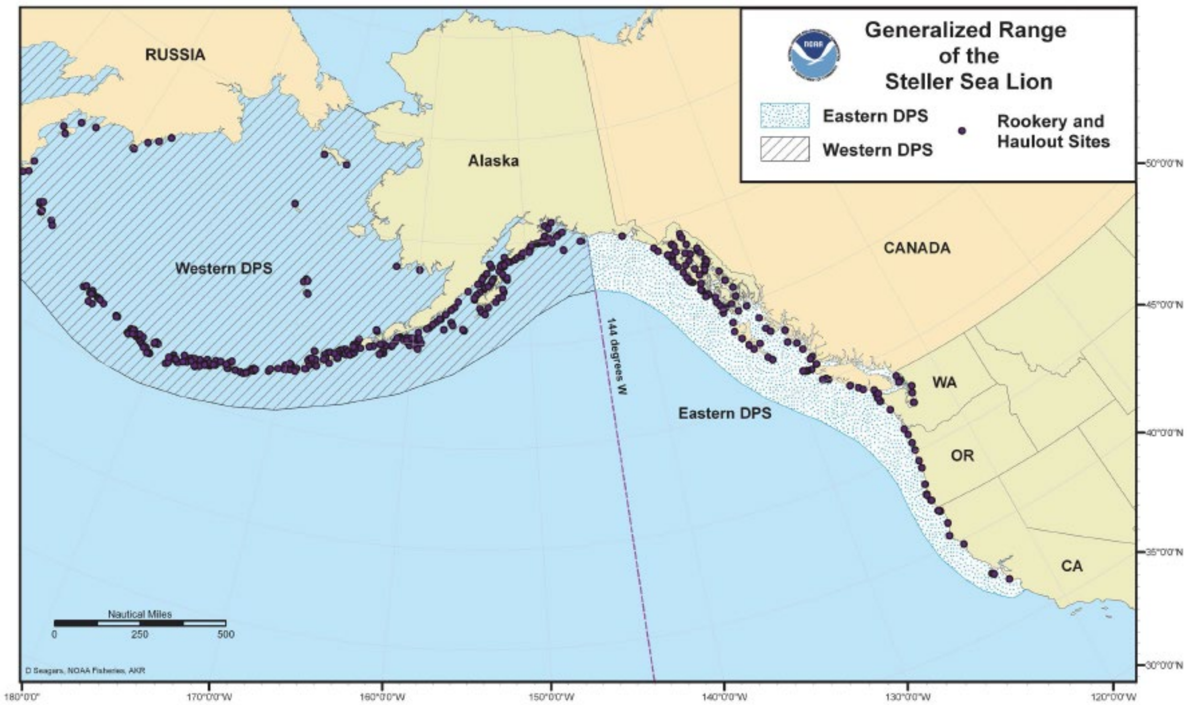

Figure 11. Map identifying the range of the endangered Western DPS of Steller sea lion.

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).

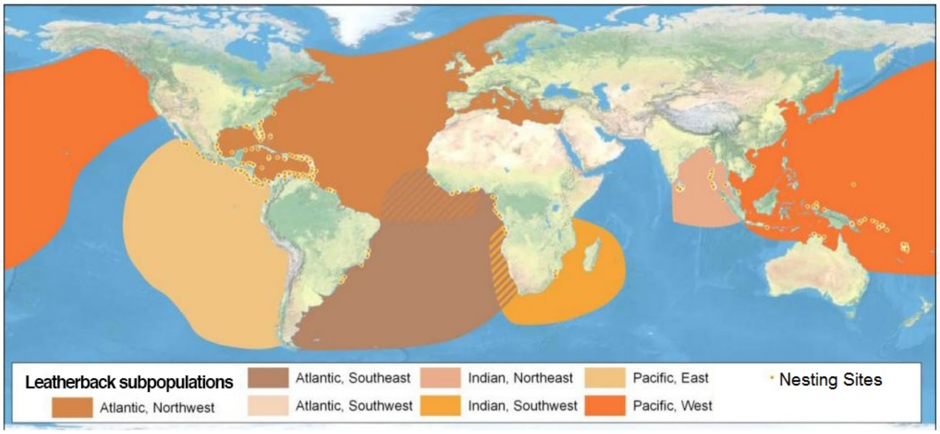

Figure 12. Map identifying the range of the endangered leatherback turtle. Adapted from (Wallace et al. 2013).

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.

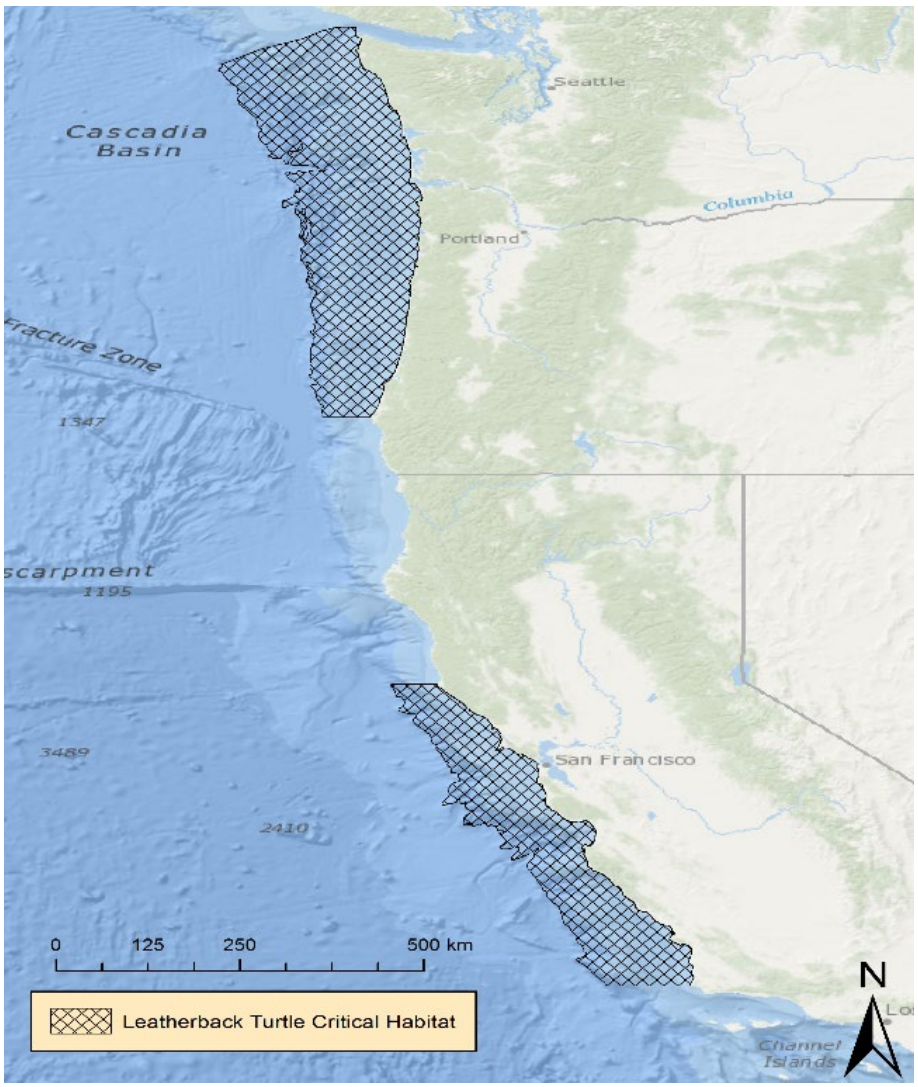

Figure 13. Map depicting leatherback turtle designated critical habitat along the United States Pacific Coast.

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-

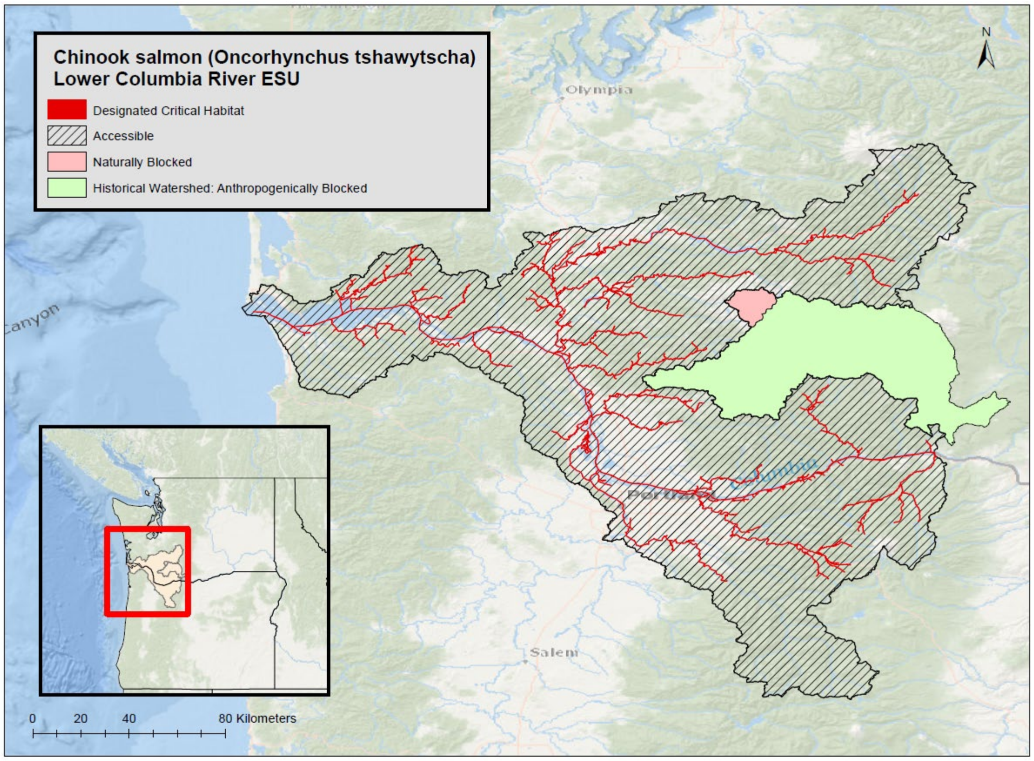

Figure 14. Geographic range and designated critical habitat of Lower Columbia River ESU Chinook salmon.

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).

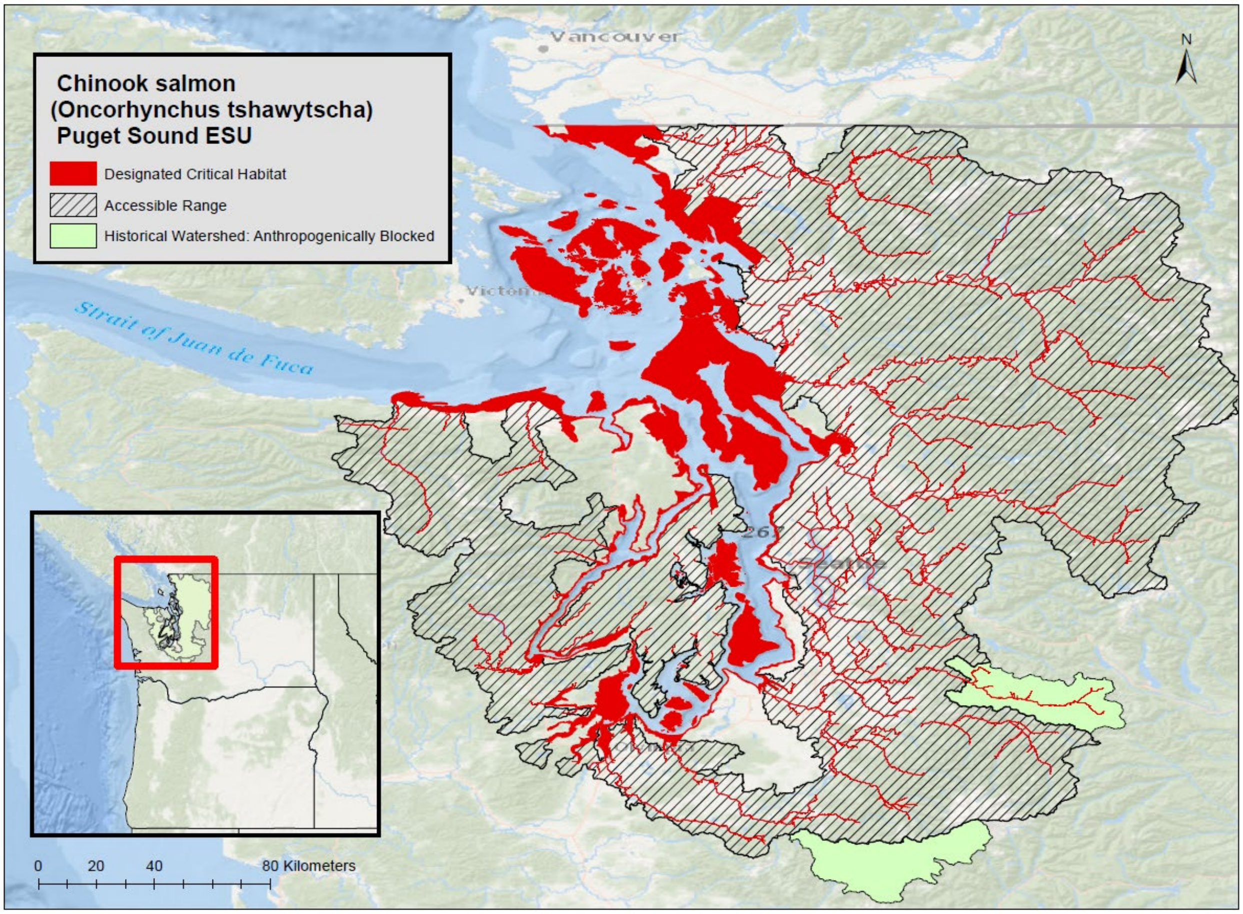

Figure 15. Geographic range and designated critical habitat of Puget Sound ESU Chinook salmon.

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).

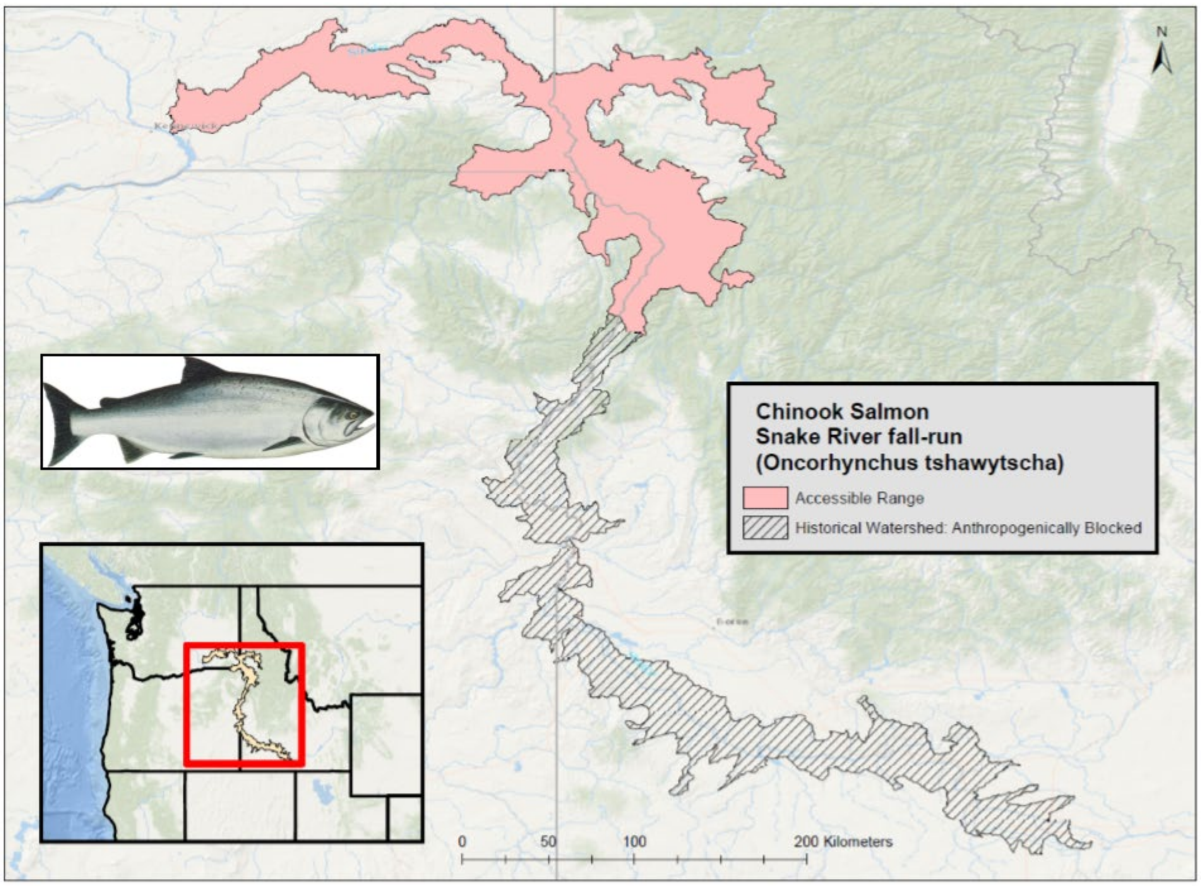

Figure 16. Geographic range of Snake River fall-run ESU Chinook salmon.

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).

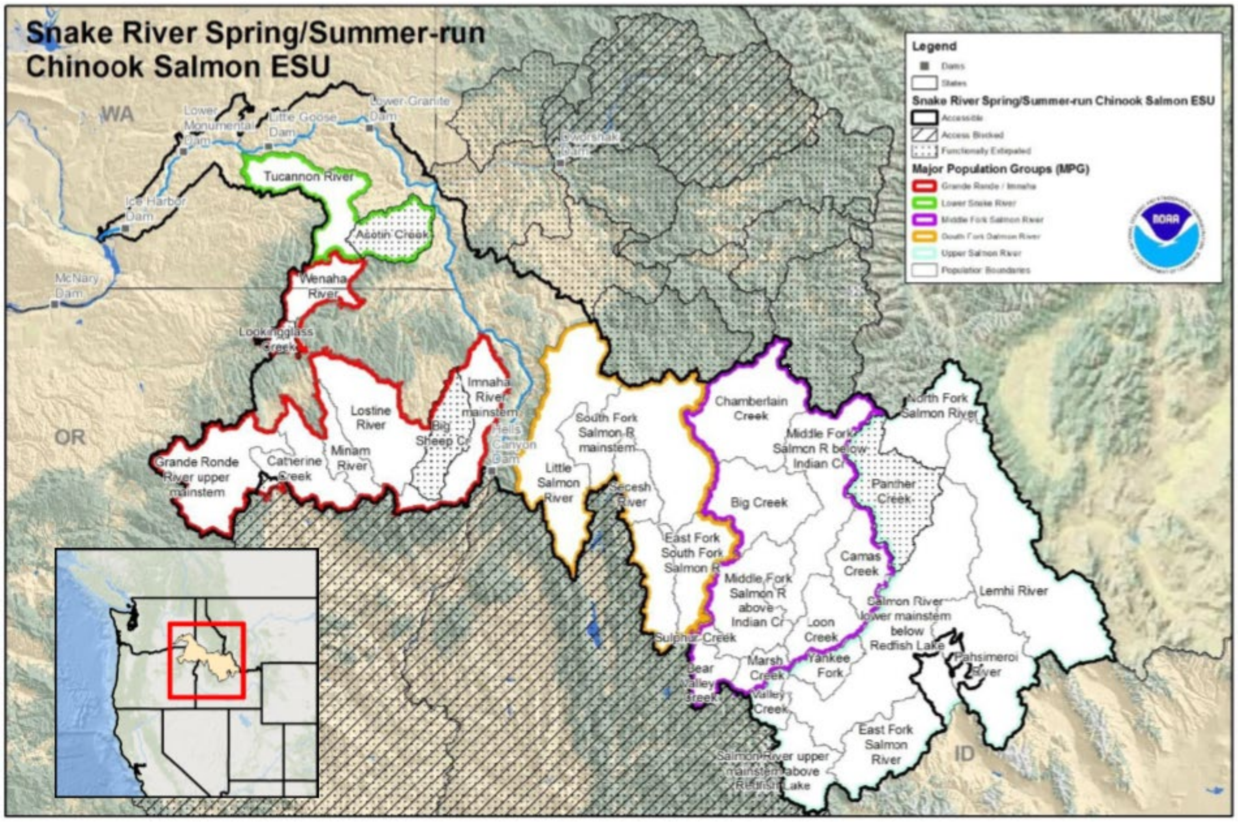

Figure 17. Geographic range and major population groups of Snake River spring/summer-run ESU Chinook salmon.

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.

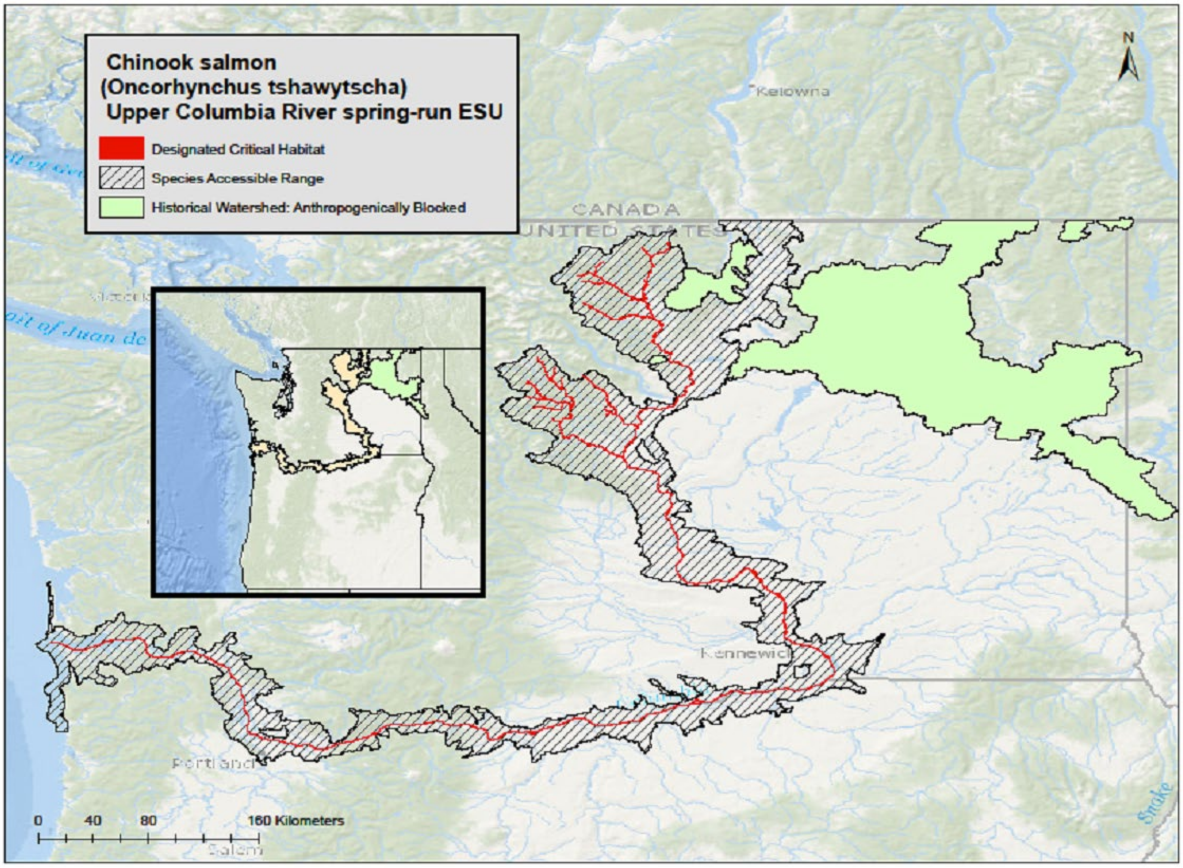

Figure 18. Geographic range and designated critical habitat of Chinook salmon, upper Columbia River ESU.

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.

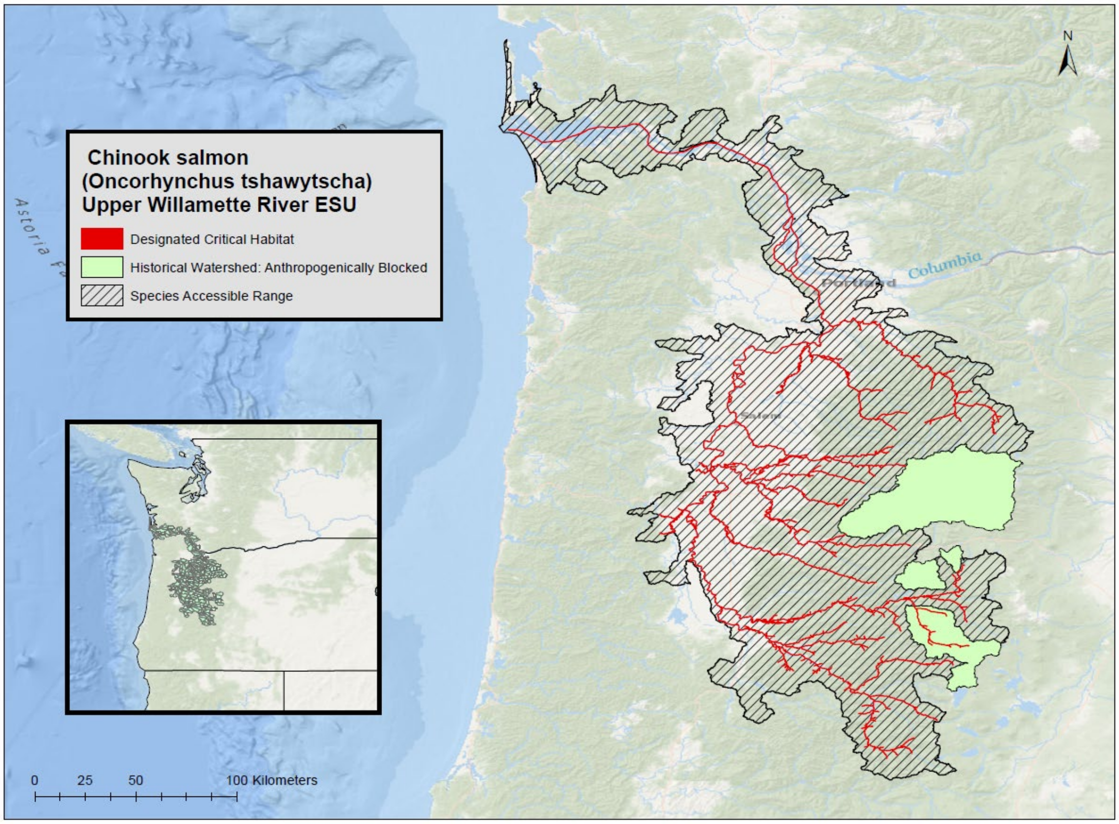

Figure 19.Geographic range and designated critical habitat of Chinook salmon, upper Willamette River ESU.

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.

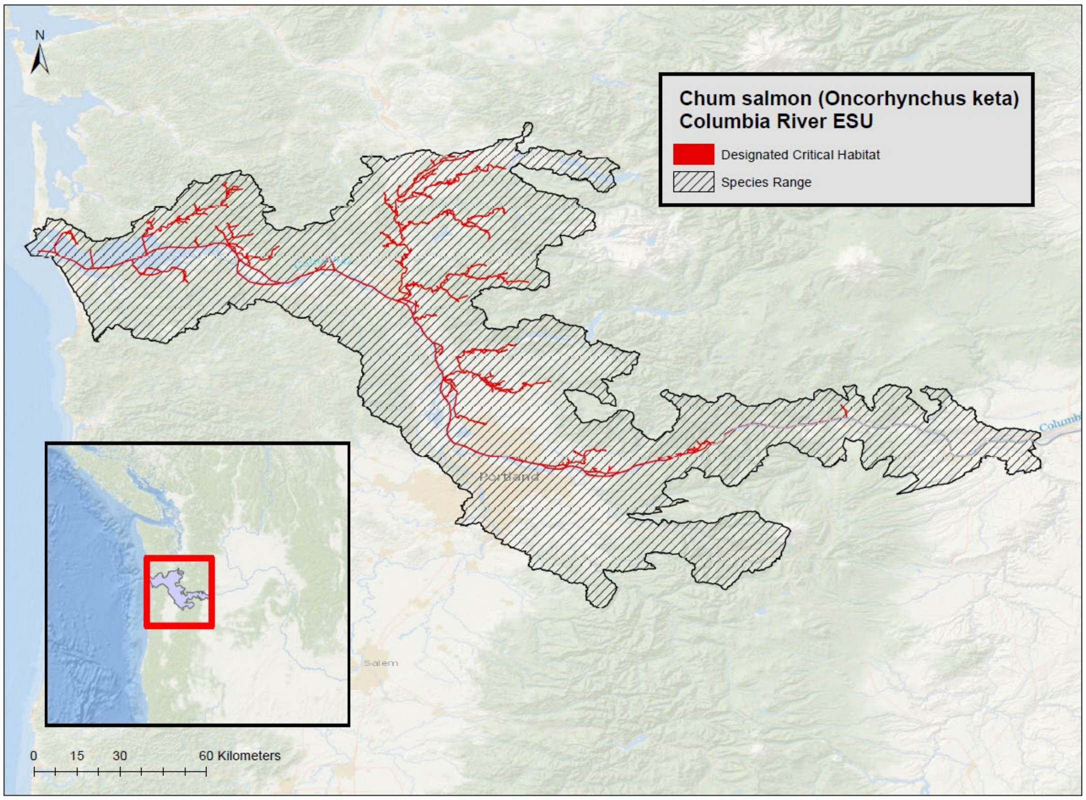

Figure 20. Geographic range and designated critical habitat of chum salmon, Columbia River ESU.

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).

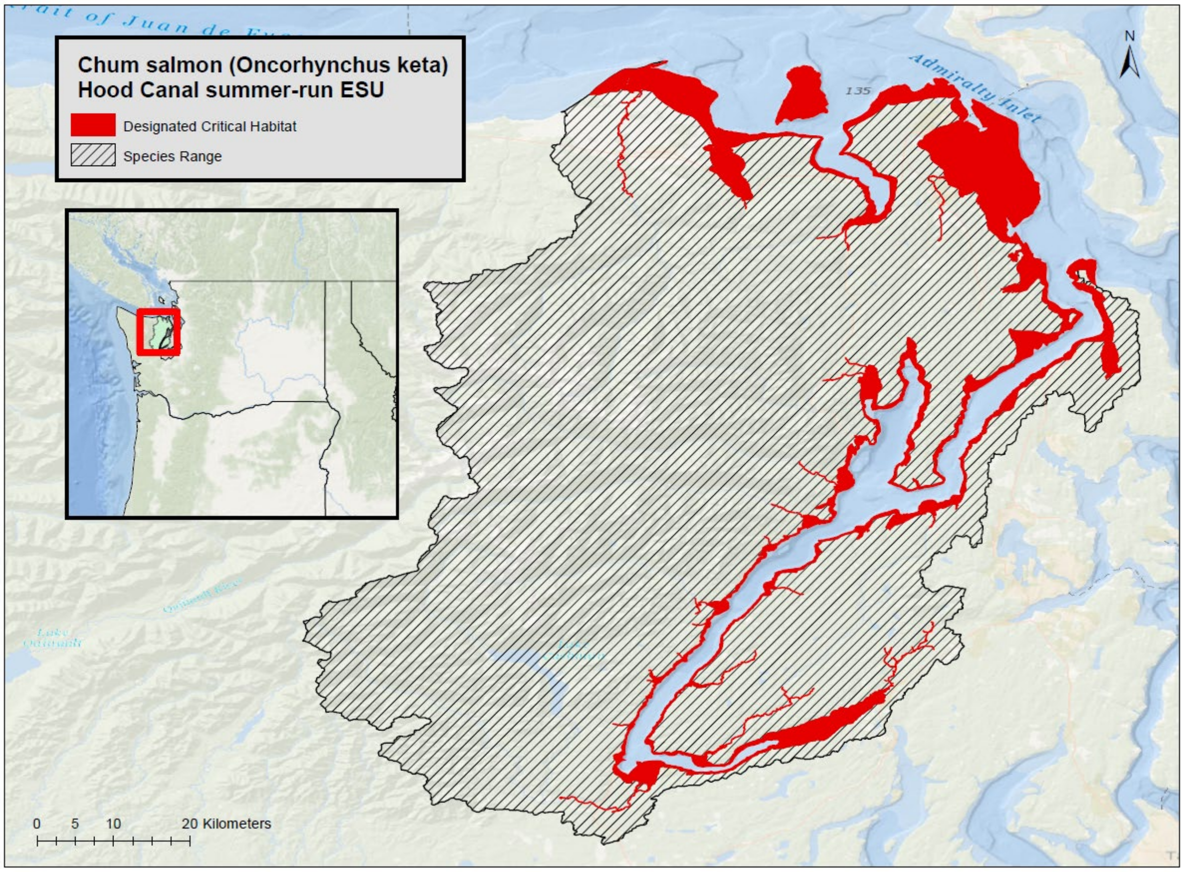

Figure 21. Geographic range and designated critical habitat of chum salmon, Hood Canal ESU.

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.

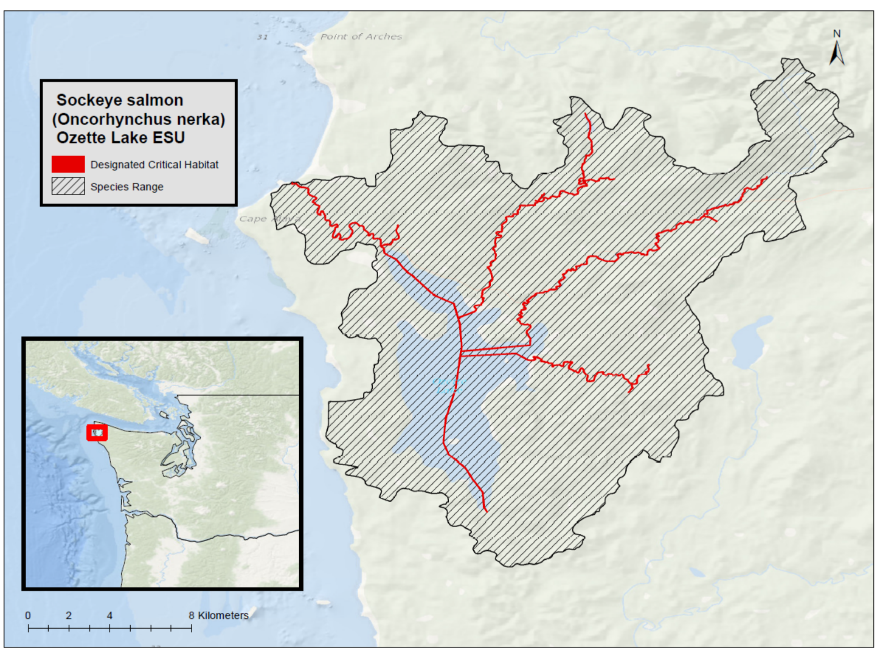

Figure 22. Range and Designated Critical Habitat of the Ozette Lake ESU of Sockeye Salmon.

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.

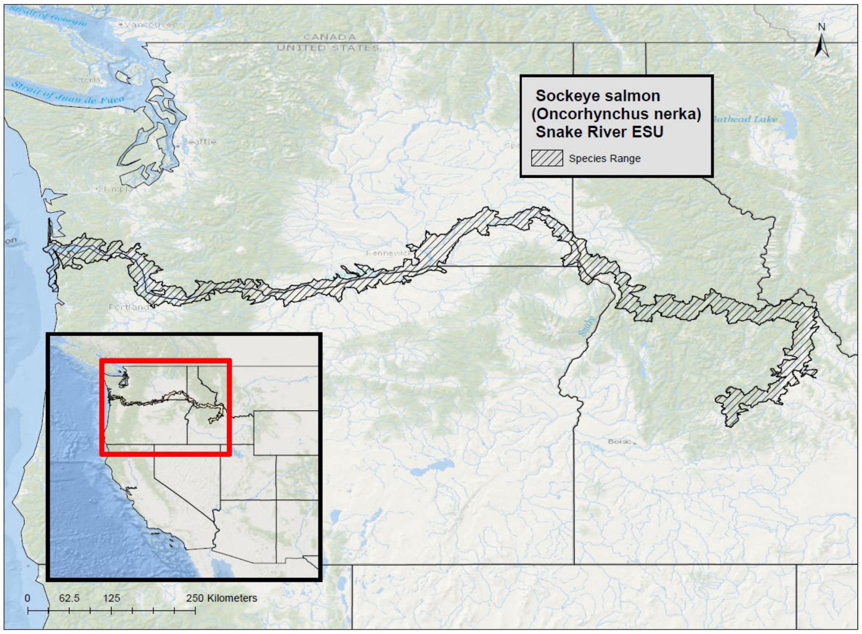

Figure 23. Geographic range of Sockeye salmon, Snake River ESU.

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).

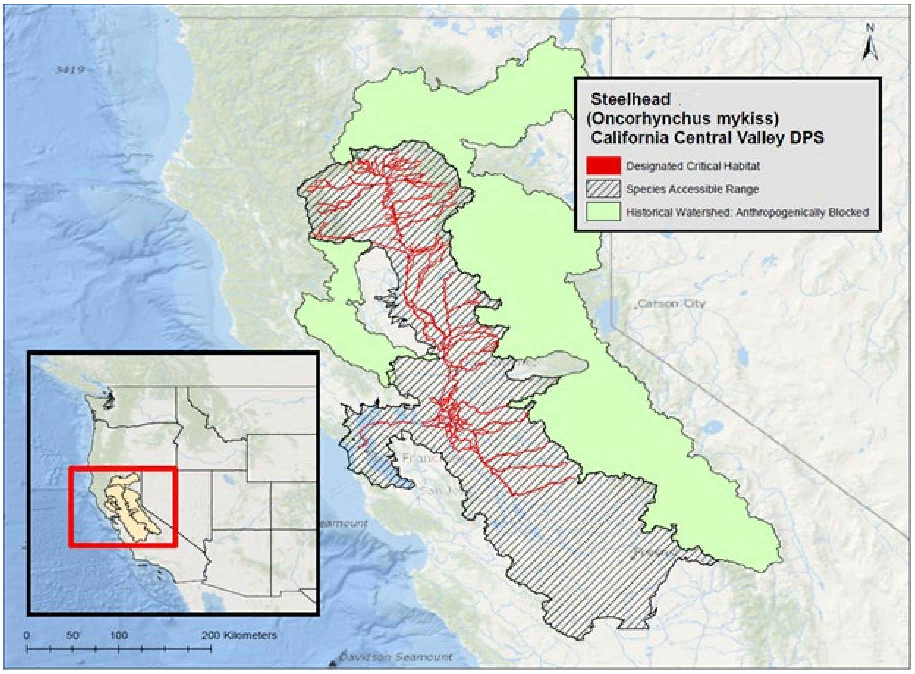

Figure 24. Geographic range and designated critical habitat of California Central Valley Steelhead.

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).

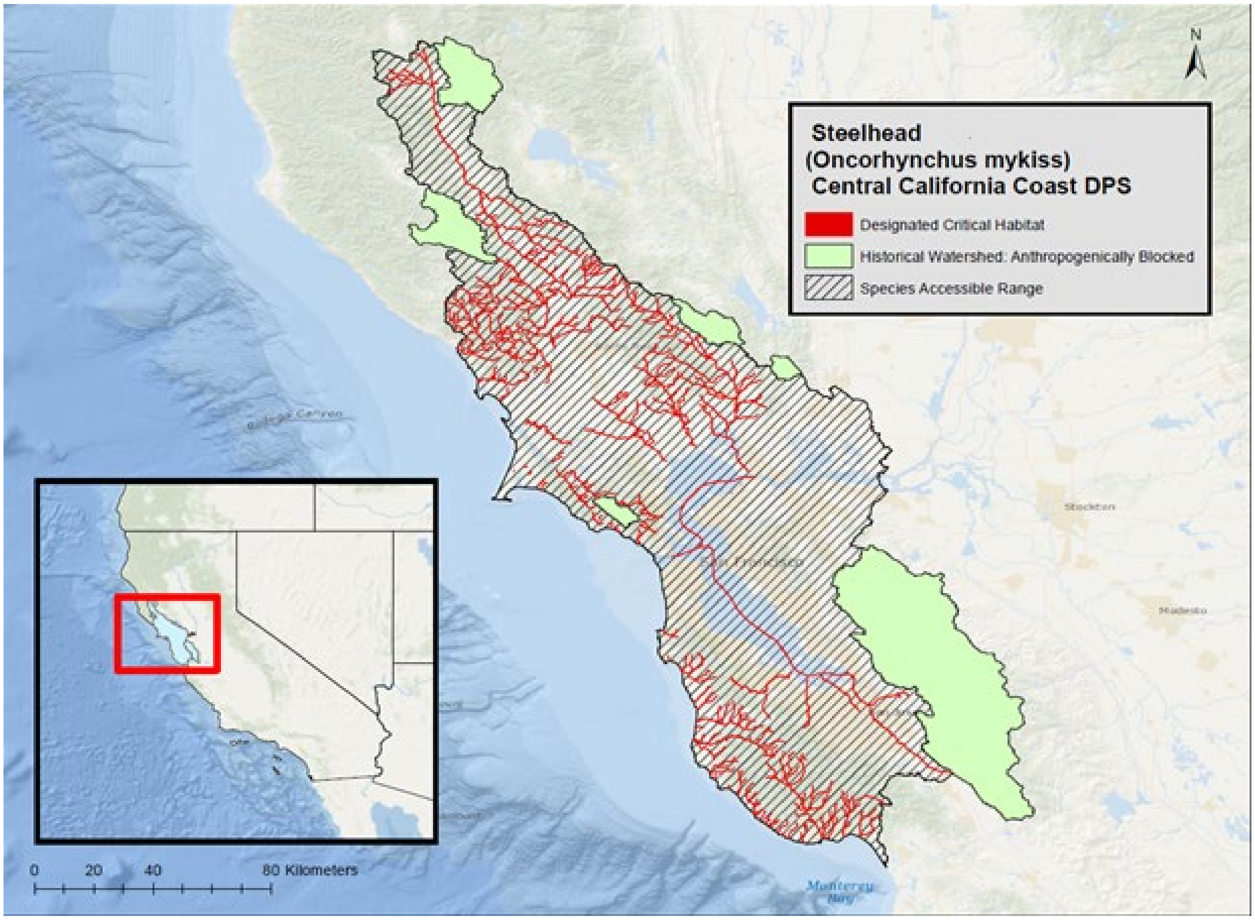

Figure 25. Geographic range and designated critical habitat of Central California Coast Steelhead.

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).

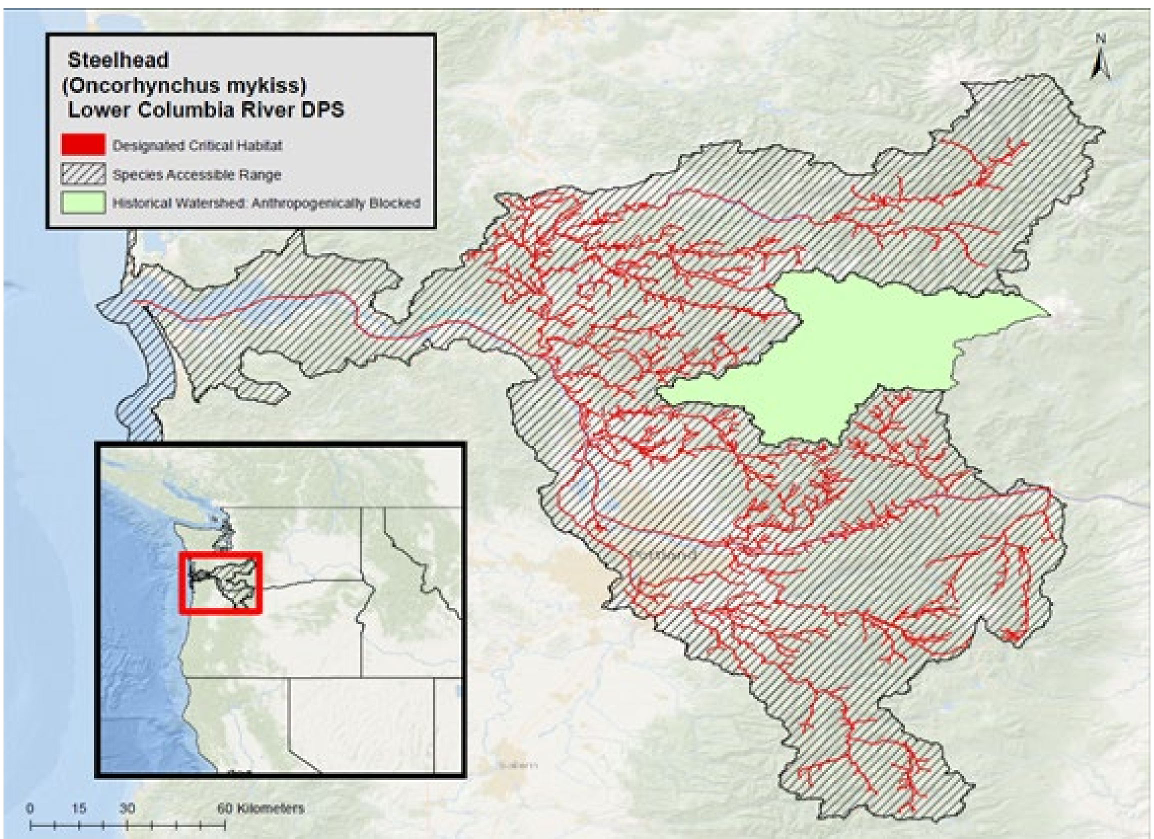

Figure 26. Geographic range and designated critical habitat of Lower Columbia River steelhead.

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).

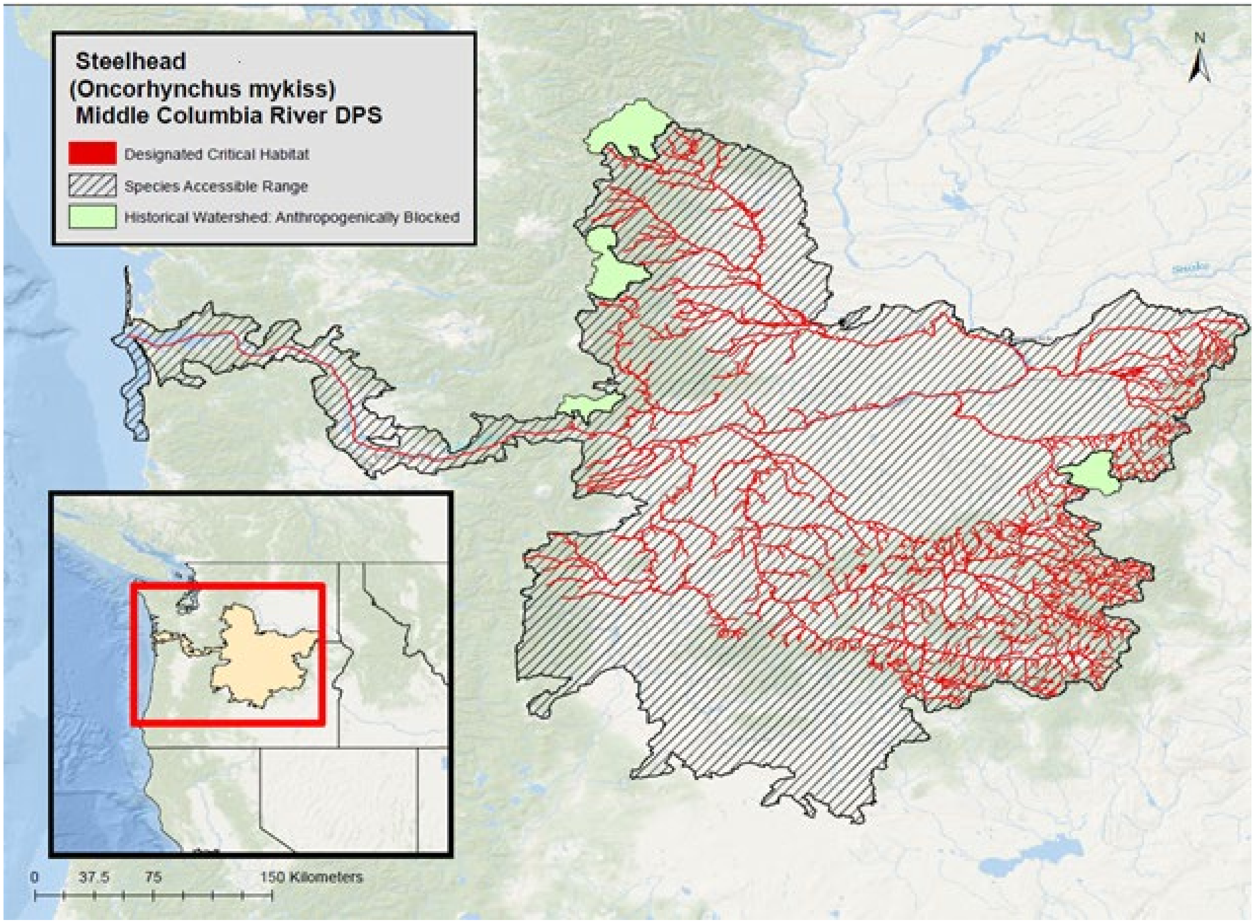

Figure 27. Geographic range and designated critical habitat of Middle Columbia River steelhead.

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).

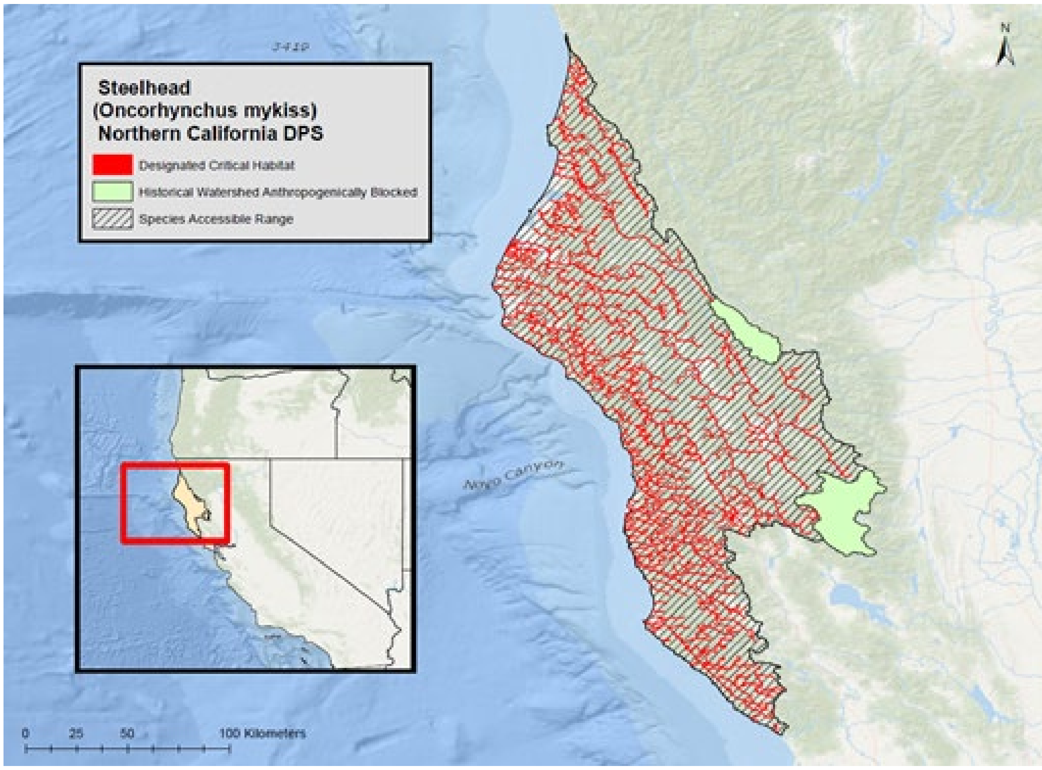

Figure 28. Geographic range and designated critical habitat of Northern California DPS steelhead.

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.

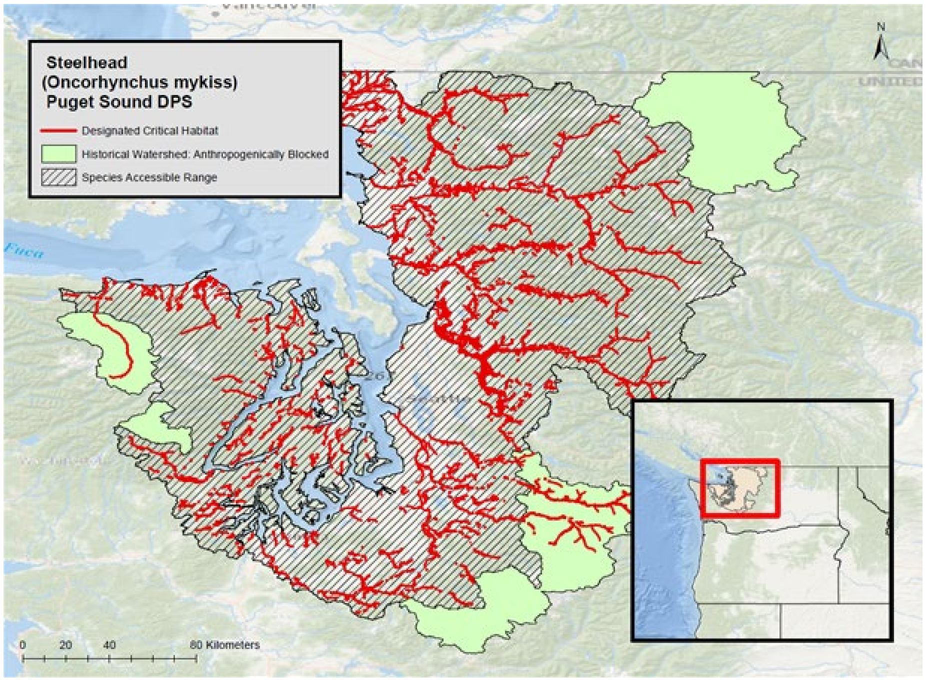

Figure 29. Geographic range and designated critical habitat of Puget Sound DPS steelhead.

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.

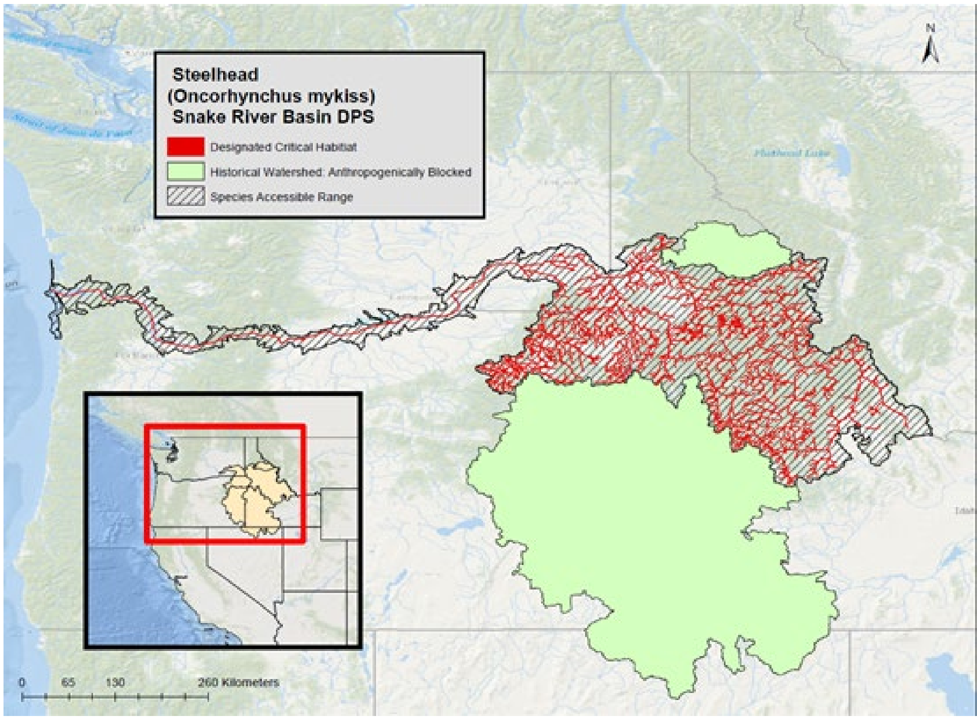

Figure 30. Geographic range and designated critical habitat of Snake River Basin steelhead.

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.

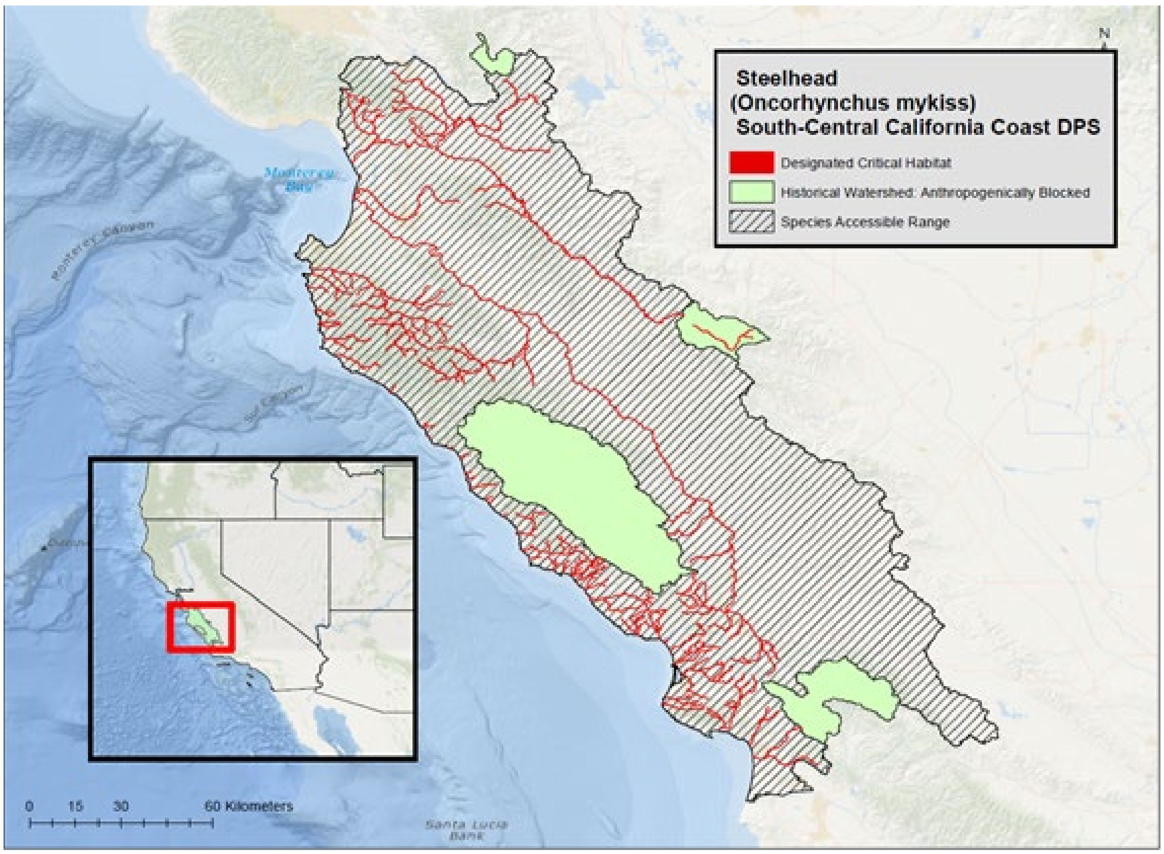

Figure 31. Geographic range and designated critical habitat of South-Central California Coast steelhead.

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.

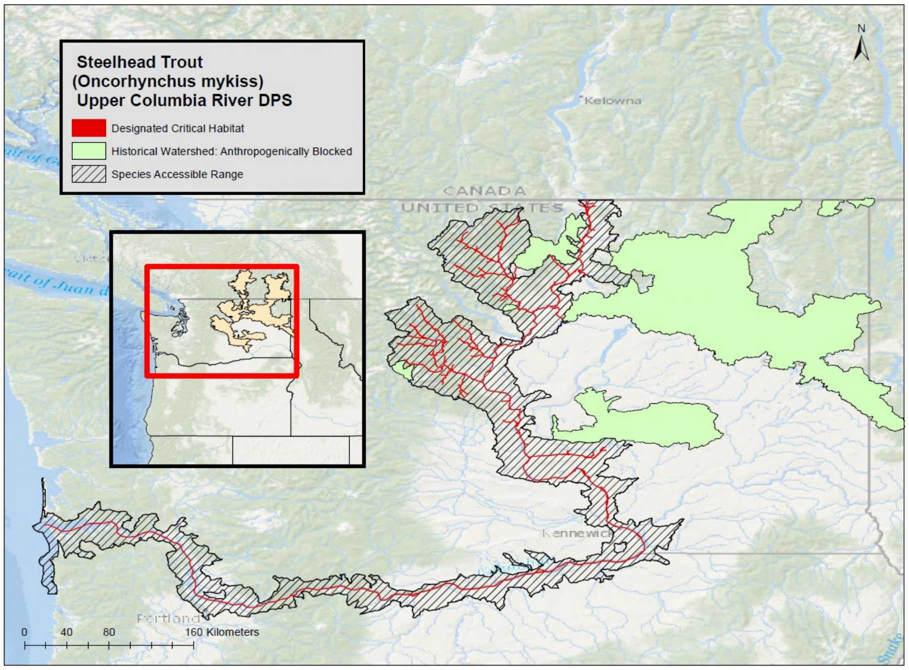

Figure 32. Geographic range and designated critical habitat of upper Columbia River steelhead.

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).

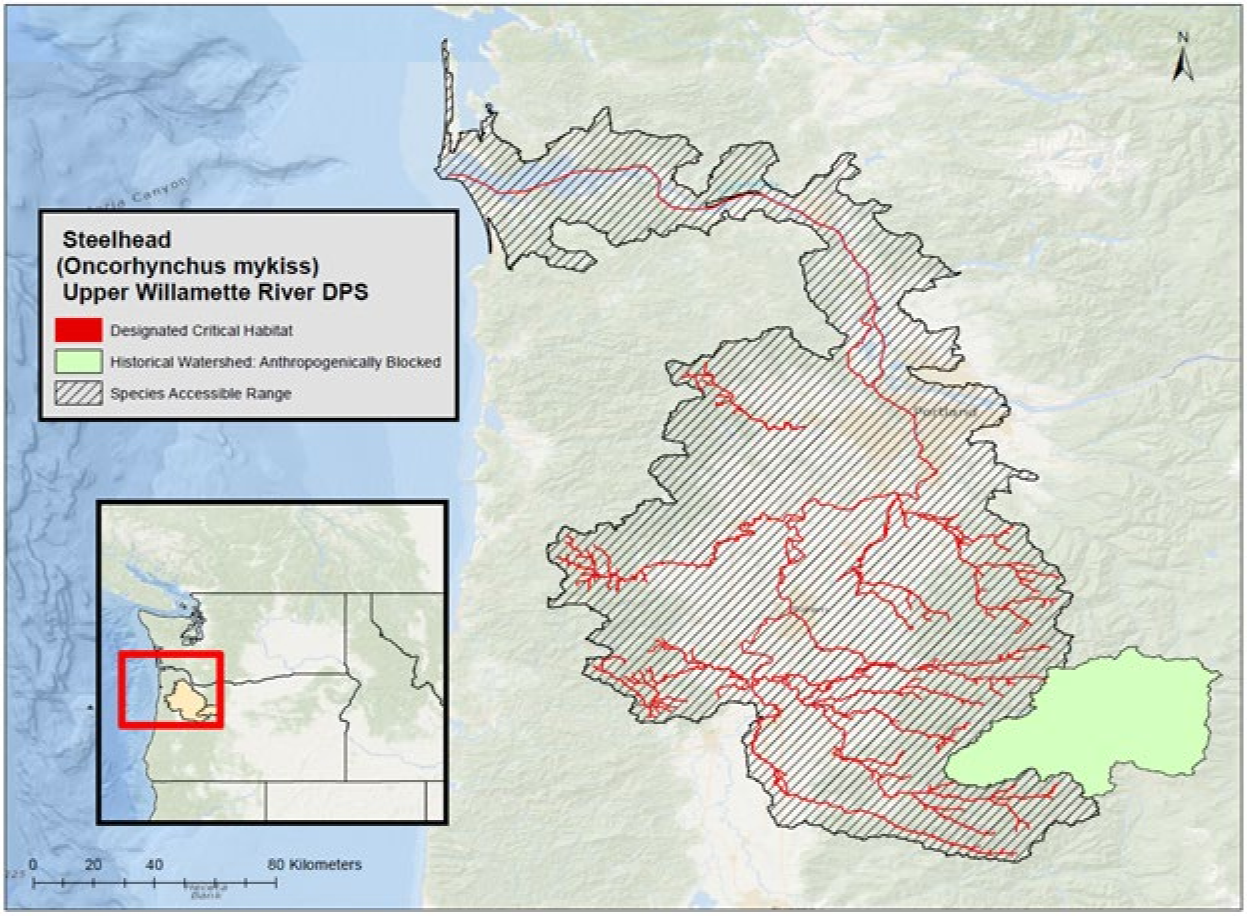

Figure 33. Geographic range and designated critical habitat of upper Willamette River steelhead.

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 ($3.9x10^{13}$ 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

in^3=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 (in^3)	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]

in^3=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]:

[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 km²	0.17 km²	225,386 km²	.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 km²	0.17 km²	639,642 km²	.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 km²	0.17 km²	225,386 km²	.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 km²	0.17 km²	467,536 km²	.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 km²	0.17 km²	198,450 km²	.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 km²	0.17 km²	639,642 km²	.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.

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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

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
1315 East-West Highway
Silver Spring, Maryland 20910

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 shutdown 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 shutdown 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 shutdown, but such observation must be communicated to the operator to prepare for the potential shutdown.

(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 shutdown (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 shutdown, pre-start clearance observation and ramp-up are required. For any shutdown at night or in periods of poor visibility (e.g., BSS 4 or greater), ramp-up is required, but if the shutdown 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) Shutdown

(i) Any PSO on duty has the authority to delay the start of survey operations or to call for shutdown 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 shutdown 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 shutdown is called for by a PSO, the airgun array must be immediately deactivated. Any dispute regarding a PSO shutdown 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 shutdown 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 shutdown 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 shutdown is required.

b. If there is uncertainty regarding identification, visual PSOs may use best professional judgment in making the decision to call for a shutdown.

(vi) Upon implementation of shutdown, 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 shutdown 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, shutdown, 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, shutdown, 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 shutdown procedures for all active acoustic

sources operating within 50 km of the stranding. Shutdown 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 shutdown around the animals' location is no longer needed.

(b) Otherwise, shutdown 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 shutdown 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
North Pacific right whale	2	0
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 in^3)	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 in^3)	>1,000	6,733
	100-1,000	9,468
	<100	12,650

United States Department of the Interior

U.S. FISH AND WILDLIFE SERVICE
1011 East Tudor Road
Anchorage, Alaska 99503

In Reply Refer to:
FWS/IR11/AFES/MMM

INCIDENTAL TAKE AUTHORIZATION
(IHA-21-01)

ISSUED: July 15, 2021
EXPIRES: December 31, 2021

The National Science Foundation and the Lamont-Doherty Earth Observatory and the National Science Foundation (NSF/L-DEO) are authorized to take, by non-lethal Level B harassment, small numbers of northern sea otters (*Enhydra lutris kenyoni*: hereafter "sea otters") during high-energy seismic surveys in the Northeast Pacific Ocean along the coast of Southeast Alaska. This Incidental Harassment Authorization (IHA) is valid between the date of issuance and December 31, 2021. It is issued by the Regional Director-Alaska Region, the U.S. Fish and Wildlife Service (Service) in accordance with section 101(a)(5)(D) of the Marine Mammal Protection Act (MMPA), as amended (16 U.S.C. 1371).

Activities are described in full in the following documents:

- Notice of receipt of application; proposed incidental harassment authorization; request for comments. Proposed Incidental Harassment Authorization for Southeast Alaska Stock of Northern Sea Otters in the Queen Charlotte Fault Region, Alaska (86 FR 30613, June 9, 2021, the "Proposed IHA").
- LGL Limited 2020. "Request by Lamont-Doherty Earth Observatory for an Incidental Harassment Authorization to Allow the Incidental Take of Marine Mammals during Marine Geophysical Surveys by R/V Marcus G. Langseth of the Queen Charlotte Fault in the Northeast Pacific Ocean, Summer 2021." Prepared for: Lamont-Doherty Earth Observatory, Palisades, New York.

General Conditions

1) The taking of Northern sea otters from the Southeast, Alaska, stock whenever the required conditions, mitigation, monitoring, and reporting measures are not fully implemented as required by the IHA is prohibited. Failure to follow measures specified may result in the suspension or revocation of the IHA.

2) If incidental take exceeds the level or type identified in this IHA (e.g., greater than 49 incidents of incidental take of 27 otters by Level B harassment), this IHA may be invalidated and the Service will reevaluate its findings. If project activities cause unauthorized take, such as any injury due to seismic noise, acute distress, or any indication of the separation of mother from pup, NSF/L–DEO must take the following actions:

a) cease its activities immediately (or reduce activities to the minimum level necessary to maintain safety);
b) report the details of the incident to the Service's MMM within 48 hours; and
c) suspend further activities until the Service has reviewed the circumstances, determined whether additional mitigation measures are necessary to avoid further unauthorized taking, and notified NSF/L–DEO that it may resume project activities.

3) All operations managers and vessel operators must receive a copy of this IHA and maintain access to it for reference at all times during project work. These personnel must understand, be fully aware of, and be capable of implementing the conditions of this IHA at all times during project work.

4) This IHA will apply to activities associated with the project as described in this document and in NSF/L–DEO's amended application (LGL 2020). Changes to the project without prior authorization may invalidate this IHA.

5) NSF/L–DEO's IHA application is approved and fully incorporated into this IHA. The application includes:

   a) NSF/L–DEO's original request for an IHA, dated December 19, 2019;
   b) NSF/L–DEO's response to requests for additional information from the Service, dated January 22, February 19 and February 26, 2020; and
   c) A revised application, dated October 29, 2020.

6) Operators will allow Service personnel or the Service's designated representative to visit project work sites to monitor impacts to sea otters and subsistence uses of sea otters at any time throughout project activities so long as it is safe to do so. "Operators" are all personnel operating under the NSF/L–DEO's authority, including all contractors and subcontractors.

Avoidance and Minimization

7) Seismic surveys must be conducted using equipment that generates the lowest practicable levels of underwater sound within the range of frequencies audible to sea otters.

8) Vessels will not approach within 100 meters (m) (328 feet[ft]) of individual sea otters or 500 m (0.3 miles [mi]) of rafts of otters. Operators will reduce vessel speed if a sea otter approaches or surfaces within 100 m (328 ft) of a vessel.

9) Vessels may not be operated in such a way as to separate members of a group of sea otters from other members of the group.

10) All vessels must avoid areas of active or anticipated subsistence hunting for sea otters as determined through community consultations.

Mitigation During Seismic Activities

11) Designated trained and qualified Protected Species Observers (PSO) must be employed to monitor for the presence of sea otters, initiate mitigation measures, and monitor, record, and report the effects of the activities on sea otters. NSF/L–DEO is responsible for providing training to PSOs to carry out mitigation and monitoring.

12) NSF/L–DEO must establish mitigation zones for their 2D seismic surveys, which generate underwater sound levels at or more than or 160 decibel (dB) between 125 Hertz (Hz) and 38 Kilohertz (kHz). Mitigation zones must include all in-water areas where work-related sound received by sea otters will match the levels and frequencies above. Mitigation zones will be designated as follows:

a) Exclusion Zones (EZ) will be established with the following minimum radii: 500 m (0.3 mi) from the source for the full seismic array and 100 m (328 ft) for the single bolt airgun (655 cubic centimeter [cm^3] or 40 cubic inch [in^3]).
b) A Safety Zone (SZ) is an area larger than the EZ and will include all areas within which sea otters may be exposed to noise levels that will likely result in Level B take.
c) Both the EZ and SZ will be centered on the sound source (the seismic array).
d) The radius of the SZs are shown in Table 1 (as calculated based on modeling techniques described in the Proposed IHA and in Appendix A of NSF/L–DEO's application).

Table 1. Estimated radial distances from the seismic sound source to the 160-dB isopleth. The area within the isopleth is designated as the Safety Zone (SZ).

Source and Volume	Water Depth (m)	Predicted distances (in m) to the 160 dB Received Sound Level
Single Bolt airgun, 40 in^3	>1,000 m	431[1]
	100–1,000 m	647[2]
	<100 m	1,041[3]
4 strings, 36 airguns, 6600 in^3	>1,000 m	6,733[1]
	100–1,000 m	9,468[4]
	<100 m	12,650[4]

[1] Distance is based on L–DEO model results.
[2] Distance is based on L–DEO model results with a 1.5 × correction factor between deep and intermediate water depths.
[3] Distance is based on empirically derived measurements in the Gulf of Mexico with scaling applied to account for differences in tow depth.
[4] Based on empirical data from Crone et al. (2014); see Appendix A of the NSF/L–DEO IHA application for details.

13) PSOs must conduct visual monitoring of the entire EZ and the visible SZ continuously during all seismic work occurring in daylight hours.

14) Prior to seismic work, a "ramp-up" procedure must be used to increase the levels of underwater sound at a gradual rate:
   a) A ramp-up will be used at the initial start of airgun operations and prior to restarting after any period greater than 30 minutes (min) without airgun operations, including a power-down or shutdown event.
   b) Visual monitoring must begin at least 30 min prior to and continue throughout ramp-up efforts.
   c) During geophysical work, the number and total volume of airguns will be increased incrementally until the full volume is achieved.
   d) The rate of ramp-up will be no more than 6 dB per 5-min period. Ramp-up will begin with the smallest gun in the array that is being used for all airgun array configurations. During the ramp-up, the applicable mitigation zones (based on type of airgun and sound levels produced) must be maintained.
   e) In thick fog or at other times when the outer part of the EZ is not visible, it is not allowed to ramp-up the full array from a complete shutdown, until visibility allows for visual observations of sea otters.
   f) Ramp-up of the airguns will not be initiated if a sea otter is sighted within the EZ at any time.
   g) If sea otters are observed during a ramp-up effort or prior to startup, a PSO must record the observation and monitor the animal's position until it moves out of visual range. Seismic work may commence if, after a full and gradual effort to ramp up the underwater sound level, the sea otter is outside of the EZ and does not show signs of visible distress (for example, vocalizing, repeatedly spy-hopping, or fleeing).

15) The following actions must be taken in response to sea otters in mitigation zones:

   a) Seismic work will be shut down completely if a sea otter is observed within the 500-m (0.3-mi) EZ for the full array or the 100-m (328-ft) EZ for the 40-in^3 array.
   b) When sea otters are observed in visible distress (for example, vocalizing, repeatedly spy-hopping, or fleeing), seismic work must be immediately shut down or powered down to reduce noise exposure.
   c) The shutdown procedure will be accomplished immediately upon determination that a sea otter is in the applicable EZ or as soon as practicable considering worker safety and equipment integrity.
   d) Following a shutdown, seismic work will not resume until the sea otter has cleared the EZ. The animal will be considered to have cleared the EZ if it is visually observed to have left the EZ or has not been seen within the EZ for 30 min or longer.
   e) Any shutdown due to sea otters sighted within the EZ must be followed by a 30-min all-clear period and then a standard full ramp-up.
   f) Any shutdown for other reasons resulting in the cessation of seismic work for a period greater than 30 min must also be followed by full ramp-up procedures.

16) Operators may reduce power to seismic equipment as an alternative to a shutdown to prevent a sea otter from entering the EZ. A power-down procedure involves reducing the volume of underwater sound generated. Vessel speed or course may be altered to achieve the same task.

a) Whenever a sea otter is detected outside the EZ and, based on its position and motion relative to the seismic work, appears likely to enter the EZ but has not yet done so, the operator may power down to reduce high-level noise exposure.
b) When a sea otter is detected in the SZ, an operator may choose to power down when practicable to reduce Level B take, but is not required to do so.
c) During a power-down, the number of airguns in use will be reduced to a single mitigation airgun (airgun of small volume such as the 655-cm^3 (40-in^3) gun), such that the EZ is reduced, making the sea otters unlikely to enter the EZ.
d) After a power-down, noise-generating work will not resume until the sea otter has cleared the EZ for the full airgun array. The sea otter will be considered to have cleared the EZ if it is visually observed to have left the EZ and has not been seen within the zone for 30 minutes.

17) Visual monitoring must continue for 30 min after the use of the acoustic source ceases or the sun sets, whichever is sooner.

Monitoring

18) Operators shall work with PSOs to apply mitigation measures and shall recognize the authority of PSOs up to and including stopping work, except where doing so poses a significant safety risk to vessels or personnel.

19) Duties of PSOs include: watching for and identifying sea otters, recording observation details, documenting presence in any applicable monitoring zone, identifying and documenting potential harassment, and working with vessel operators to implement all appropriate mitigation measures.

20) A sufficient number of PSOs will be onboard to meet the following criteria: 100 percent monitoring coverage during all daytime periods of seismic activity; a maximum of 4 consecutive hours on watch per PSO; a maximum of approximately 12 hours on watch per day per PSO; and at least 1 observer each on the source vessel and support vessel.

21) All PSOs will complete a training course designed to familiarize individuals with monitoring and data collection procedures. A field crew leader with prior experience as a marine mammal observer will supervise the PSO team. New or inexperienced PSOs will be paired with experienced PSOs so that the quality of marine mammal observations and data recording is kept consistent. Resumes for candidate PSOs will be made available for the Service to review.

22) Observers will be provided with reticule binoculars (10×42), big-eye binoculars or spotting scopes (30×), inclinometers, and range finders. Field guides, instructional handbooks, maps and a contact list will also be made available.

Measures to Reduce Impacts to Alaska Native Subsistence Users

23) Prior to conducting the work, NSF/L–DEO will take the following steps to reduce potential

effects on Alaska Native subsistence harvest of sea otters:

a) Avoid work in areas of known Alaska Native sea otter subsistence harvest;
b) Discuss the planned activities with Alaska Native subsistence stakeholders including Southeast Alaska tribal governments and traditional councils that may be impacted by the activities;
c) Identify and work to resolve concerns of Alaska Native stakeholders, if any, regarding the project's effects on Alaska Native subsistence hunting of sea otters; and
d) If any concerns are not resolved, develop a in consultation with the Service and Alaska Native subsistence stakeholders to address these concerns.

Reporting Requirements

24) NSF/L–DEO must notify the Service at least 48 hours prior to commencement of activities.

25) Reports will be submitted to the Service's MMM weekly during project activities. The reports will summarize project work and monitoring efforts.

26) A final report will be submitted to the Service's MMM within 90 days after completion of work or expiration of the IHA. It will summarize all monitoring efforts and observations, describe all project activities, and discuss any additional work yet to be done. Factors influencing visibility and detectability of marine mammals (e.g., sea state, number of observers, fog, and glare) will be discussed. The report will describe changes in sea otter behavior resulting from project activities and any specific behaviors of interest. Sea otter observation records will be provided in the form of electronic database or spreadsheet files. The report will assess any effects NSF/L–DEO's operations may have had on the availability of sea otters for subsistence harvest and if applicable, evaluate the effectiveness of the POC for preventing impacts to subsistence users of sea otters.

27) Injured, dead, or distressed sea otters that are not associated with project activities (e.g., animals found outside the project area, previously wounded animals, or carcasses with moderate to advanced decomposition or scavenger damage) must be reported to the Service within 24 hours of discovery. Photographs, video, location information, or any other available documentation shall be provided to the Service.

28) All reports shall be submitted by email to *fw7_mmm_reports@fws.gov*.

29) NSF/L–DEO must notify the Service upon project completion or end of the work season.

___________________________________ ______________________

Assistant Regional Director Date
Fisheries and Ecological Services, Alaska Region
U.S. Fish and Wildlife Service