Attachment 1

Final Environmental Assessment/Analysis of Marine Geophysical Surveys by R/V *Marcus G. Langseth* of the Cascadia Subduction Zone in the Northeast Pacific Ocean, 2021

Prepared for

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ABSTRACT

Researchers from Lamont-Doherty Earth Observatory (L-DEO) of Columbia University, Woods Hole Oceanographic Institution (WHOI), and the University of Texas at Austin Institute of Geophysics (UTIG), with funding from the U.S. National Science Foundation (NSF), and in collaboration with researchers from Dalhousie University and Simon Fraser University (SFU), propose to conduct high-energy seismic surveys from the Research Vessel (R/V) *Marcus G. Langseth* (*Langseth*) in combination with Ocean Bottom Seismometers and Nodes at the Cascadia Subduction Zone in the Northeast Pacific Ocean during late spring/summer 2021. R/V *Langseth* is owned by Columbia University and operated by L-DEO. The proposed two-dimensional (2-D) seismic surveys would occur within Exclusive Economic Zones (EEZ) of Canada and the U.S., including U.S. and 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 60–4400 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 two research proposals that have been reviewed under the NSF merit review process and identified as an NSF program priority. They would serve to investigate the Cascadia Subduction Zone and provide data necessary to illuminate the depth, geometry, and physical properties of the seismogenic portion and updip extent of the megathrust zone between the subducting Juan de Fuca plate and the overlying accretionary wedge/North American plate providing essential constraints for earthquake and tsunami hazard assessment in this heavily populated region of the Pacific Northwest. The portion of the megathrust targeted for this survey is the source region for great earthquakes that occurred at Cascadia in pre-historical times, comparable in size to the Tohoku M9 earthquake in 2011; an earthquake of similar size is possible at Cascadia within the next century.

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 U.S. Geological Survey (USGS) has agreed to be a Cooperating Agency. As operator of R/V *Langseth*, L-DEO, on behalf of itself, NSF, WHOI, and UTIG, requested an Incidental Harassment Authorization (IHA) from the U.S. National Marine Fisheries Service (NMFS) and the 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. This document also tiers to the Environmental Assessment of Marine Geophysical Surveys by the R/V *Marcus G. Langseth* in the Northeastern Pacific Ocean, June–July 2012 and issued Finding of No Significant Impact for similar seismic surveys conducted in 2012 in, or near, the proposed survey area.

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, humpback (Central America Distinct Population Segment or DPS), sei, fin, blue, sperm, and Southern Resident DPS of killer whales. It is unlikely that a gray whale from the ***endangered*** Western North Pacific DPS would occur in the project area at the time of the surveys. In addition, the ***threatened*** Mexico DPS of the humpback whale and the ***threatened*** Guadalupe fur seal could occur in the proposed project area. The North Pacific right whale, the Pacific populations of 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. After discussions with USFWS, the original survey design was adjusted to minimize take of sea otters. The sea otter is considered *special concern* under SARA.

ESA-listed sea turtle species that could occur in the project area include the ***endangered*** leatherback turtle and ***threatened*** East Pacific DPS of the green turtle; the Pacific population of leatherback turtle is also listed as *endangered* under SARA, but the green turtle is not listed. ESA-listed seabirds that could be encountered in the area include the ***endangered*** short-tailed albatross (also *endangered* under SARA) and Hawaiian petrel, and the ***threatened*** marbled murrelet (also *threatened* under SARA); the Hawaiian petrel is not listed under SARA.

Several ESA-listed fish species occur in the area, including the ***endangered*** Puget Sound/Georgia Basin DPS of bocaccio; the ***threatened*** Pacific eulachon (Southern DPS), green sturgeon (Southern DPS), yelloweye rockfish, and several DPSs of steelhead trout; and various ***endangered*** and ***threatened*** evolutionary significant units (ESUs) of chinook, chum, coho, and sockeye salmon. In addition, the ***threatened*** bull trout could also occur in shallow water along the coast. In Canada, the South Coast British Columbia population of bull trout is considered *special concern*. The basking shark and northern abalone are listed as *endangered* under SARA

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 still be taken; 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 at least 30 min with no detections; PAM via towed hydrophones during both day and night to complement visual monitoring; shut downs when marine mammals are detected in or about to enter the 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 any 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. Ultimately, 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
ADCP	Acoustic Doppler Current Profiler
AEP	Auditory Evoked Potential
AIS	Automatic Identification System
AMVER	Automated Mutual-Assistance Vessel Rescue
B.C.	British Columbia, Canada
BIA	Biologically Important Area
CA	California
CBD	Convention on Biological Diversity
CCE	California Current Ecosystem
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	(Canada) Department of Fisheries and Oceans
DPS	Distinct Population Segment
EA	Environmental Assessment/Analysis
EBSA	Ecologically or Biologically Significant Marine Areas
EFH	Essential Fish Habitat
EHV	Endeavour Hydrothermal Vents
EIS	Environmental Impact Statement
EO	Executive Order
ESA	(U.S.) Endangered Species Act
ETOMO	Endeavour Tomography
ETP	Eastern Tropical Pacific
EZ	Exclusion Zone
FM	Frequency Modulated
FONSI	Finding of no significant impact
GIS	Geographic Information System
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	The North Pacific Current
NRC	(U.S.) National Research Council
NSF	National Science Foundation
OBN	Ocean Bottom Node
OBS	Ocean Bottom Seismometer
OBSIC	Ocean Bottom Seismometer Instrument Center
ODFW	Oregon Department of Fish and Wildlife
OEIS	Overseas Environmental Impact Statement
OFCC	Oregon Fishermen's Cable Committee
OOI	Ocean Observatories Initiative
p or pk	peak
PDO	Pacific Decadal Oscillation
PEIS	Programmatic Environmental Impact Statement
PI	Principal Investigator
PTS	Permanent Threshold Shift
PSO	Protected Species Observer
QAA	Qualitative Analysis Area
rms	root-mean-square
ROV	remotely operated vehicle
R/V	research vessel
s	second
SAFE	Scientists and Fishermen Exchange (Program)
SARA	(Canada) *Species at Risk Act*
SBP	Sub-bottom Profiler
SEL	Sound Exposure Level (a measure of acoustic energy)
SFU	Simon Fraser University
SIO	Scripps Institution of Oceanography
SPL	Sound Pressure Level
SOSUS	(U.S. Navy) Sound Surveillance System
SWFSC	Southwest Fisheries Science Center
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
UTIG	University of Texas at Austin, Institute of Geophysics
μPa	microPascal
vs.	versus
WCMC	World Conservation Monitoring Centre
WHOI	Woods Hole Oceanographic Institution
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. This document also tiers to the EA of Marine Geophysical Surveys by R/V *Marcus G. Langseth* in the Northeastern Pacific Ocean, June–July 2012 and associated Finding of No Significant Impact (FONSI) for similar seismic surveys conducted in 2012 in, or near, the proposed survey area.[1] 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) has agreed 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 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[2] during the proposed seismic surveys by Columbia University's Lamont-Doherty Earth Observatory (L-DEO) in the Northeast Pacific Ocean during late spring/summer 2021. 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, public comment periods, and tribal coordination, including those received during the NSF NEPA, NMFS/FWS IHA, NMFS/USFWS ESA, and Olympic Coast National Marine Sanctuary (OCNMS) processes, (2) a schedule change from late spring 2020 to late spring/summer 2021 due to COVID-19 impacts, and (3) a change in the mitigation zones from the Draft EA, 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

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[1] EA and FONSI available on the NSF website (https://www.nsf.gov/geo/oce/envcomp/index.jsp).

[2] 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.

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 and Ocean Bottom Seismometers (OBS) and Ocean Bottom Nodes (OBN) to investigate the Cascadia Subduction Zone and provide data necessary to illuminate the depth, geometry, and physical properties of the seismogenic portion and updip extent of the megathrust zone between the subducting Juan de Fuca plate and the overlying accretionary wedge/North American plate, providing new constraints on earthquake and tsunami potential in this heavily populated region of the Pacific Northwest. The proposed activities would collect data in support of two research proposals that were reviewed through the NSF merit review process and were 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;
- 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))[3]; NSF procedures for implementing NEPA and CEQ regulations (45 CFR 640);
- Marine Mammal Protection Act (MMPA) of 1972 (16 USC 1631 *et seq*.);
- Endangered Species Act (ESA) of 1973 (16 USC ch. 35 §1531 *et seq.*);
- National Historic Preservation Act (NHPA) (Public Law 89-665; 54 USC 300101 *et seq.*);
- Coastal Zone Management Act (CZMA) of 1972 (16 USC §§1451 *et seq.*);
- National Marine Sanctuaries Act (16 USC §1431 *et seq.*); and
- Magnuson-Stevens Fishery Conservation and Management Act - Essential Fish Habitat (EFH) (Public Law 94-265; 16 USC ch. 38 §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. Additionally, two 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.

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[3] 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 posted for public comment on the NSF website 7 February 2020), and the agency has decided to proceed under the 1978 regulations.

2.1 Proposed Action

The Final EA includes analysis for two separate proposals received by NSF; however, due to their linked and dependent nature, they are considered the Proposed Action and are jointly analyzed herein. The Proposed Action, including project objectives and context, activities, and monitoring/mitigation measures for the proposed seismic surveys and use of OBSs and OBNs, is described in the following subsections.

2.1.1 Project Objectives and Context

Researchers from L-DEO, Woods Hole Oceanographic Institution (WHOI), and the University of Texas at Austin Institute of Geophysics (UTIG), have proposed to conduct seismic surveys using R/V *Langseth* in the Northeast Pacific Ocean (Fig. 1). Although not funded through NSF, collaborators from the USGS, Drs. M. Nedimovic (Dalhousie University), and A. Calvert (Simon Fraser University; SFU) would work with the PIs to achieve the research goals, providing assistance, such as through logistical support, and data acquisition and exchange.

OBSs and OBNs would leverage the seismic surveys by R/V *Langseth*. A complementary land-based research effort is also under consideration for NSF funding. Although the project has independent utility and therefore would undergo separate environmental review, the project would capitalize on proposed R/V *Langseth* marine-based activities and would vastly expand the geophysical dataset available for analysis for the Cascadia region. In addition, the proposed deep-penetration survey would complement the shallow-imaging study by the USGS that is planned for the region as part of their multi-year hazard assessment study. The collection of seismic data by R/V *Langseth* would also represent an essential step in the development of International Ocean Discovery Program (IODP) activities along the Cascadia margin. The IODP project, which is not part of the Proposed Action, has been reviewed in a pre-proposal by the IODP Science Evaluation Panel. To complete the full proposal and subsequently execute its science plan, seismic data must be collected to identify drilling targets and to evaluate their suitability from both scientific and safety perspectives. The following information provides an overview of the research project objectives associated with the surveys.

At the Cascadia Subduction Zone, the slow ongoing descent of the Juan de Fuca plate beneath the northwestern coast of North America has generated large earthquakes and associated tsunamis in the past. Geologic records suggest that some sections of the subduction zone fault or "megathrust", which extends ~35–90 mi. seaward from the coasts of northern California all the way to southern British Columbia (B.C.), slipped less than other sections during the last earthquake (1700 AD), and that in some prior large earthquakes, only parts of the subduction zone ruptured. The last earthquake is estimated to have been of magnitude 9, similar to that of the Tohoku earthquake in Japan in 2011; an earthquake of similar size is possible at Cascadia within the next century. Whether current inferences of along-margin variations in fault slip during the last earthquake may persist in future ruptures has important implications for quantifying earthquake and tsunami hazards for the population centers of the Pacific Northwest. Geologic structure such as seamounts and other topographic features in the descending Juan de Fuca plate, the structure and properties of the thick folded and faulted package of sediments that forms above the subduction zone fault, or the properties of megathrust fault rocks, could contribute to these along-margin variations. While at most of the World's subduction zones there is abundant present-day seismicity along the megathrust which can be used to constrain first-order properties of the subduction fault including its depth and geometry, the Cascadia Subduction Zone is "eerily" quiet with little seismicity recorded from much of the megathrust. With the paucity of instrumentally-recorded seismicity and the lack of offshore geodetic constraints on the distribution of interseismic locking, little is known of the properties of the subduction zone fault interface

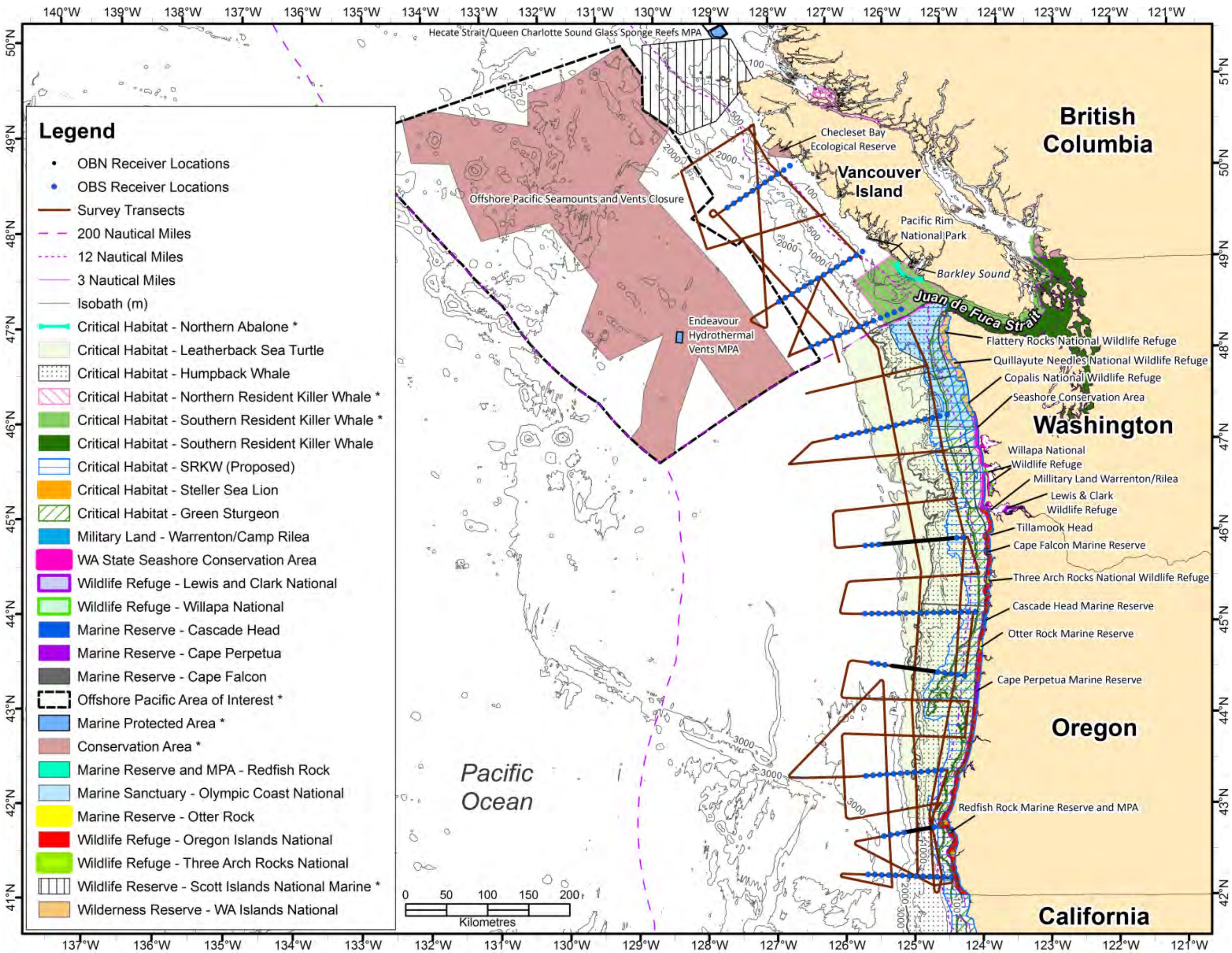


FIGURE 1. Location of the proposed seismic surveys in the Northeast Pacific Ocean and conservation areas near the proposed survey location. Canadian conservation areas and critical habitat are denoted by *. WA = Washington; SRKW – Southern Resident Killer Whale.

within the mega-thrust earthquake zone and how they vary along and across strike. The current observations allow for a wide range of possible future earthquake scenarios.

The acquired data would be designed to characterize: 1) the deformation and topography of the incoming plate; 2) the depth, topography, and reflectivity of the megathrust; 3) sediment properties and amount of sediment subduction; and 4) the structure and evolution of the accretionary wedge, including geometry and reflectivity of fault networks, and how these properties vary along strike, spanning the full length of the margin and down dip across what may be the full width of the seismogenic zone at Cascadia. The data would be processed to pre-stack depth migration using state-of-the art seismic processing techniques and would be made openly available to the community, providing a high-quality data set illuminating the regional subsurface architecture all along the Cascadia Subduction Zone.

Aside from localized surveys conducted in 2012 by R/V *Langseth* using an 8-km streamer, no modern multi-channel seismic (MCS) data have been acquired at the Cascadia Subduction Zone. Data acquired prior to these surveys were collected in the 80's and 90's with much shorter streamers (2.6–4 km) and poorer quality sources and provide poor-to-no image of the earthquake fault interface at Cascadia. Long streamer (>8 km) MCS data represent major advances over the previous generation of MCS studies in the region for two primary reasons. (1) Data acquired with long-offset streamers support advanced techniques for noise and multiple suppression that enable imaging with improved clarity and resolution of the plate interface to much greater depths than previously obtained. (2) They enable construction of high-resolution, high-accuracy velocity models, which not only contribute to improved imaging via pre-stack depth migration, but can provide constraints on material properties at the megathrust that affect slip behavior. The proposed 15-km long streamer would provide significantly improved velocity determination from both reflection move-out based analysis and recorded refractions. The proposed study would also provide the first regional-scale characterization of the full length of the Cascadia Subduction Zone, enabling the first study of along-strike segmentation in megathrust properties. It would move the Cascadia megathrust zone from arguably one of the least well characterized heavily populated megathrust regions to one of the best.

Modern long-offset marine seismic reflection imaging techniques provide the best tools available for illuminating a subduction zone to the depths of the earthquake source region and below. They also provide constraints on geologic structure and material properties at the subduction fault that contribute to frictional state and variations in slip behavior along the fault. The overall goal of the seismic program proposed by L-DEO, UTIG, and WHOI is to acquire a regional grid of modern marine seismic reflection data spanning the entire Cascadia Subduction Zone to image how the geologic structure and properties of this subduction zone vary both along and across the margin. To achieve the project goals, the Principal Investigators (PI) Drs. S. Carbotte (L-DEO), P. Canales (WHOI), and S. Han (UTIG) propose to utilize 2-D seismic reflection capabilities of R/V *Langseth* and OBSs and OBNs.

2.1.2 Proposed Activities

2.1.2.1 Location of the Survey Activities

The proposed survey would occur within ~42–51°N, ~124–130°W. Representative survey tracklines are shown in Figure 1. As described further in this document, however, some deviation in actual track lines, 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, as well as in U.S. state waters and Canadian Territorial Waters, ranging in depth 60–4400 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, and a shot interval of 37.5 m (~17 s). The receiving system would consist of a 15-km long hydrophone streamer. OBSs and OBNs would be deployed from a second vessel, R/V *Oceanus*; this OBS program would leverage the seismic surveys by R/V *Langseth*.

As the airgun arrays are towed along the survey lines, the hydrophone streamer would transfer the data to the on-board processing system; the OBSs and OBNs would receive and store the returning acoustic signals internally for later analysis. Approximately 6540 km of transect lines would be surveyed in the Northeast Pacific Ocean. Most of the survey (69%) would occur in deep water (>1000 m), 28% would occur in intermediate water (100–1000 m deep), and ~3% would take place in shallow water <100 m deep. Approximately 3.6% of the transect lines (234 km) would be undertaken in Canadian Territorial Waters, with most effort in intermediate waters.

Long 15-km-offset MCS data would be acquired along numerous 2-D profiles oriented perpendicular to the margin and located to provide coverage in areas inferred to be rupture patches during past earthquakes and their boundary zones. The survey would also include several strike lines including one continuous line along the continental shelf centered roughly over gravity-inferred fore-arc basins to investigate possible segmentation near the down-dip limit of the seismogenic zone. The margin normal lines would extend ~50 km seaward of the deformation front to image the region of subduction bend faulting in the incoming oceanic plate, and landward of the deformation front to as close to the shoreline as can be safely maneuvered. It is proposed that the southern transects off Oregon are acquired first, followed by the profiles off Washington and Vancouver Island, B.C.

In addition to the operation 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 40 days, including ~37 days of seismic operations, 2 days of equipment deployment, and 1 day of transit. R/V *Langseth* would likely leave out of Newport, OR, and return to port in Seattle, WA, during late spring/summer 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 (late spring/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).

R/V *Oceanus* would be used to deploy OBSs and OBNs. R/V *Oceanus* has a length of 54 m, a beam of 10 m, and a draft of 5.3 m. The ship is powered by one EMD diesel engine, producing 3000 hp, which drives the single screw propeller. The vessel also has a 350 hp bowthruster. The cruising speed is 20 km/h, the endurance is 30 days, and the range is ~13,000 km.

Other details of R/V *Oceanus* include the following:

Owner:	National Science Foundation
Operator:	Oregon State University
Flag:	United States of America
Date Built:	1975
Gross Tonnage:	261
Accommodation Capacity:	25 including ~13 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; 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 37.5 m.

2.1.2.6 OBS and OBN Description

The OBSs would consist of short-period multi-component OBSs from the Ocean Bottom Seismometer Instrument Center (OBSIC) and a large-*N* array of OBNs from a commercial provider to record shots along ~10 margin-perpendicular profiles. OBSs would be deployed at 10-km spacing along ~10 profiles from Vancouver Island to Oregon, and OBNs would be deployed at a 500-m spacing along a portion of three profiles off Oregon. Two OBS deployments would occur with a total of 115 instrumented locations. One deployment consisting of 60 OBSs to instrument six profiles off Oregon, and a second deployment of 55 OBSs to instrument four profiles off Washington and Vancouver Island. The first deployment off Oregon would occur prior to the start of the proposed survey, after which R/V *Langseth* would acquire data in the southern portion of the study area. R/V *Oceanus* would start recovering the OBSs from deployment 1, and then re-deploy 55 OBSs off Washington and Vancouver Island, so that R/V *Langseth* can acquire data in the northern portion of the survey area. The OBSs have a height and diameter of ~1 m, and most would have an ~80 kg anchor made of steel. OBSs deployed within the OCNMS (three total) would have a concrete anchor, ~0.3 m x 0.3 m x 0.16 m, weighing ~36 kg in air and ~20 kg in water. The concrete anchors disintegrate faster than the steel anchors. While the concrete anchors have some steel embedded as an attachment point for the OBS, they would degrade, mainly to sand.

A total of 350 nodes would be deployed: 179 nodes along one transect off northern Oregon, 1007 nodes along a second transect off central Oregon, and 64 nodes along a third transect off southern Oregon. The nodes are not connected to each other; each node is independent from each other, and there are no cables attached to them. Each node has internal batteries; all data is recorded and stored internally. The nodes weigh 21 kg in air (9.5 kg in water). As the OBNs are small (330 mm x 289 mm x 115 mm), compact, not buoyant, and lack an anchor-release mechanism, they cannot be deployed/recovered by free-fall as with the OBSs. The nodes would be deployed and retrieved using a tethered remotely operated vehicle (ROV);

the ROV would be deployed from R/V *Oceanus*. OBNs would be deployed ~17 days prior to the start of the R/V *Langseth* cruise. The ROV would be fitted with a skid with capacity for 32 units, lowered to the seafloor, and towed at a speed of 0.6 kt at 5–10 m above the seafloor between deployment sites. After the 32 units are deployed, the ROV would be retrieved, the skid would be reloaded with another 32 units, and sent back to the seafloor for deployment, and so on. The ROV would recover the nodes 3 days after the completion of the R/V *Langseth* cruise. The nodes would be recovered one by one by a suction mechanism.

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. 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. However, OBSs would not be recovered by R/V *Langseth*.

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 those recommendations 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 full R/V *Langseth* source array is needed to reach the deep imaging targets of the megathrust and oceanic Moho under the continental margin (up to ~20 km bsl). This large source is also needed to ensure recording of refracted arrivals at large ranges of up to 200 km on the planned OBS array as well as an array of land stations that may be deployed.

***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*. Although marine mammals, including baleen whales, are expected to occur regularly in the proposed survey area during the spring and summer, the peak migration period for gray whales is expected to occur before the start of the surveys. Late spring/summer is the most practical season for the proposed surveys based on operational requirements.

Changes to the location of proposed seismic transect were also made during consultation with NMFS, USFWS, and DFO. Off Washington and Oregon, all transect lines and the associated Level B ensonified areas (based on the 160-dB re 1µPa_{rms} sound level) were moved out of high-density killer whale habitat and/or areas off Washington and B.C. in water <100 m depth. All lines off Washington were also moved out of the 100-m isobath to avoid part of the proposed critical habitat for killer whales and >21 km from shore to avoid sea otters takes. In addition, off Oregon, proposed transect lines and associated 160-dB ensonified areas around the lines were moved outside of potential sea otter habitat (within the 40-m isobath) off Newport, Cape Arago, and Cape Blanco. After discussions with Canadian Department of Fisheries and Oceans (DFO), transect lines and associated 160-dB ensonified areas were moved out of Canadian designated critical habitat for killer whales off Vancouver Island, B.C.

***Mitigation Zones*.—**During the planning phase, mitigation zones for the proposed marine seismic surveys using the 36-airgun array (at a tow depth of 12 m) were not derived from the farfield signature but based on modeling by L-DEO for both the exclusion zones (EZ) for Level A takes and full mitigation zones (160 dB re 1µPa_{rms}) for Level B takes. L-DEO model results were used to determine the 160-dB_{rms} radius for the 36-airgun array and 40-in^3 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).In the Draft EA, the radii for intermediate water depths (100–1000 m) were derived from the deep-water ones by applying a correction factor of 1.5. For shallow water (<100 m), radii were based on empirically derived measurements in the Gulf of Mexico (GoM) with scaling applied to account for differences in tow depth (see Appendix A).

However, after consultation with NMFS, the mitigation zones for the Level B (160-dB) threshold were revised based on a combination of empirical data and modeling. The background information and methodology for this are provided in Appendix A. The L-DEO model results were still 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. However, for the 36-airgun array, radii for intermediate-water depths (100–1000 m) and shallow water (<100 m) were 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 and shallow water were derived as before.

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 U.S. Navy (USN 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 (USN 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).

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]

[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] An EZ of 100 m would be used as the shut-down distance for sea turtles in all water depths.
[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. 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 Turtles
PTS SEL$_{cum}$	**426.9**	0	1.3	13.9	0	**20.5**
PTS Peak	38.9	**13.6**	**268.3**	**43.7**	**10.6**	10.6

This document was 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 power 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, and dwarf and pygmy sperm whales. 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. However, based on recent direction from NMFS, power downs would not be allowable under the IHA; shut downs would be implemented for marine mammals within the designated EZ. A power down would be implemented for sea turtles or diving ESA-listed seabirds in U.S. waters. A 100-m EZ would be used for shut downs of the single airgun during power downs for sea turtles and seabirds. Enforcement of mitigation zones via power and shut downs 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).

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). Vessels would maintain a separation distance of 500 m from any right whale, 400 m from killer whales in Canadian waters between the U.S. EEZ and just north of Barkley Sound, 200 m from killer whales in all other 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, North Pacific Right Whale, and all killer whales, whether they are detected visually or acoustically. Shut downs within an EZ of 1500 m would occur for pygmy sperm, dwarf sperm, and beaked whales. In U.S. waters, the designated EZ for shut downs for other marine mammals (with the exception of bow-riding dolphins) is 500 m. In Canadian waters, the designated EZ for shut downs for other marine mammal species and sea turtles is 1000 m, except for sperm whales, for which the EZ is 1500 m.

Additional mitigation measures for the endangered southern resident killer whale stock would be implemented. The "Management measures to protect southern resident killer whales" released by DFO would be adhered to, and are included in the summary above regarding separation distances. . North of Tillamook Head, OR, there would be no night-time seismic operations in water <200 m deep; survey operations would occur in daylight hours only (i.e., from 30 minutes prior to sunrise through 30 minutes following sunset) to ensure the ability to use visual observation as a detection-based mitigation tool and to implement shut down procedures for species or situations with additional shut-down requirements outlined above (e.g., killer whale of any ecotype, North Pacific right whale, aggregation of six or more large whales, large whale with a calf).

Additionally, while R/V *Langseth* is surveying north of Tillamook Head OR, in waters 200 m deep or less, and when operating within the OCNMS and Makah Tribal U&A Fishing Areas, a secondary monitoring vessel with additional PSOs would be employed to observe ahead of and communicate with R/V *Langseth* regarding presence of killer whales and other cetaceans for assistance with implementation of mitigation measures. This secondary vessel would travel ~5 km ahead of R/V *Langseth*, and two PSOs would be on watch during all survey operations to alert PSOs on R/V *Langseth* of any marine mammal sightings so that they may be prepared to initiate shut down, if necessary. Each day of survey operations, L–DEO would contact NMFS Northwest Fisheries Science Center, NMFS West Coast Region, The Whale Museum, Orca Network, Canada's DFO, the Makah Tribe, and/or other sources to obtain near real-time reporting for the whereabouts of Southern Resident killer whales.

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 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

Table 3 provides a summary of the Proposed Action, alternative, and alternatives eliminated from further analysis.

2.3.1 Alternative E1: Alternative Location

At the Cascadia Subduction Zone, the slow ongoing descent of the Juan de Fuca plate beneath the northwestern coast of North America has generated large earthquakes and associated tsunamis in the past in this heavily populated region of the Pacific Northwest. This would be the first seismic imaging investigation spanning nearly the entire length of the Cascadia Subduction Zone and would move the Cascadia megathrust zone from arguably one of the least well characterized heavily populated megathrust regions to one of the best. The overarching goal of the study is to use modern MCS data to characterize subducting plate and accretionary wedge structure, and properties of the megathrust, along the full length of the Cascadia Subduction Zone. This regional characterization would be used to determine whether there are any systematic relationships among upper and lower plate properties, paleorupture segmentation, and along-margin variations in present-day coupling at Cascadia. The data would also be used to characterize down-dip variations along the megathrust that may be linked to transitions in fault properties, from the updip region near the deformation front, which is of most interest for tsunamigenesis, to near shore where the downdip transition in the locked zone may reside.

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 ~39 days, plus 1 day for transit. Additional operational days would be expected for 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. and Canada. 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 increasing our understanding of Cascadia Subduction Zone, adding to the comprehensive assessment of geohazards for the Pacific Northwest such as earthquakes and tsunamis, and for the development of an earthquake early warning network, 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	At the Cascadia Subduction Zone, the slow ongoing descent of the Juan de Fuca plate beneath the northwestern coast of North America has generated large earthquakes and associated tsunamis in the past in this heavily populated region of the Pacific Northwest. This would be the first seismic imaging investigation spanning nearly the entire length of the Cascadia Subduction Zone and would move the Cascadia megathrust zone from arguably one of the least well characterized heavily populated megathrust regions to one of the best. The acquired data would add to the comprehensive assessment of geohazards for the Northeast Pacific region. 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.

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. 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).

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 from the actions being proposed here; other activities (e.g., land-based component) will be analyzed under separate review. 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. 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 disturbances to seafloor sediments from OBN and 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 majority of the peration area is outside of the land and coastal viewshed.
- *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 Oregon, Washington, and B.C. (see Section 3.9), the proposed activities would occur in water depths >60 m, outside the range for recreational SCUBA diving. Human activities in the area around the survey vessel would be limited to fishing activities, NMFS trawl surveys, 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. The North Pacific Current (NPC) is a warm water current that flows west to east between 40ºN 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 California Current system nutrifies offshore waters by mixing with water from the shelf edge (Buchanan et al. 2001).

The northern portion of the proposed survey area (i.e., Vancouver Island) is located within the Gulf of Alaska Large Marine Ecosystem (LME); this LME is classified as a Class II, moderately productive (150–300 $gC/m^2/y$) ecosystem (Aquarone and Adams 2009a). The southern portion of the proposed survey area (Washington and Oregon) is located within the California Current LME. This LME is considered a Class III low productivity ecosystem (<150 $gC/m^2/y$) although seasonal upwelling of cold nutrient-rich water in this region generate localized areas of high productivity supporting fisheries (Aquarone and Adams 2009b). Winds blowing toward the equator cause upwelling during March–November and are strongest over the main flow of the California Current which is 200–400 km offshore (Longhurst 2007). Persistent eddies in the summer in some locations, like the Strait of Juan de Fuca, can transport upwelling waters up to several hundred kilometers offshore (Longhurst 2007). Even in winter, cold upwelled water "tongues" can extend offshore for hundreds of kilometers, increasing nutrient levels offshore (Longhurst 2007). The highest productivity occurs in May–June (Longhurst 2007). Acoustic backscatter surveys within the California Current LME showed that fish and zooplankton are associated with shallow bathymetry in this region; the highest densities were located in water <4000 m deep (Philbrick et al. 2003).

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 Gulf of Alaska 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 (CCE) 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 the U.S.

Several habitats near or within the proposed survey area have been specifically identified as important to U.S. ESA-listed species, including critical habitat for marine mammals, sea turtles, seabirds, and fish. Although there is critical habitat adjacent to the survey area for the ***threatened*** Pacific Coast population of western snowy plover and the ***threatened*** marbled murrelet, this habitat is strictly terrestrial and would not be affected by the proposed activities.

***Steller Sea Lion Critical Habitat*.—**Federally designated critical habitat for Steller sea lions in Oregon and California includes all rookeries (NMFS 1993). Although the Eastern Distinct Population Segment (DPS) was delisted from the ESA in 2013, the designated critical habitat remains valid (NOAA 2019b). The critical habitat in Oregon is located along the coast at Rogue Reef (Pyramid Rock) and Orford Reef (Long Brown Rock and Seal Rock; see Fig. 1). The critical habitat area includes aquatic zones that extend 0.9 km seaward and air zones extending 0.9 km above these terrestrial and aquatic zones (NMFS 1993). The Orford Reef and Rogue Reef critical habitats are located ~13.5 km and ~17 km from the nearest proposed seismic transect line, respectively.

Southern Resident Killer Whale Critical Habitat*.—**Critical habitat for the ***endangered Eastern North Pacific Southern Resident stock of killer whales is defined in detail in the Code of Federal Regulations (NMFS 2006). Critical habitat currently includes three specific marine areas of Puget Sound, WA: the Summer Core Area, Puget Sound, and the Strait of Juan de Fuca. The critical habitat includes all waters relative to a contiguous shoreline delimited by the line at a depth of 6.1 m relative to extreme high water. The western boundary of the Strait of Juan de Fuca Area is Cape Flattery, WA (48.38°N; 124.72°W), which is ~49 km from the closest seismic transect line (Fig. 1). None of the proposed transect lines and associated ensonified areas occur within designated critical habitat, and all tracklines are >21 km from shore.

In January 2014, NMFS received a petition requesting an expansion to the Southern Resident killer whale critical habitat to include Pacific Ocean marine waters along the U.S. west coast from Cape Flattery, WA, to Point Reyes, CA, extending ~76 km offshore; NMFS released a 12-month finding in February 2015 accepting the validity of a critical habitat expansion (NMFS 2015a). Although no revisions have yet been made to the critical habitat, NMFS recently issued a proposed rule for the expansion of critical habitat to include U.S. coastal waters between the 6.1-m and 200-m isobath from the border with Canada south to Point Sur, CA (NMFS 2019a). Some of the proposed survey lines enter the proposed critical habitat.

All originally-proposed transect lines and their associated 160-dB ensonified areas have been moved away from (1) high-density killer whale habitat along the coasts of Oregon and Washington, and/or (2) shallow water <100 m deep off Washington, as required by NMFS, and shallow water <100 m deep off B.C. In addition, most tracklines in water <100 m deep off Oregon were eliminated, except for a section of the coast with a larger protrusion of shallow-water topography. Airgun operations in water 100–200 m deep north of Tillamook Head, OR, would only occur during the daytime, and a secondary monitoring vessel would be used to look for killer whales ahead of the survey. Each day of survey operations, L–DEO would contact NMFS Northwest Fisheries Science Center, NMFS West Coast Region, The Whale Museum, Orca Network, Canada's DFO or other sources to obtain near real-time reporting for the whereabouts of Southern Resident killer whales.

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 2021a). Critical habitat for the Central America and Mexico DPSs includes waters within the CCE off the coasts California, Oregon, and Washington (Fig. 1). Off Washington, critical habitat includes waters from the 50-m to 1200-m isobaths, as well as the Strait of Juan de Fuca eastward to Angeles Point; however, there is an exclusion area of 1461 nmi^2 around the Navy's Quinault Range Site. Off Oregon, the critical habitat spans from the 50-m to 1200-m isobath, except for areas south of 42.17°N, where the offshore boundary is at the 2000-m isobath. There is also critical habitat for the Mexico and Western Pacific DPSs in Alaska waters (NMFS 2021a). No transect lines or ensonified areas would occur within the 100-m isobath between Tillamook Head, OR, and Barkley Sound; most of the survey and ensonified areas off Oregon are also outside the 100-m isobath.

Leatherback Sea Turtle Critical Habitat.—In January 2012, NMFS designated critical habitat for the ***endangered*** leatherback sea turtle along the west coast of the U.S. (NMFS 2012). The critical habitat includes marine areas of ~64,760 km^2 from Cape Flattery, WA, to Cape Blanco, OR, and ~43,798 km^2 off California (NMFS 2012). The survey area east of the 2000-m contour is located within critical habitat (see Fig. 1).

Green Sturgeon Critical Habitat.—Coastal U.S. marine critical habitat for the ***threatened*** Southern DPS of North American green sturgeon includes waters within ~109 m (60 fathoms) depth from Monterey Bay, CA, north to Cape Flattery, WA, to its U.S. boundary, encompassing 29,581 km^2 of marine habitat (NMFS 2009). The proposed survey area that is located in water depths less than 109 m occurs within this critical habitat (see Fig. 1). Between Tillamook Head and Barkley Sound, all transect lines and 160-dB ensonified areas would occur outside of the 100-m isobath. Off Oregon, the majority of transect lines are located outside of the 109-m isobath, but some effort on Hecate Bank is proposed to occur in water depths 60–109 m.

Rockfish Critical Habitat.—Critical habitats have been designated for the ***threatened*** Puget Sound/Georgia Basin DPS of yelloweye rockfish and for the ***endangered*** Puget Sound/Georgia Basin DPS of bocaccio (NMFS 2014). However, no critical habitat occurs within the proposed survey area.

Pacific Eulachon Critical Habitat.—Critical habitat has been designated for the ***threatened*** Southern DPS of Pacific eulachon/smelt for Washington and Oregon. Most of the critical habitat occurs in freshwater rivers and creeks, but some does include estuarine waters (NMFS 2011a; NOAA 2019b). However, none of the proposed seismic transect lines enter critical habitat.

Salmonid Critical Habitat.—Critical habitat has been designated for a number of ESA-listed salmonid species or evolutionary significant units (ESU) for Washington and Oregon (see Section 3.7.1, Table 6, for list of species). Most of the critical habitat occurs in freshwater rivers and creeks, but some of it includes nearshore marine waters (NOAA 2019b). However, none of the proposed seismic transect enter critical habitat.

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 two populations of marine mammals 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 ***threatened*** marbled murrelet occurs adjacent to the study area, but this habitat is strictly terrestrial and would not be affected by the proposed activities. 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" (DFO 2018a). According to DFO, critical habitat could include areas used for spawning, rearing young, feeding and migration, depending on the species and may not be destroyed (DFO 2018a).

Southern Resident Killer Whale Critical Habitat.—Critical habitat has been designated in the trans-boundary waters in southern B.C., including the southern Strait of Georgia, Haro Strait, and Strait of Juan de Fuca (DFO 2018a). The continental shelf waters off southwestern Vancouver Island, including Swiftsure and La Pérouse Banks have also been designated as critical habitat (DFO 2018a). The critical habitat has features such as prey availability (specifically chinook and chum salmon), suitable acoustic environment, water quality, and physical space that provide areas for feeding, foraging, reproduction, socializing, and resting (DFO 2018a). After consultations with DFO, none of the proposed transect lines or their associated 160-dB ensonified areas would enter the critical habitat on Swiftsure and La Pérouse banks (see Fig. 1). In addition, in 2020, DFO released 'Management measures to protect southern resident killer whales, that specify that a minimum distance of 200 m must be kept from killer whales in all Canadian Pacific waters, except for designated areas (including critical habitat) in which a minimum distance of 400 m must be kept (DFO 2021). The R/V *Langseth* would not approach any killer whales within 200 m. In addition, during seismic acquisition, the vessel would be traveling at a speed of 4.2 kt which is below the recommended speed when killer whales are within 1000 m. If practicable, R/V *Langseth* would slow down to 7 kt while transiting to and from the survey area, if killer whales are within 1000 m.

Northern Resident Killer Whale Critical Habitat.—Critical habitat has been designated in Johnstone Strait and southeastern Queen Charlotte Strait. The continental shelf waters off southwestern Vancouver Island, including Swiftsure and La Pérouse Banks, have also been designated as critical habitat, as well as western Dixon Entrance along the north coast of Graham Island, Haida Gwaii (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). After consultations with DFO, none of the proposed transect lines or their associated 160-dB ensonified areas would enter the critical habitat on Swiftsure and La Pérouse Banks (see Fig. 1).

***Northern Abalone Critical Habitat*.—**Critical habitat for northern abalone has been identified within four distinct geospatial areas that include Barkley Sound and surrounding waters on the southwest coast of Vancouver Island (see Fig. 1), the west and east coasts of Haida Gwaii, and the north and central coasts of B.C. (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). The critical habitat is located at least 40 km from the closest seismic transect (see Fig. 1).

3.2.3 Other Conservation Areas in U.S. Waters

There are two portions of U.S. military land which are closed to access near the mouth of the Columbia River, referred to as Warrenton/Camp Rilea (USGS 2019). All conservation areas near the project area are listed below and shown on Fig. 1. Only those areas within 100 km of the proposed survey area are discussed below.

***Washington Islands National Wildlife Refuges*.—**The Washington Islands National Wildlife Refuges (NWRs) are located along 161 km of the outer coast of the Olympic Peninsula, encompassing more than 600 islands, sea stacks, rocks, and reefs. The area is comprised of three NWRs: Copalis NWR (47.13–47.48ºN), Quillayute Needles NWR (47.63–48.03ºN), and Flattery Rocks NWR (48.03–48.38ºN). The refuges do not include islands that are part of designated Native American reservations. Along much of the coastline adjacent to the islands lies the Olympic National Park (ONP). In 1970, all three of the Washington Islands NWRs were designated as Wilderness Areas, except for Destruction Island in Quillayute Needles NWR. As many as 500 Steller sea lions haul out and 150,000 pelagic birds nest annually on these islands (USFWS 2007). The OCNMS incorporates the entire area surrounding the islands and rocks of all three refuges (USFWS 2007). At its closest point, the Washington Islands NWR is ~30 km east of the nearest seismic transect (see Fig. 1). There are ~150 km of seismic transects within the sanctuary; 138 km are in intermediate water, and 12 km in deep water. No effort would occur in shallow water.

***Olympic Coast National Marine Sanctuary*.—**The OCNMS, designated in 1994, includes 8259 km^2 of marine waters off the Washington coast, extending 40–72 km seaward and covering much of the continental shelf and several major submarine canyons (NOAA 2011). The sanctuary protects a productive upwelling zone with high productivity and a diversity of marine life (NOAA 2011). This area also has numerous shipwrecks. The OCNMS management plan provides a framework for the sanctuary to manage potential threats to the sanctuary's marine resources under the *National Marine Sanctuaries Act*. Federal law provides national marine sanctuaries the authority to adopt regulations and issue permits for certain activities, including taking any marine mammal, sea turtle, or seabird in or above the sanctuary, except as authorized by the MMPA, the ESA, and the *Migratory Bird Treaty Act*. The easternmost portions of some seismic transects (totaling 150 km) would enter the OCNMS, and three OBSs are proposed to be deployed within the OCNMS, (Fig. 1). None of the transect lines within the OCNMS would occur in water <100 m deep.

Coastal Treaty Tribes (Hoh, Makah, Quileute, and Quinault) and the State of Washington also have responsibility for regulation of activities and management of marine resources within the boundaries of the OCNMS; therefore, OCNMS coordinates with them on regulatory jurisdiction over marine resources and activities within the boundaries of the Sanctuary. The OCNMS shares an overlapping boundary in the intertidal zone with the ONP. The ONP, designated in 1938, is a zone of exclusive federal jurisdiction encompassing 3734 km^2 and including some of the beaches and headlands along the coast (USFWS 2007). Approximately 75% of the coastal strip is in Congressionally designated wilderness, which is afforded additional protections under the *Wilderness Act*. The OCNMS is a partner in the management of the ONP marine resources.

***Lewis and Clark National Wildlife Refuge*.—**The Lewis and Clark NWR includes ~20 islands stretching over 43.5 km of the Columbia River, from the mouth upstream to nearly Skamakowa, WA (USFWS 2019). This refuge was established in 1972 to preserve the fish and wildlife habitat of the Columbia River estuary and supports large numbers of waterfowl, gulls, terns, wading birds, shorebirds, raptors, and songbirds. It is located ~60 km southeast of the closest seismic transect (see Fig. 1).

***Willapa National Wildlife Refuge*.—**The Willapa NWR is located within Willapa Bay and Columbia River, WA. It was established in 1973 by President Franklin D. Roosevelt to protect migrating birds and their habitat (USFWS 2013). It consists of multiple segments, with the nearest located ~43 km northeast of the closest seismic transect (see Fig. 1).

***Oregon Islands National Wildlife Refuge*.—**The Oregon Islands NWR (OINWR) spans 515 km of the Oregon coast from the Oregon/California border to Tillamook Head (~45.9°N) and includes all rocks and islands above the line of mean high tide, except for rocks and islands of the Three Arch Rocks NWR. All of the island acreage is designated National Wilderness, with the exception of Tillamook Rock (USFWS 2015). The OINWR is located ~2.3 km east of the nearest seismic transect (see Fig. 1).

***Three Arch Rocks National Wildlife Reserve*.—**Three Arch Rocks NWR consists of 60 m^2 on three large and six small rocky islands located ~1 km from shore. It is one of the smallest designated wilderness areas in the U.S. and is the only pupping site for the Steller sea lion in northern Oregon (USFWS 2016a). This NWR is located ~13 km southeast from the closest seismic transect (see Fig. 1).

***Washington State Seashore Conservation Area*.—**The Washington State Seashore Conservation Area includes all seashore between the line of ordinary high tide and the line of extreme low tide between Cape Disappointment (~46.3°N) and Griffiths Priday State Park (~47.1°N). The Conservation Area is under the jurisdiction of the Washington state parks and recreation commission (Washington State Parks n.d.). The Seashore Conservation Area is ~32 km east of the closest seismic transect (see Fig. 1).

***Cape Falcon Marine Reserve*.—**The Cape Falcon Marine Reserve combines a marine reserve and two marine protected areas (MPAs) located at ~45.7ºN, 124ºW. The entire protected area extends ~7 km along the coast of Oregon and out to ~7 km (see Fig. 1). The reserve and MPA portions are 32 km^2 and 20 km^2, respectively (ODFW 2019a). No animals or seaweed may be taken from the reserve (ODFW 2019a). The Cape Falcon Marine Reserve is located ~13.5 km east of the closest seismic transect (see Fig. 1).

***Cascade Head Marine Reserve*.—**This site includes a marine reserve surrounded by three MPAs and is located off the central Oregon coast at ~45°N, 124ºW. The entire protected area extends 16 km along the coast (see Fig. 1) and out to 5.6 km (ODFW 2019a), with total areas of 25.1 km^2 and 59.7 km^2 for the marine reserve and MPA portions, respectively. No animals or seaweed may be taken from the reserve (ODFW 2019a). Cascade Head Marine Reserve is located ~6 km east of the closest seismic transect (see Fig. 1).

***Otter Rock Marine Reserve*.—**The Otter Rock Marine Reserve encompasses 3 km^2 of nearshore rocky intertidal habitat at ~44.72–44.75°N (ODFW 2019a). No animals or seaweed may be taken from the reserve (ODFW 2019a). The reserve is located ~16 km east of the closest seismic transect (see Fig. 1).

***Cape Perpetua Marine Reserve*.—**This site combines a marine reserve, two MPAs, and a seabird protection area. It is located off the central coast of OR at ~44.2ºN, 124.1ºW. The entire protected area extends ~26.5 km along the coast (see Fig. 1) and out to ~5 km, with total areas of 37 km^2 and 49 km^2 for the reserve and MPA portions, respectively (ODFW 2019a). This marine reserve is located ~7 km east of the closest seismic transect (see Fig. 1).

***Redfish Rock Marine Reserve and Marine Protected Area*.—**The Redfish Rock Marine Reserve and MPA is located at ~42.67–44.70°N. The marine reserve encompasses 7 km^2 of nearshore water, and the adjacent MPA covers an additional ~13 km^2 (ODFW 2019a). Redfish Rock Marine Reserve is located 18 km east of the closest seismic transect (see Fig. 1).

3.2.4 Other Conservation Areas in Canada

Only those conservation areas within 100 km of the proposed survey area are discussed below. Race Rocks Ecological Reserve is located in the Strait of Juan de Fuca ~101 km from the nearest survey transect; it is currently under consideration for designation as an MPA and is an Area of Interest (AOI) (DFO 2017a). Hecate Strait/Queen Charlotte Sound Glass Sponge Reefs MPA is located 112 km from the nearest proposed seismic transect. There are several rockfish conservation areas (RCAs) adjacent to the proposed survey area; these are discussed in Section 3.6.5.

***Offshore Pacific Area of Interest/Proposed Offshore Pacific MPA*.—**The Offshore Pacific Area of Interest encompasses 139,700 km^2 of the Offshore Pacific Bioregion (OPB) west of Vancouver Island (DFO 2020a). It has unique seafloor features such as seamounts and hydrothermal vents and ecosystems that support the OPB. It includes the Offshore Pacific Seamounts and Vents Closure area, where all bottom contact from recreational and commercial fishing is prohibited, as well as other activities incompatible with the conservation of the ecological components. An advisory committee has been established for this AOI, and a management approach is being developed to move towards the protection of this area. The western-most seismic transects enter the AOI (see Fig. 1).

***Endeavour Hydrothermal Vents MPA*.—**The Endeavour Hydrothermal Vents (EHV) were designated as the first MPA under Canada's *Oceans Act* in 2003 (DFO 2018b). The EHV area covers 97 km^2 and is located on the Juan de Fuca Ridge, 256 km offshore from Vancouver Island, 2250 m below the ocean's surface (Tunnicliffe and Thompson 1999); it occurs within the AOI. Under the Canadian *Oceans Act,* underwater activities that may result in the disturbance, damage, destruction, or removal of the seabed, or any living marine organism or any part of its habitat, are prohibited in this MPA (Government of Canada 2021a). The EHV area is located ~84 km west of the closest seismic transect (see Fig. 1).

***Scott Islands Marine National Wildlife Area*.—**This area (11,546 km^2) was established in June 2018 under Canada's *Wildlife Act* and consists of the marine waters extending out from the northwestern tip of Vancouver Island and surrounding the five islands of the Scott Islands (Government of Canada 2021b). The Scott Islands support the greatest concentration of breeding seabirds on the Pacific coast of Canada, hosting over 1 million nesting seabirds a year, including tufted puffins, common murres, Cassin's auklets, and rhinoceros auklets (Government of Canada 2021b). It also attracts up to 10 million migratory birds annually, including short-tailed albatross, black-footed albatross, pink-footed shearwater, marbled murrelet, and ancient murrelet (Government of Canada 2021b). Pinniped rookeries are also located at the Scott Islands (Hoyt 2011), and the region encompasses a RCA. This National Wildlife Area is located ~30 km from the closest proposed seismic transect (see Fig. 1).

This area is also an Ecologically and Biologically Significant Area (EBSA) as determined by DFO due to its biologically rich environment, the diversity of marine mammals and fish, and it is important habitat for marine mammal species listed under SARA. In this National Wildlife Reserve, regulations prohibit any activity that is likely to disturb, damage, or destroy wildlife or its habitat. Among other restrictions, it is not permitted to be within 300 m of the low water mark of Triangle, Sartine, or Beresford islands, and vessels exceeding 400 t cannot anchor within 1 n.mi. of the aforementioned three islands (Government of Canada 2021c).

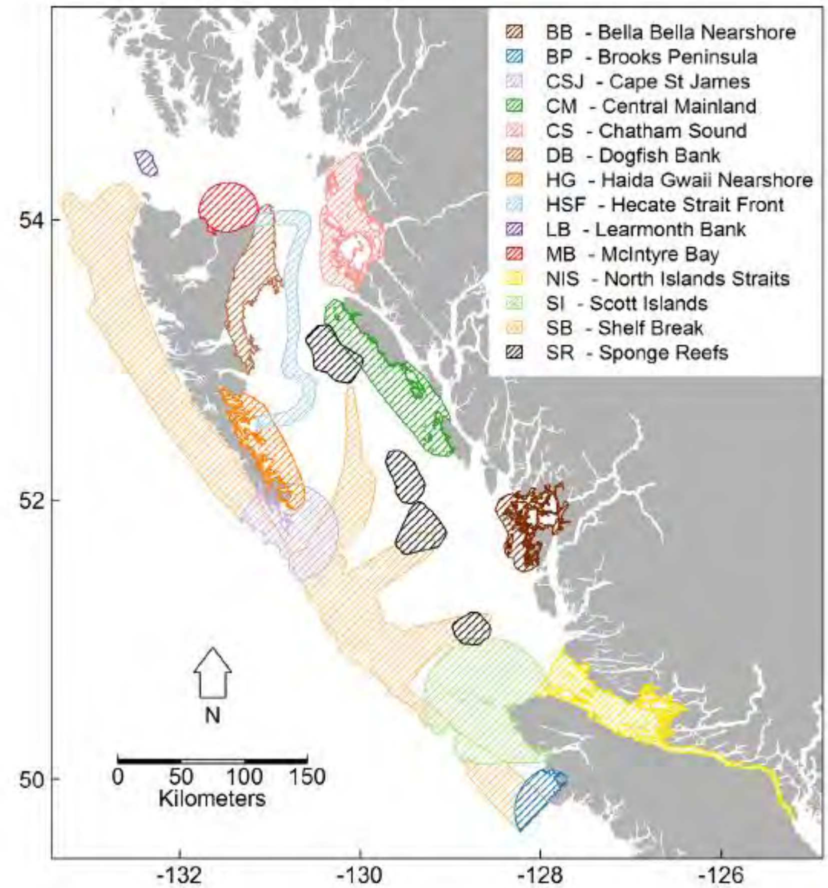
***Checleset Bay Ecological Reserve*.—**This ecological reserve is 346.5 km^2 and is located between Kyuquot and the Brooks Peninsula, off the northwest coast of Vancouver Island. It encompasses marine habitat for a reintroduced population of sea otters to increase their range and abundance; it also includes an RCA (B.C. Parks 2019). Fisheries restrictions are in effect in the reserve and research activities may be carried out but only under permit (B.C. Parks 2019). The Checleset Bay Ecological Reserve is located adjacent to the survey area (see Fig. 1).

***Pacific Rim National Park Reserve*.—**The marine component of this National Park Reserve covers 220.5 km^2 (Hoyt 2011). It is located in coastal and nearshore waters of southwestern Vancouver Island, including parts of Barkley Sound, and encompasses habitat for gray whales, in particular during the summer, as well as for numerous other marine species (Hoyt 2011). It is located 16 km east of the closest seismic transect. The National Park Reserve is partially located within the Clayoquot Sound UNESCO World Biosphere Reserve and includes several RCAs.

Clayoquot Sound UNESCO Biosphere Reserve encompasses a diverse range of ecosystems; it was designated in 2000 (UNESCO 2019). The marine component of Clayoquot Sound supports mudflats, beaches, and estuaries and contains the largest cover of eelgrass on the west coast of Vancouver Island. The marine area is important for gray whales, humpback whales, killer whales, and a variety of other marine mammal species.

***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 northern portion of the survey area. 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 EBSA is an area of relatively higher ecological or biological significance than surrounding areas (Rubridge et al. 2018). 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 five EBSAs within the survey area and two EBSAs adjacent to the survey area (Fig. 2; Table 4).



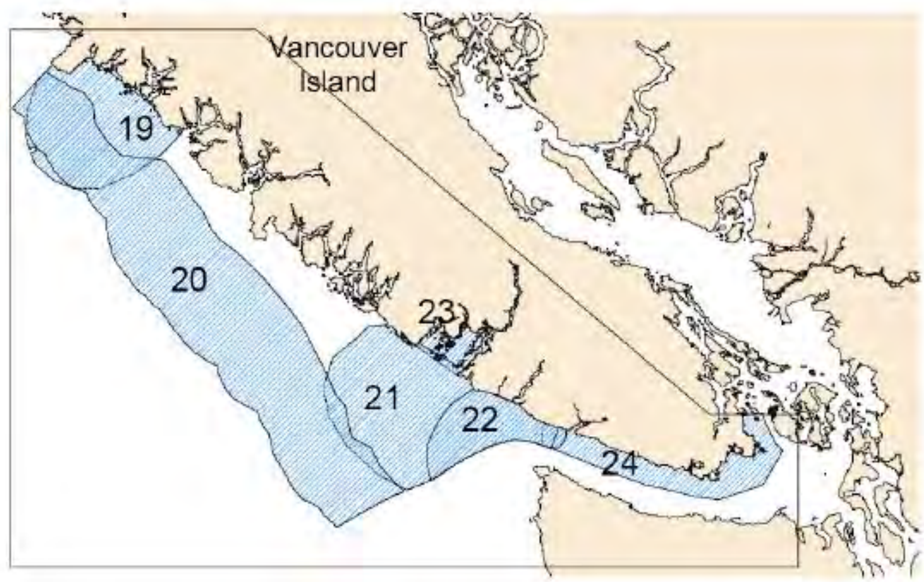


FIGURE 2. EBSAs off the B.C. coast in (a) the Pacific Northern Shelf Bioregion (Source: Rubidge et al. 2018) and (b) the Southern Shelf Bioregion (Source: DFO 2013b; 19 = Brooks Peninsula; 20 = Shelf Break; 21 = Continental Shelf Off Of Barkley Sound; 22 = Juan de Fuca Eddy; 23 = Barkley Sound and Alberni Inlet; 24 = Strait of Juan de Fuca).

TABLE 4. Summary of the Ecologically or Biologically Significant Marine Areas (a) within Canadian waters of the proposed survey area, and (b) adjacent to the proposed survey area.

(a)

EBSA	Location	Significance	References
Scott Islands (SI)	Archipelago of five islands (Lanz, Cox, Sartine, Beresford, Triangle Island) located off the northwestern point of Vancouver Island, ~10 km off Cape Scott Provincial Park	• Area of significant upwelling and tidal mixing • High plankton productivity Important Species: • Spawning, breeding, or rearing: Pacific cod, lingcod, sablefish, arrowtooth flounder, Petrale sole, butter sole, rock sole, dover sole, English sole, widow rockfish, Steller sea lion, Cassin's auklet, rhinoceros auklet, tufted puffin, common murre, cormorants, pigeon guillemot, storm petrel, glaucous winged gull • Feeding: Pacific hake, Pacific herring, gray whale, northern fur seal • Aggregation: humpback whale, sea otter	Clarke and Jamieson (2006); DFO (2013b); Ban et al. (2016); Rubidge et al. (2018)
Brooks Peninsula (BI)	West coast of Vancouver Island. Brooks Peninsula juts 20 km into the Pacific Ocean and is home to a Provincial Park	• High diversity of breeding and migrating bird species • High plankton productivity • Bottleneck between Brooks Peninsula and the Southern Shelf Break Important Species: • Spawning, rearing, or breeding: lingcod, common murre, tufted puffin, glaucous-winged gull, rhinoceros auklet • Aggregation: sea otter • Migration: possibly green sturgeon	DFO (2013b); Ban et al. (2016); Rubidge et al. (2018)
Southern Shelf Break (SSB)	West coast of Vancouver Island from the Brooks Peninsula down to Barkley Sound along the shelf	• High productivity and aggregation of plankton • Site of strong trophic transfers Important Species: • Spawning, rearing, or breeding: sablefish, dover sole, rockfish • Feeding: humpback whale, hake, northern fur seal • Aggregation: sperm, fin, blue, and sei whale; coral; tanner crab; possibly leatherback turtle	DFO (2013b); Ban et al. (2016)
Continental Shelf off Barkley Sound	West coast of Vancouver Island that forms the entrance Alberni Inlet	• High productivity and aggregation of plankton • Submarine banks, convergent circulation, and shallow depths • High trophic transfer Important Species: • Spawning, rearing, or breeding: Pacific herring, Pacific cod, sand lance • Feeding: humpback whale, southern resident killer whale, porpoise, northern fur seal, Steller sea lion, Pacific sardine, Pacific hake, candlefish • Aggregation: green sturgeon, dungeness crab, shrimp • Migration: Pacific sardine, candlefish, gray whale	DFO (2013b)
Juan de Fuca Eddy	West coast of Vancouver Island and to the northwest coast of the Olympic Peninsula, WA	• Geographical bottleneck Important Species: • Spawning, rearing, or breeding: Pacific herring • Feeding: gray whale, Pacific salmon • Aggregation: harbor porpoise, Dover sole, Pacific hake, green sea urchin • Migration: Pacific salmon, Pacific herring, candlefish	DFO (2013b)

(b)

EBSA	Location	Significance	References
Barkley Sound and Alberni Inlet	West coast of Vancouver Island that forms the entrance to Alberni Inlet	• Geographical bottleneck Important Species: • Spawning, rearing, or breeding: Pacific herring, juvenile eulachon, flatfish, gull, pelagic cormorant, • Feeding: gray whale, humpback whale, harbor seal, Steeler sea lion, salmon, sardine, surf scoter • Aggregation: Pacific loon, pigeon guillemot, marbles murrelets, Olympia oyster, Pacific oyster • Migration: green sturgeon, Pacific salmon • Uniqueness: Pacific hake (resident) inshore stock, historical basking shark records	DFO (2013b)
Juan de Fuca Strait	West coast of Vancouver Island and to the northwest coast of the Olympic Peninsula of Washington	• Geographical bottleneck Important Species: • Spawning, rearing, or breeding: Pacific herring • Feeding: gray whale, Pacific salmon • Aggregation: harbor porpoise, Dover sole, Pacific hake, green sea urchin, dungeness crab • Migration: Pacific salmon, eulachon • Uniqueness: killer whale critical habitat	DFO (2013b)

3.3 Marine Mammals

Thirty-three marine mammal species could occur in or near the proposed survey area, including 7 mysticetes (baleen whales), 19 odontocetes (toothed whales), 6 pinnipeds (seals and sea lions), and the northern sea otter (Table 5). Seven of the species are listed under the U.S. ESA as ***endangered***, including the sperm, humpback (Central America DPS), sei, fin, blue, North Pacific right, and Southern Resident DPS of killer whales. The ***threatened*** Mexico DPS of the humpback whale and the ***threatened*** Guadalupe fur seal could also occur in the proposed survey area. It is very unlikely that gray whales from the ***endangered*** Western North Pacific DPS would occur in the proposed survey area. The long-beaked common dolphin (*D. capensis*) and rough-toothed dolphin (*Steno bredanensis*) are distributed farther to the south. These species are unlikely to be seen in the proposed survey area and are not addressed in the summaries below. Although no sightings of *D. capensis* have been made off Oregon/Washington, Ford (2005) reported seven confirmed *D. capensis* sightings in B.C. waters from 1993–2003. All records occurred in inshore waters; Ford (2005) described *D. capensis* as a "rare visitor" to B.C. waters, more likely to occur during warm-water periods. No other sightings have been made since 2003 (Ford 2014).

General information on the taxonomy, ecology, distribution and movements, and acoustic capabilities of marine mammals are given in § 3.6.1, § 3.7.1, § 3.8.1, and § 3.8.1 of the PEIS. One of the qualitative analysis areas (QAAs) defined in the PEIS, the B.C. Coast, is located just to the north 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. Southern California was chosen as a detailed analysis area (DAA) in the PEIS. The general distribution of mysticetes, odontocetes, pinnipeds, and sea otters in southern California is discussed in § 3.6.2.3, § 3.7.2.3, § 3.8.2.3, and § 3.9.2.2 of the PEIS, respectively. The rest of this section deals specifically with species distribution in the proposed survey area. Although Harvey et al. (2007) and Best et al. (2015) provide information on densities and marine mammal hotspots in B.C. waters, their survey areas do not cover the proposed study area.

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]
					COSEWIC[4]	SARA[5]		
Mysticetes								
North Pacific right whale	Rare	Coastal, shelf, offshore	400-500[8]	EN	EN	EN	CR[9]	I
Gray whale	Common	Coastal, shelf	232[10]; 26,960	DL[11]	EN[12]	NS	LC[13]	I
Humpback whale	Common	Mainly nearshore and banks	2,900; 10,103[14]	EN/T[15]	SC	SC	LC	I
Common minke whale	Uncommon	Nearshore, offshore	636; 20,000[16]	NL	NAR	NS	LC	I
Sei whale	Rare	Mostly pelagic	519; 27,197[17]	EN	EN	EN	EN	I
Fin whale	Common	Slope, pelagic	9,029; 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	1,997; 26,300[20]	EN	NAR	NS	VU	I
Pygmy sperm whale	Rare	Deep, off shelf	4111	NL	NAR	NS	DD	II
Dwarf sperm whale	Rare	Deep, shelf, slope	N.A.	NL	NS	NS	DD	II
Cuvier's beaked whale	Uncommon	Pelagic	3,274	NL	NAR	NS	LC	II
Baird's beaked whale	Uncommon	Pelagic	2,697	NL	NAR	NS	DD	I
Blainville's beaked whale	Rare	Pelagic	3,044[21]	NL	NAR	NS	DD	II
Hubbs' beaked whale	Rare	Slope, offshore	3,044[21]	NL	NAR	NS	DD	II
Stejneger's beaked whale	Uncommon	Slope, offshore	3,044[21]	NL	NAR	NS	DD	II
Common bottlenose dolphin	Rare	Coastal, shelf, deep	1,924[22]	NL	NAR	NS	LC	II
Striped dolphin	Rare	Off continental shelf	29,211	NL	NAR	NS	LC	II
Short-beaked common dolphin	Uncommon	Shelf, pelagic, seamounts	969,861	NL	NAR	NS	LC	II
Pacific white-sided dolphin	Common	Offshore, slope	26,814 22,160[41]	NL	NAR	NS	LC	II
Northern right whale dolphin	Common	Slope, offshore waters	26,556	NL	NAR	NS	LC	II
Risso's dolphin	Uncommon	Shelf, slope, seamounts	6,336	NL	NAR	NS	LC	II
False killer whale	Rare	Pelagic	N.A.	NL	NAR	NS	NT	II
Killer whale	Common	Widely distributed	75[23] 243[24] 302[25] 300[26]	EN[27]	EN/T[28]	EN/T[28]	DD	II
Short-finned pilot whale	Rare	Pelagic, high-relief	836	NL	NAR	NS	LC	II
Harbor porpoise	Common	Shelf	21,487[29]; 24,195[30] 8,091[41]	NL	SC	SC	LC	II
Dall's porpoise	Common	Shelf, slope, offshore	25,750 5,303[41]	NL	NAR	NS	LC	II
Pinnipeds								
Guadalupe fur seal	Rare	Mainly coastal, pelagic	34,187	T	NAR	NS	LC	I

Species	Occurrence in Area[1]	Habitat	Abund-ance[2]	U.S. ESA[3]	Canada		IUCN[6]	CITES[7]
					COSEWIC[4]	SARA[5]		
Northern fur seal	Uncommon	Pelagic, offshore	14,050[31] 620,660[32]	NL	T	NS	VU	N.A.
Northern elephant seal	Uncommon	Coastal, pelagic in migration	179,000[33]	NL	NAR	NS	LC	N.A.
Harbor seal	Common	Coastal	24,732[34] 105,000[42]	NL	NAR	NS	LC	N.A.
Steller sea lion	Common	Coastal, offshore	77,149[35] 4,037[41]	DL[36]	SC	SC	NT[37]	N.A.
California sea lion	Uncommon	Coastal	257,606[38]	NL	NAR	NS	LC	N.A.
Fissipeds								
Northern Sea Otter	Rare	Coastal	2,058[39] 6,754[43] 2,928[44]	NL[40]	SC	SC	EN	II

[1] Occurrence in area at the time of the survey; based on professional opinion and available data.
[2] Abundance for Eastern North Pacific, U.S., or CA/OR/WA stock from Carretta et al. (2020), unless otherwise stated.
[3] U.S. *Endangered Species Act* (ESA; NOAA 2019d): EN = Endangered, T = Threatened, NL = Not listed.
[4] Committee on the Status of Endangered Wildlife in Canada (COSEWIC) status (Government of Canada 2021); 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 2021d); 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 2019); CR = Critically Endangered; EN = Endangered; VU = Vulnerable; LC = Least Concern; DD = Data Deficient.
[7] Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES; UNEP-WCMC 2017): 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 critically endangered; globally, the North Pacific right whale is endangered.
[10] Pacific Coast Feeding Group (Calambokidis et al. 2019).
[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 (IWC 2018).
[17] Central and Eastern North Pacific (Hakamada and Matsuoka 2015a).
[18] North Pacific (Ohsumi and Wada 1974).
[19] Eastern North Pacific Stock (Calambokidis and Barlow 2013).
[20] Eastern Temperate Pacific; estimate based on visual sightings (Barlow and Taylor 2005).
[21] All mesoplodont whales (Moore and Barlow 2017; Carretta et al. 2020).
[22] California/Oregon//Washington offshore stock (Carretta et al. 2020).
[23] Southern Resident stock (OrcaNetwork 2021).
[24] West Coast Transient stock; minimum estimate (Muto et al. 2020).
[25] Northern Resident stock (Muto et al. 2020).
[26] North Pacific Offshore stock (Carretta et al. 2020).
[27] The Southern Resident DPS is listed as endangered; no other stocks are listed.
[28] Southern resident population is as endangered; the northern resident, offshore, and transient populations are threatened.
[29] Northern Oregon/southern Washington stock (Carretta et al. 2020).
[30] Northern California/Southern Oregon stock (Carretta et al. 2020).
[31] California stock (Carretta et al. 2020).
[32] Eastern Pacific stock (Muto et al. 2020).
[33] California breeding stock (Carretta et al. 2020).
[34] Oregon and Washington Coast stock; estimate >8 years old (Carretta et al. 2020).
[35] Estimate for entire Eastern stock (Muto et al. 2020).
[36] The Eastern DPS was delisted in 2013 (78 FR 66139, 4 November 2013); the Western DPS is listed as endangered.
[37] Globally considered as near threatened; western population listed as endangered.
[38] U.S. stock (Carretta et al. 2020).
[39] Washington (Jeffries et al. 2019).
[40] Southwest Alaska DPS is listed as threatened.
[41] Coastal waters of B.C. (Best et al. 2015).
[42] B.C. (Ford 2014).
[43] B.C. (Nichol et al. 2015).
[44] USFWS (2021).

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 Gulf of Alaska, 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).

Whaling records indicate that right whales once ranged across the entire North Pacific north of 35ºN and occasionally occurred as far south as 20ºN (Kenney 2018). Although right whales were historically reported off the coast of Oregon, occasionally in large numbers (Scammon 1874; Rice and Fiscus 1968), extensive shore-based and pelagic commercial whaling operations never took large numbers of the species south of Vancouver Island (Rowlett et al. 1994). Nonetheless, Gilmore (1956) proposed that the main wintering ground for North Pacific right whales was off the Oregon coast and possibly northern California, postulating that the inherent inclement weather in those areas discouraged winter whaling (Rice and Fiscus 1968).

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 acoustically (McDonald and Moore 2002; Munger et al. 2003; 2005, 2008; Berchok et al. 2009). They are known to occur in the 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 Gulf of Alaska 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 Gulf of Alaska 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 Gulf of Alaska 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 (located in water 1390 m deep) 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). Since 1951, there have only been three 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 2017b). The third and most recent sighting was made off Haida Gwaii in June 2018 (CBC 2018a). 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., Washington, and Oregon in recent decades, and the likelihood that animals would be feeding in the Bering Sea and Gulf of Alaska at the time of the survey, it is possible although very 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, although it is unlikely that a gray whale from the Western North Pacific DPS would be encountered during the time of the survey. 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. In 2009, Punt and Wade (2012) estimated that the eastern North Pacific population was at 85% of its carrying capacity of 25,808 individuals.

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–June (Rice and Wolman 1971), with a peak into the Gulf of Alaska during mid-April (Braham 1984). Instead of migrating to arctic and sub-arctic 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 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), and the U.S. and Canada recognize it as such (COSEWIC 2017; Carretta et al. 2019). However, the status of the PCFG as a separate stock is currently unresolved (Weller et al. 2013). For the purposes of abundance estimates, the PCFG is defined as occurring between 41°N to 52°N from 1 June to 30 November (IWC 2012). The 2017 abundance estimate for the PCFG was 232 whales (Calambokidis et al. 2019); ~100 of those may occur in B.C. 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 the mainland (Ford 2014). During surveys in B.C. waters during summer, most sightings were made within 10 km from shore in water shallower than 100 m (Ford et al. 2010a).

BIAs for feeding gray whales along the coasts of Washington, Oregon, and California have been identified, including northern Puget Sound, Northwestern Washington, and Grays Harbor (WA); Depoe Bay and Cape Blanco & Orford Reef (OR), and Point St. George (CA); most of these areas are of importance from late spring through early fall (Calambokidis et al. 2015). Resident gray whales have been observed foraging off the coast of Oregon from May–October (Newell and Cowles 2006) and off Washington from June through November (Scordino et al. 2014). A least 28 gray whales were observed near Depoe Bay, OR (~44.8°N), for three successive summers (Newell and Cowles 2006). BIAs have also been identified for migrating gray whales along the entire coasts of Washington, Oregon, and California; although most whales travel within 10 km from shore, the BIAs were extended out to 47 km from the coastline (Calambokidis et al. 2015). Gray whales from the far north begin to migrate south to breeding grounds on the west coast of Baja California and the southeastern Gulf of California in October and November (Braham 1984; Rugh et al. 2001). Gray whales migrate closest to the Washington/Oregon coastline during spring (April–June), when most strandings are observed (Norman et al. 2004).

Oleson et al. (2009) observed 116 gray whales off the outer Washington coast (~47ºN) during 42 small boat surveys from August 2004 through September 2008; mean distances from shore during the southern migration (December–January), northern migration (February–April), and summer feeding (May–October) activities were 29, 9, and 12 km, respectively; mean bottom depths during these activities were 126, 26, and 33 m, respectively. Ortega-Ortiz and Mate (2008) tracked the distribution and movement patterns of gray whales off Yaquina Head on the central Oregon coast (~44.7°N) during the southbound and northbound migration in 2008. The average distance from shore to tracked whales ranged from 200 m to 13.6 km; average bottom depth of whale locations was 12–75 m. The migration paths of tracked whales seemed to follow a constant depth rather than the shoreline. During aerial surveys over the shelf and slope off Oregon and Washington, gray whales were seen during the months of January, June–July, and September; one sighting was made off the Columbia River estuary in water >200 m during June 2011 (Adams et al. 2014). Two sightings of three whales were seen from R/V *Northern Light* during a survey off southern Washington in July 2012 (RPS 2012a).

In B.C., gray whales are common off Haida Gwaii and western Vancouver Island (Williams and Thomas 2007), in particular during 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. 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).

The proposed surveys would occur during the late spring/summer feeding season, when most individuals from the eastern North Pacific stock occur farther north. However, some migrating gray whales could occur within the nearshore waters of the survey area. All transect lines off Washington are located at least 21 km from shore, and at least 9.5 km off Oregon. As most whales are likely to occur closer to shore when migrating, gray whales are unlikely to be encountered within the survey area; nonetheless, the airgun array would be shut down if a gray whale mother-calf pair were sighted during operations. In addition to migrating whales, individuals from the PCFG could be encountered in nearshore waters of the proposed project area, although few are expected to be seen more than 10 km from shore.

In 2019, NOAA declared an unusual mortality event (UME) for gray whales, as an elevated number of strandings have occurred along the coast of the Pacific Northwest since January 2019 (NOAA 2021a). As of 8 March 2021, a total of 418 stranded gray whales have been reported, including 203 in the U.S. (48 in Washington; 9 in Oregon), 199 in Mexico, and 16 in B.C.; some of the whales were emaciated (NOAA 2021a). A UME for gray whales was also declared in 1999–2000 (NOAA 2021a).

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. 2019). 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 from the Hawaii, Mexico, and Central America DPSs could occur in the proposed survey area. According to Wade (2017), off southern B.C. and Washington, ~63.5%, 27.9%, and 8.7% are from the Hawaii, Mexico, and Central America DPSs, respectively; off Oregon and California, the majority are from the Central America DPS (67.2%), with 32.7% from the Mexico DPS, and none 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). Individuals encountered in the proposed survey area would be from the Hawaii, Mexico, and/or Central America DPSs (Calambokidis et al. 2008; Ford 2014). The humpback whale is the most common species of large cetacean reported off the coasts of Oregon and Washington from May–November (Green et al. 1992; Calambokidis et al. 2000, 2004). The highest numbers have been reported off Oregon during May and June and off Washington during July–September. Humpbacks occur primarily over the continental shelf and slope during the summer, with few reported in offshore pelagic waters (Green et al. 1992; Calambokidis et al. 2004, 2015; Becker et al. 2012; Barlow 2016). BIAs for feeding humpback whales along the coasts of Oregon and Washington, which have been designated from May–November, are all within ~80 km from shore, and include the waters off northern Washington, and Stonewall and Heceta Bank, OR; another five BIAs occur off California (Calambokidis et al. 2015). Six humpback whale sightings (8 animals) were made off Washington/Oregon during the June–July 2012 L-DEO Juan de Fuca plate seismic survey. There were 98 humpback whale sightings (213 animals) made during the July 2012 L-DEO seismic survey off southern Washington (RPS 2012a), and 11 sightings (23 animals) during the July 2012 L-DEO seismic survey off Oregon (RPS 2012c).

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). Critical habitat for humpbacks has been designated in B.C., including the waters of the proposed survey area off southwestern Vancouver Island (DFO 2013a). Humpback whales were detected acoustically on La Pérouse Bank off southwestern Vancouver Island from May through September 2007 (Ford et al. 2010b).

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). Humpback whales identified in southern B.C. show a low level of interchange with those seen off California/Oregon/ Washington (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 Gulf of Alaska 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).

Sightings have been made off Oregon and Washington in shelf and deeper waters (Green et al. 1992; Adams et al. 2014; Barlow 2016; Carretta et al. 2019). An estimated abundance of 211 minke whales was reported for the Oregon/Washington region based on sightings data from 1991–2005 (Barlow and Forney 2007), whereas a 2008 survey did not record any minke whales while on survey effort (Barlow 2010). The abundance for Oregon/Washington for 2014 was estimated at 507 minke whales (Barlow 2016). There were no sightings of minke whales off Oregon/Washington during the June–July 2012 L-DEO Juan de Fuca plate seismic survey or during the July 2012 L-DEO seismic survey off Oregon (RPS 2012b,c). One minke whale was seen during the July 2012 L-DEO seismic survey off southern Washington (RPS 2012a).

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 where they occur in shallow and deeper water (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 Gulf of Alaska and down to southern California, as well as in the western Pacific from Japan to Korea. Its winter distribution is concentrated at ~20°N (Rice 1998).

Sei whales are rare in the waters off California, Oregon, and Washington (Brueggeman et al. 1990; Green et al. 1992; Barlow 1994, 1997). Less than 20 confirmed sightings were reported in that region during extensive surveys during 1991–2014 (Green et al. 1992, 1993; Hill and Barlow 1992; Carretta and Forney 1993; Mangels and Gerrodette 1994; Von Saunder and Barlow 1999; Barlow 2003, 2010, 2014; Forney 2007; Carretta et al. 2019). Based on surveys conducted in 1991–2008, the estimated abundance of sei whales off the coasts of Oregon and Washington was 52 (Barlow 2010); for 2014, the abundance estimate was 468 (Barlow 2016). Two sightings of four individuals were made during the June–July 2012 L-DEO Juan de Fuca plate seismic survey off Washington/Oregon (RPS 2012b). No sei whales were sighted during the July 2012 L-DEO seismic surveys off Oregon and Washington (RPS 2012a,c).

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). 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 (e.g., Moore et al. 2006; Stafford et al. 2007, 2009; Edwards et al. 2015). In the central North Pacific, the Gulf of Alaska, and Aleutian Islands, call rates peak during fall and winter (Moore et al. 1998, 2006; Watkins et al. 2000a,b; Stafford et al. 2009).

Fin whales are routinely sighted during surveys off Oregon and Washington (Barlow and Forney 2007; Barlow 2010, 2016; Adams et al. 2014; Calambokidis et al. 2015; Edwards et al. 2015; Carretta et al. 2019), including in coastal as well as offshore waters. They have also been detected acoustically in those waters during June–August (Edwards et al. 2015). Eight fin whale sightings (19 animals) were made off Washington/Oregon during the June–July 2012 L-DEO Juan de Fuca plate seismic survey; sightings were made in waters 2369–3940 m deep (RPS 2012b). Fourteen fin whale sightings (28 animals) were made during the July 2012 L-DEO seismic surveys off southern Washington (RPS 2012a). No fin whales were sighted during the July 2012 L-DEO seismic survey off Oregon (RPS 2012c). Fin whales were also seen off southern Oregon during July 2012 in water >2000 m deep during surveys by Adams et al. (2014).

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 appear to be more common in northern B.C., but sightings have been made along the shelf edge and in deep waters off western Vancouver Island (Ford et al. 2010a; Calambokidis et al. 2003; 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). 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). 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. 2019). 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). Broad-scale acoustic monitoring indicates that blue whales occurring in the northeast Pacific during summer and fall may winter in the eastern tropical Pacific (Stafford et al. 1999, 2001).

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). Stafford et al. (2009) reported that sea-surface temperature is a good predictor variable for blue whale call detections in the North Pacific. 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). The eastern North Pacific stock feeds in California waters from June–November (Calambokidis et al. 1990; Mate et al. 1999). There are nine BIAs for feeding blue whales off the coast of California (Calambokidis et al. 2015), and core areas have also been identified there (Irvine et al. 2014).

Blue whales are considered rare off Oregon, Washington, and B.C. (Buchanan et al. 2001; Gregr et al. 2006; Ford 2014), although satellite-tracked individuals have been reported off the coast (Bailey et al. 2009). Based on modeling of the dynamic topography of the region, blue whales could occur in relatively high densities off Oregon during summer and fall (Pardo et al. 2015: Hazen et al. 2017). Densities along the U.S. west coast, including Oregon, were predicted to be highest in shelf waters, with lower densities in deeper offshore areas (Becker et al. 2012; Calambokidis et al. 2015). Blue whales have been detected acoustically off Oregon (McDonald et al. 1995; Stafford et al. 1998; Von Saunder and Barlow 1999).

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 (Ford 2014; DFO 2017b) 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, B.C., 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), with the most recent one 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). 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). Off California, they occur year-round (Dohl et al. 1983; Barlow 1995; Forney et al. 1995), with peak abundance from April to mid-June and from August to mid-November (Rice 1974). Off Oregon, sperm whales are seen in every season except winter (Green et al. 1992). Sperm whales were sighted during surveys off Oregon in October 2011 and off Washington in June 2011 (Adams et al. 2014). Sperm whale sightings were also made off Oregon and Washington during the 2014 Southwest Fisheries Science Center (SWFSC) vessel survey (Barlow 2016). Sperm whales were detected acoustically in waters off Oregon and Washington in August 2016 during the SWFSC Passive Acoustics Survey of Cetacean Abundance Levels (PASCAL) study using drifting acoustic recorders (Keating et al. 2018). Oleson et al. (2009) noted a significant diel pattern in the occurrence of sperm whale clicks at offshore and inshore monitoring locations off Washington, whereby clicks were more commonly heard during the day at the offshore site and at night at the inshore location, suggesting possible diel movements up and down the slope in search of prey. Sperm whale acoustic detections were also reported at an inshore site from June through January 2009, with an absence of calls during February–May (Širović et al. 2012).

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). A single sperm whale was sighted during the 2009 ETOMO survey, west of the proposed survey area (Holst 2017). 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). Sperm whales are likely to be encountered in the proposed survey area.

3.3.2.2 Pygmy and Dwarf Sperm Whales (*Kogia breviceps and K. sima*)

Dwarf and pygmy sperm whales are distributed throughout tropical and temperate waters of the Atlantic, Pacific and Indian oceans, but their precise distributions are unknown because much of what we know of the species comes from strandings (McAlpine 2018). They are difficult to sight at sea, because of their dive behavior and perhaps because of their avoidance reactions to ships and behavior changes in relation to survey aircraft (Würsig et al. 1998). The two species are often difficult to distinguish from one another when sighted (McAlpine 2018).

Both *Kogia* species are sighted primarily along the continental shelf edge and slope and over deeper waters off the shelf (Hansen et al. 1994; Davis et al. 1998; Jefferson et al. 2015). Stomach content analyses from stranded whales further support this distribution (McAlpine 2018). Recent data indicate that both *Kogia* species feed in the water column and on/near the seabed, likely using echolocation to search for prey (McAlpine 2018). Several studies have suggested that pygmy sperm whales live and feed mostly beyond the continental shelf edge, whereas dwarf sperm whales tend to occur closer to shore, often over the continental shelf and slope (Rice 1998; Wang et al. 2002; MacLeod et al. 2004; McAlpine 2018). It has also been suggested that the pygmy sperm whale is more temperate and the dwarf sperm whale more tropical, based at least partially on live sightings at sea from a large database from the eastern tropical Pacific (Wade and Gerrodette 1993; McAlpine 2018).

Pygmy and dwarf sperm whales are rarely sighted off Oregon and Washington, with only one sighting of an unidentified *Kogia* sp. beyond the U.S. EEZ, during the 1991–2014 NOAA vessel surveys (Carretta et al. 2019). Norman et al. (2004) reported eight confirmed stranding records of pygmy sperm whales for Oregon and Washington, five of which occurred during autumn and winter. There are several unconfirmed sighting reports of the pygmy sperm whale from the Canadian west coast (Baird et al. 1996). There is a stranding record of a pygmy sperm whale for northeastern Vancouver Island (Ford 2014), and there is a single dwarf sperm whale stranding record for southwestern Vancouver Island in September 1981 (Ford 2014). Willis and Baird (1998) state that the dwarf sperm whale is likely found in B.C. waters more frequently than recognized, but Ford (2014) suggested that the presence of *Kogia* spp. in B.C. waters is extralimital. Despite the limited number of sightings, it is possible that pygmy or dwarf sperm whales could be encountered within the proposed project area.

3.3.2.3 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).

The population in the California Current LME seems to be declining (Moore and Barlow 2013). Nonetheless, MacLeod et al. (2006) reported numerous sightings and strandings along the Pacific coast of the U.S. Cuvier's beaked whale is the most common beaked whale off the U.S. west coast (Barlow 2010), and it is the beaked whale species that has stranded most frequently on the coasts of Oregon and Washington. From 1942–2010, there were 23 reported Cuvier's beaked whale strandings in Oregon and

Washington (Moore and Barlow 2013). Most (75%) Cuvier's beaked whale strandings reported occurred in Oregon (Norman et al. 2004).

Four beaked whale sightings were reported in water depths >2000 m off Oregon/Washington during surveys in 2008 (Barlow 2010). None were seen in 1996 or 2001 (Barlow 2003), and several were recorded from 1991–1995 (Barlow 1997). One Cuvier's beaked whale sighting during surveys in 2014 (Barlow 2016). Acoustic monitoring in Washington offshore waters detected Cuvier's beaked whale calls between January and November 2011 (Ŝirović et al. 2012b *in* USN 2015). Cuvier's beaked whales were detected acoustically in waters off Oregon and Washington in August 2016 during the SWFSC PASCAL study using drifting acoustic recorders (Keating et al. 2018). Records of Cuvier's beaked whale in B.C. are scarce, although 20 strandings, one incidental catch, and five sightings have been reported, including off western Vancouver Island (Ford 2014). Most strandings have been reported in summer (Ford 2014). Cuvier's beaked whales could be encountered during the proposed survey.

3.3.2.4 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).

Along the U.S. west coast, Baird's beaked whales have been sighted primarily along the continental slope (Green et al. 1992; Becker et al. 2012; Carretta et al. 2019) from late spring to early fall (Green et al. 1992). The whales move out from those areas in winter (Reyes 1991). In the eastern North Pacific Ocean, Baird's beaked whales apparently spend the winter and spring far offshore, and in June, they move onto the continental slope, where peak numbers occur during September and October. Green et al. (1992) noted that Baird's beaked whales on the U.S. west coast were most abundant in the summer, and were not sighted in the fall or winter. MacLeod et al. (2006) reported numerous sightings and strandings of *Berardius* spp. off the U.S. west coast.

Green et al. (1992) sighted five groups during 75,050 km of aerial survey effort in 1989–1990 off Washington/Oregon spanning coastal to offshore waters: two in slope waters and three in offshore waters. Two groups were sighted during summer/fall 2008 surveys off Washington/Oregon, in waters >2000 m deep (Barlow 2010). Acoustic monitoring offshore Washington detected Baird's beaked whale pulses during January through November 2011, with peaks in February and July (Ŝirović et al. 2012b *in* USN 2015). Baird's beaked whales were detected acoustically in the waters off Oregon and Washington in August 2016 during the SWFSC PASCAL study using drifting acoustic recorders (Keating et al. 2018).

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 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.

3.3.2.5 Blainville's Beaked Whale (*Mesoplodon densirostris*)

Blainville's beaked whale is found in tropical and warm temperate waters of all oceans (Pitman 2018). It has the widest distribution throughout the world of all *Mesoplodon* species (Pitman 2018). Like other beaked whales, Blainville's beaked whale is generally found in waters 200–1400 m deep (Gannier 2000; Jefferson et al. 2015). Occasional occurrences in cooler, higher-latitude waters are presumably related to warm-water incursions (Reeves et al. 2002). MacLeod et al. (2006) reported stranding and sighting records in the eastern Pacific ranging from 37.3°N to 41.5°S. However, none of the 36 beaked whale stranding records in Oregon and Washington during 1930–2002 included Blainville's beaked whale (Norman et al. 2004). One Blainville's beaked whale was found stranded (dead) on the Washington coast in November 2016 (COASST 2016).

There was one acoustic encounter with Blainville's beaked whales recorded in Quinault Canyon off Washington in waters 1400 m deep during 2011 (Baumann-Pickering et al. 2014). Blainville's beaked whales were not detected acoustically off Washington or Oregon during the August 2016 SWFSC PASCAL study using drifting acoustic recorders (Keating et al. 2018). No sightings have been made off B.C. (Ford 2014). Although Blainville's beaked whales could be encountered during the proposed survey, an encounter would be unlikely because the proposed survey area is beyond the northern limits of this tropical species' usual distribution.

3.3.2.6 Hubbs' Beaked Whale (*Mesoplodon carlhubbsi*)

Hubbs' beaked whale occurs in temperate waters of the North Pacific (Mead 1989). Its distribution appears to be correlated with the deep subarctic current (Mead et al. 1982). Numerous stranding records have been reported for the west coast of the U.S. (MacLeod et al. 2006). Most are from California, but at least seven strandings have been recorded along the B.C. coast as far north as Prince Rupert (Mead 1989; Houston 1990a; Willis and Baird 1998; Ford 2014). Two strandings are known from Washington/Oregon (Norman et al. 2004). In addition, at least two sightings off Oregon/Washington, but outside the U.S. EEZ, were reported by Carretta et al. (2019). During the 2016 SWFSC PASCAL study using drifting acoustic recorders, detections were made of beaked whale sounds presumed to be from Hubbs' beaked whales off Washington and Oregon during August (Griffiths et al. submitted manuscript cited *in* Keating et al. 2018). There have been no confirmed sightings of Hubbs' beaked whales in B.C. This species seems to be less common in the proposed survey area than some of the other beaked whales, but it could be encountered during the survey.

3.3.2.7 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). After Cuvier's beaked whale, Stejneger's beaked whale was the second most commonly stranded beaked whale species in Oregon and Washington (Norman et al. 2004). Stejneger's beaked whale calls were detected during acoustic monitoring offshore Washington between January and June 2011, with an absence of calls from mid-July–November 2011 (Ŝirović et al. 2012b *in* USN 2015). Analysis of these data suggest that this species could be more than twice as prevalent in this area than Baird's beaked whale (Baumann-Pickering et al. 2014). Stejneger's beaked whales were also detected acoustically in waters off Oregon and Washington in August 2016 during the SWFSC PASCAL study using drifting acoustic recorders (Keating et al. 2018).

At least five stranding records exist for B.C. (Houston 1990b; 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.

3.3.2.8 Common Bottlenose Dolphin (*Tursiops truncatus*)

The bottlenose dolphin is distributed worldwide in coastal and shelf waters of tropical and temperate oceans (Jefferson et al. 2015). There are two distinct bottlenose dolphin types: a shallow water type, mainly found in coastal waters, and a deep-water type, mainly found in oceanic waters (Duffield et al. 1983; Hoelzel et al. 1998; Walker et al. 1999). Coastal common bottlenose dolphins exhibit a range of movement patterns including seasonal migration, year-round residency, and a combination of long-range movements and repeated local residency (Wells and Scott 2009).

Bottlenose dolphins occur frequently off the coast of California, and sightings have been made as far north as 41ºN, but few records exist for Oregon and Washington (Carretta et al. 2019). Three sightings and one stranding of bottlenose dolphins have been documented in Puget Sound since 2004 (Cascadia Research 2011 *in* USN 2015). It is possible that offshore bottlenose dolphins may range as far north as the proposed survey area during warm-water periods (Carretta et al. 2019). Adams et al. (2014) made one sighting off Washington during September 2012. There are no confirmed records of bottlenose dolphins for B.C., although an unconfirmed record exists for offshore waters (Baird et al. 1993). It is possible, although unlikely, that bottlenose dolphins could be encountered in the proposed survey area.

3.3.2.9 Striped Dolphin (*Stenella coeruleoalba*)

The striped dolphin has a cosmopolitan distribution in tropical to warm temperate waters from ~50°N to 40°S (Perrin et al. 1994; Jefferson et al. 2015). It occurs primarily in pelagic waters, but has been observed approaching shore where there is deep water close to the coast (Jefferson et al. 2015). The striped dolphin is typically found in waters outside the continental shelf and is often associated with convergence zones and areas of upwelling; however, it has also been observed approaching shore where there is deep water close to the coast (Jefferson et al. 2015).

Striped dolphins regularly occur off California (Becker et al. 2012), including as far offshore as ~300 n.mi. during the NOAA Fisheries vessel surveys (Carretta et al. 2019). However, few sightings have been made off Oregon, and no sightings have been reported for Washington (Carretta et al. 2019). However, strandings have occurred along the coasts of Oregon and Washington (Carretta et al. 2016). During surveys off the U.S. west coast in 2014, striped dolphins were seen as far north as 44ºN; based on those sightings, Barlow (2016) calculated an abundance estimate of 13,171 striped dolphins for Oregon/Washington. The abundance estimates for 2001, 2005, and 2008 were zero (Barlow 2016).

Striped dolphins are rare in the waters of B.C. and are considered extralimital there (Ford 2014). There is a total of 14 confirmed records of stranded individuals or remains for Vancouver Island (Ford 2014). A single confirmed sighting was made in September 2019 in the Strait of Juan de Fuca (Pacific Whale Watch Association 2019). One bycatch record exists in waters far offshore from Vancouver Island (Ford 2014). It is possible, although unlikely, that striped dolphins could be encountered in the proposed survey area.

3.3.2.10 Short-beaked Common Dolphin (*Delphinus delphis*)

The short-beaked common dolphin is found in tropical and warm temperate oceans around the world (Jefferson et al. 2015), ranging from ~60ºN to ~50ºS (Jefferson et al. 2015). It is the most abundant dolphin species in offshore areas of warm-temperate regions in the Atlantic and Pacific (Perrin 2018). It can be found in oceanic and coastal habitats; it is common in coastal waters 200–300 m deep and is also associated with prominent underwater topography, such as seamounts (Evans 1994). Short-beaked common dolphins have been sighted as far as 550 km from shore (Barlow et al. 1997).

The distribution of short-beaked common dolphins along the U.S. west coast is variable and likely related to oceanographic changes (Heyning and Perrin 1994; Forney and Barlow 1998). It is the most abundant cetacean off California; some sightings have been made off Oregon, in offshore waters (Carretta et al. 2019). During surveys off the west coast in 2014 and 2017, sightings were made as far north as 44°N (Barlow 2016; SIO n.d.). Based on the absolute dynamic topography of the region, short-beaked common dolphins could occur in relatively high densities off Oregon during July–December (Pardo et al. 2015). In contrast, habitat modeling predicted moderate densities of common dolphins off the Columbia River estuary during summer, with lower densities off southern Oregon (Becker et al. 2014). There are three stranding records for B.C., including one for northwestern Vancouver Island, one for the Strait of Juan de Fuca, and one for Hecate Strait (Ford 2014). Common dolphins could be encountered in the proposed survey area.

3.3.2.11 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).

Results of aerial and shipboard surveys strongly suggest seasonal north–south movements of the species between California and Oregon/Washington; the movements apparently are related to oceanographic influences, particularly water temperature (Green et al. 1993; Forney and Barlow 1998; Buchanan et al. 2001). During winter, this species is most abundant in California slope and offshore areas; as northern waters begin to warm in the spring, it appears to move north to slope and offshore waters off Oregon/Washington (Green et al. 1992, 1993; Forney 1994; Forney et al. 1995; Buchanan et al. 2001; Barlow 2003). The highest encounter rates off Oregon and Washington have been reported during March–May in slope and offshore waters (Green et al. 1992). Similarly, Becker et al. (2014) predicted relatively high densities off southern Oregon in shelf and slope waters.

Based on year-round aerial surveys off Oregon/Washington, the Pacific white-sided dolphin was the most abundant cetacean species, with nearly all (97%) sightings occurring in May (Green et al. 1992, 1993). Barlow (2003) also found that the Pacific white-sided dolphin was one of the most abundant marine mammal species off Oregon/Washington during 1996 and 2001 ship surveys, and it was the second most abundant species reported during 2008 surveys (Barlow 2010). Adams et al. (2014) reported numerous offshore sightings off Oregon during summer, fall, and winter surveys in 2011 and 2012. Based on surveys conducted during 2014, the abundance was estimated at 20,711 for Oregon/Washington (Barlow 2016).

Fifteen Pacific white-sided dolphin sightings (231 animals) were made off Washington/Oregon during the June–July 2012 L-DEO Juan de Fuca plate seismic survey (RPS 2012b). There were fifteen Pacific white-sided dolphin sightings (462 animals) made during the July 2012 L-DEO seismic surveys off southern Washington (RPS 2012a). This species was not sighted during the July 2012 L-DEO seismic survey off Oregon (RPS 2012c). One group of 10 Pacific white-sided dolphins was sighted during the 2009 ETOMO survey west of the proposed survey area (Holst 2017).

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 (1991a) 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 1991a). 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. (2011b) reported that most sightings occur in water depths <500 m and within 20 km from shore. 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.

3.3.2.12 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).

Aerial and shipboard surveys suggest seasonal inshore-offshore and north-south movements in the eastern North Pacific Ocean between California and Oregon/Washington; the movements are believed to be related to oceanographic influences, particularly water temperature and presumably prey distribution and availability (Green et al. 1993; Forney and Barlow 1998; Buchanan et al. 2001). Green et al. (1992, 1993) found that northern right whale dolphins were most abundant off Oregon/Washington during fall, less abundant during spring and summer, and absent during winter, when this species presumably moves south to warmer California waters (Green et al. 1992, 1993; Forney 1994; Forney et al. 1995; Buchanan et al. 2001; Barlow 2003).

Becker et al. (2014) predicted relatively high densities off southern Oregon, and moderate densities off northern Oregon and Washington. Based on year-round aerial surveys off Oregon/Washington, the northern right whale dolphin was the third most abundant cetacean species, concentrated in slope waters but also occurring in water out to ~550 km offshore (Green et al. 1992, 1993). Barlow (2003, 2010) also found that the northern right whale dolphin was one of the most abundant marine mammal species off Oregon/Washington during 1996, 2001, 2005, and 2008 ship surveys. Offshore sightings were made in the waters of Oregon during summer, fall, and winter surveys in 2011 and 2012 (Adams et al. 2014).

There are 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 Haida Gwaii (Ford 2014). Most sightings have occurred in water depths >900 m (Baird and Stacey 1991a). One group of six northern right whale dolphins was seen west of Vancouver Island in water deeper than 2500 m during a survey from Oregon to Alaska (Hauser and Holst 2009). Northern right whale dolphins are likely to be encountered in the proposed survey area.

3.3.2.13 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).

Off the U.S. west coast, Risso's dolphin is believed to make seasonal north-south movements related to water temperature, spending colder winter months off California and moving north to waters off Oregon/Washington during the spring and summer as northern waters begin to warm (Green et al. 1992, 1993; Buchanan et al. 2001; Barlow 2003; Becker 2007). The distribution and abundance of Risso's dolphins are highly variable from California to Washington, presumably in response to changing oceanographic conditions on both annual and seasonal time scales (Forney and Barlow 1998; Buchanan et al. 2001). The highest densities were predicted along the coasts of Washington, Oregon, and central and southern California (Becker et al. 2012). Off Oregon and Washington, Risso's dolphins are most abundant over continental slope and shelf waters during spring and summer, less so during fall, and rare during winter (Green et al. 1992, 1993). Green et al. (1992, 1993) reported most Risso's dolphin groups off Oregon between ~45 and 47ºN. Several sightings were made off southern Oregon during surveys in 1991–2014 (Carretta et al. 2019). Sightings during ship surveys in summer/fall 2008 were mostly between ~30 and 38ºN; none were reported in Oregon/Washington (Barlow 2010). Based on 2014 survey data, the abundance for Oregon/Washington was estimated at 430 (Barlow 2016).

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.

3.3.2.14 False Killer Whale (*Pseudorca crassidens*)

The false killer whale is found worldwide in tropical and temperate waters, generally between 50ºN and 50ºS (Odell and McClune 1999). It is widely distributed, but not abundant anywhere (Carwardine 1995). The false killer whale generally inhabits deep, offshore waters, but sometimes is found over the continental shelf and occasionally moves into very shallow (Jefferson et al. 2015; Baird 2018b). It is gregarious and forms strong social bonds, as is evident from its propensity to strand en masse (Baird 2018b). In the eastern North Pacific, it has been reported only rarely north of Baja California (Leatherwood et al. 1982, 1987; Mangels and Gerrodette 1994); however, the waters off the U.S. west coast all the way north to Alaska are considered part of its secondary range (Jefferson et al. 2015).

Its occurrence in Washington/Oregon is associated with warm-water incursions (Buchanan et al. 2001). However, no sightings of false killer whales were made along the U.S. west coast during surveys conducted from 1986–2001 (Ferguson and Barlow 2001, 2003; Barlow 2003) or in 2005 and 2008 (Forney 2007; Barlow 2010). One pod of false killer whales occurred in Puget Sound for several months during the 1990s (USN 2015). Two false killer whales were reported stranded along the Washington coast during 1930–2002, both in El Niño years (Norman et al. 2004).

Stacey and Baird (1991b) suggested that false killer whales are at the limit of their distribution in Canada and have always been rare. Sightings have been made along the northern and central mainland B.C. coast, as well as in Queen Charlotte Strait, Strait of Georgia, and along the west coast of Vancouver Island; there are no records for deeper water in the proposed survey area (Ford 2014). This species is unlikely to be encountered during the proposed survey.

3.3.2.15 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 Aleutians and 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 (Muto et al. 2019; Carretta et al. 2019). Individuals from the ***endangered*** Southern Resident stock, as well as the Northern Resident, West Coast Transient, and Offshore stocks could be encountered in the proposed project area.

Resident killer whales mainly feed on salmon, in particular Chinook, and their movements coincide with those of their prey (Ford 2014). During the spring, summer, and fall, 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; Olson et al. 2018; Carretta et al. 2019). These areas have been designated as critical habitat either by the U.S. or Canada. High-use areas along the coast of Washington have also been reported (Hanson et al. 2017, 2018) and are soon to be designated as critical habitat (NMFS 2019a).

Southern resident killer whales occur along the outer coasts of B.C. and Washington throughout the year, but individuals have been reported as far south as California and as far north as Alaska (Hanson et al. 2017, 2018; Carretta et al. 2019). There appears to be a recent occupancy shift from the Salish Sea in spring/summer to other waters, possibly offshore (Shields et al. 2018a; Maples 2019). Southern resident killer whales have been detected acoustically at Swiftsure Bank off southwestern Vancouver Island throughout the year, with peak activity during the summer (Riera et al. 2019). Southern resident whales appear to spend the majority of their time on the continental shelf, within 34 km from the coast, in water <100 m deep (Hanson et al. 2017). K/L pods primarily occur on the Washington coast, from Grays Harbor to the Columbia River; high use areas for J pod primarily occur at the western entrance of the Strait of Juan de Fuca and northern Strait of Georgia (Hanson et al. 2017). This population has decreased from a census count of 99 animals in 1995 (Carretta et al. 2019) to a current size of 75 individuals (OrcaNetwork 2021); this small population is threatened by reduced prey availability, contaminants, and vessel disturbance including noise (Williams et al. 2016; Lacy et al. 2017; DFO 2018c; Murray et al. 2019; NMFS 2021b).

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. (Muto et al. 2019). 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). Northern resident killer whales have been detected acoustically at Swiftsure Bank off southwestern Vancouver Island throughout the year, with peak activity during summer (Riera et al. 2019).

The main diet of transient killer whales consists of marine mammals, in particular porpoises and seals. West coast transient whales (also known as Bigg's killer whales) range from Southeast Alaska to California (Muto et al. 2019). 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 Vancouver Island (Ford 2014) as well as the Salish Sea (Shields et al. 2018b). Green et al. (1992) noted that most groups seen during their surveys off Oregon and Washington were likely transients; during those surveys, killer whales were sighted only in shelf waters. Two of 17 killer whales that stranded in Oregon were confirmed as transient (Stevens et al. 1989 *in* Norman et al. 2004).

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) reported sightings off Washington and Oregon in the summer, and sightings in the Strait of Juan de Fuca during spring. 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 is 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 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.

Eleven sightings of ~536 individuals were reported off Oregon/Washington during the 2008 SWFSC vessel survey (Barlow 2010). Killer whales were sighted offshore Washington during surveys from August 2004 to September 2008 (Oleson et al. 2009). Keating et al. (2015) analyzed cetacean whistles from recordings made during 2000–2012; several killer whale acoustic detections were made offshore Washington. Killer whales were sighted off Washington in July and September 2012 (Adams et al. 2014).

Killer whales could be encountered during the proposed surveys, including northern and southern resident killer whales in their critical habitat in Canada. However, most sightings within the critical habitat off southwestern Vancouver Island have occurred closer to shore than the proposed seismic transects.

3.3.2.16 Short-finned Pilot Whale (*Globicephala macrorhynchus*)

The short-finned pilot whale is found in tropical and warm temperate waters (Olson 2018); it is seen as far south as ~40ºS and as far north as ~50ºN (Jefferson et al. 2015). Pilot whales are generally nomadic, but may be resident in certain locations, including California and Hawaii (Olson 2018). Short-finned pilot whales were common off southern California (Dohl et al. 1980) until an El Niño event occurred in 1982–1983 (Carretta et al. 2019). Few sightings were made off California/Oregon/ Washington in 1984–1992 (Green et al. 1992; Carretta and Forney 1993; Barlow 1997), but sightings remain rare (Barlow 1997; Buchanan et al. 2001; Barlow 2010). No short-finned pilot whales were seen during surveys off Oregon and Washington in 1989–1990, 1992, 1996, and 2001 (Barlow 2003). Carretta et al. (2019) reported one sighting off Oregon during 1991–2014. Several stranding events in Oregon/southern Washington have been recorded over the past few decades, including in March 1996, June 1998, and August 2002 (Norman et al. 2004).

Short-finned pilot whales are considered rare in B.C. waters (Baird and Stacey 1993; Ford 2014). There are 10 confirmed records, including three bycatch records in offshore waters, six sightings in offshore waters, and one stranding; the stranding occurred in the Strait of Juan de Fuca (Ford 2014). There are also unconfirmed records for nearshore waters of western Vancouver Island (Baird and Stacey 1993; Ford 2014). Pilot whales are expected to be rare in the proposed survey area.

3.3.2.17 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).

Based on genetic data and density discontinuities, six stocks have been identified in California/ Oregon/Washington: (1) Washington Inland Waters, (2) Northern Oregon/Washington Coast, (3) Northern California/Southern Oregon, (4) San Francisco-Russian River, (5) Monterey Bay, and (6) Morro Bay (Carretta et al. 2019). Harbor porpoises from the Northern Oregon/Washington and the Northern California/Southern Oregon stocks could occur in the proposed project area (Carretta et al. 2019).

Harbor porpoises inhabit coastal Oregon and Washington waters year-round, although there appear to be distinct seasonal changes in abundance there (Barlow 1988; Green et al. 1992). Green et al. (1992) reported that encounter rates were similarly high during fall and winter, intermediate during spring, and low during summer. Encounter rates were highest along the Oregon/Washington coast in the area from Cape Blanco (~43°N) to California, from fall through spring. During summer, the reported encounter rates decreased notably from inner shelf to offshore waters. Green et al. (1992) reported that 96% of harbor porpoise sightings off Oregon/Washington occurred in coastal waters <100 m deep, with a few sightings on the slope near the 200-m isobath. Similarly, predictive density distribution maps show the highest in nearshore waters along the coasts of Oregon/Washington, with very low densities beyond the 500-m isobath (Menza et al. 2016).

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 of Vancouver Island (Ford 2014), including within the proposed survey area. Occasional sightings have also been made in shallow water of Swiftsure and La Pérouse banks off southwestern Vancouver Island (Ford 2014). Harbor porpoises could be encountered in shallower water in the eastern portions of the proposed project area.

3.3.2.18 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).

Off Oregon and Washington, 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 (Morejohn 1979; Green et al. 1992; Becker et al. 2014; Fleming et al. 2018; Carretta et al. 2019). Combined results of various surveys out to ~550 km offshore indicate that the distribution and abundance of Dall's porpoise varies between seasons and years. North-south movements are believed to occur between Oregon/Washington and California in response to changing oceanographic conditions, particularly temperature and distribution and abundance of prey (Green et al. 1992, 1993; Mangels and Gerrodette 1994; Barlow 1995; Forney and Barlow 1998; Buchanan et al. 2001). Becker et al. (2014) predicted high densities off southern Oregon throughout the year, with moderate densities to the north. According to predictive density distribution maps, the highest densities off southern Washington and Oregon occur along the 500-m isobath (Menza et al. 2016).

Encounter rates reported by Green et al. (1992) during aerial surveys off Oregon/Washington were highest in fall, lowest during winter, and intermediate during spring and summer. Encounter rates during the summer were similarly high in slope and shelf waters, and somewhat lower in offshore waters (Green et al. 1992). Dall's porpoise was the most abundant species sighted off Oregon/Washington during 1996, 2001, 2005, and 2008 ship surveys up to ~550 km from shore (Barlow 2003, 2010). Oleson et al. (2009) reported 44 sightings of 206 individuals off Washington during surveys form August 2004 to September 2008. Dall's porpoise were seen in the waters off Oregon during summer, fall, and winter surveys in 2011 and 2012 (Adams et al. 2014).

Nineteen Dall's porpoise sightings (144 animals) were made off Washington/Oregon during the June–July 2012 L-DEO Juan de Fuca plate seismic survey (RPS 2012b). There were 16 Dall's porpoise sightings (54 animals) made during the July 2012 L-DEO seismic surveys off southern Washington (RPS 2012a). This species was not sighted during the July 2012 L-DEO seismic survey off Oregon (RPS 2012c).

Dall's porpoise is found all along the B.C. coast and 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. Best et al. (2015) provided an estimate of 5303 individuals based on surveys during 2004–2008. During a survey from Oregon to Alaska, Dall's porpoises were sighted west of Vancouver Island and Haida Gwaii in early October during the southbound transit, but none were sighted in mid-September during the northward transit; all sightings were made in water deeper than 2000 m (Hauser and Holst 2009). Dall's porpoise was the most frequently sighted marine mammal species (5 sightings or 28 animals) during the 2009 ETOMO survey west of the proposed survey area (Holst 2017). Dall's porpoise is likely to be encountered during the proposed seismic survey.

3.3.3 Pinnipeds

3.3.3.1 Guadalupe Fur Seal (*Arctocephalus townsendi*)

Most breeding and births occur at Isla Guadalupe, Mexico; a secondary rookery exists at Isla Benito del Este (Maravilla-Chavez and Lowry 1999; Aurioles-Gamboa et al. 2010). 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 (Stewart et al. 1987; Carretta et al. 2019). 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 (Peterson et al. 1968), although they can also inhabit caves and recesses (Belcher and 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. 2019; Norris 2017 *in* USN 2019a,b). 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 2375 km (Ronald and Gots 2003). Several rehabilitated Guadalupe fur seals that were satellite tagged and released in central California traveled as far north as B.C. (Norris et al. 2015; Norris 2017 *in* USN 2019a,b). Fur seals younger than two years old are more likely to travel to more northerly, offshore areas than older fur seals (Norris 2017 *in* USN 2019a,b). Stranding data also indicates that fur seals younger than 2 years are more likely to occur in the proposed survey area, as this age class was most frequently reported (Lambourn et al. 2012 *in* USN 2019a,b). In 2015–2016, 175 Guadalupe fur seals stranded on the coast of California; NMFS declared this an unusual mortality event (Carretta et al. 2019). Guadalupe fur seals could be encountered during the proposed seismic surveys off the coasts of Washington and Oregon, but most animals are likely to occur at their breeding sites further south at the time of the survey.

3.3.3.2 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. 2019). 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. 2019). 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. 2019). In the U.S., two stocks are recognized—the Eastern Pacific and the California stocks (Muto et al. 2019). 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. 2019).

When not on rookery islands, northern fur seals are primarily pelagic but occasionally haul out on rocky shorelines (Muto et al. 2019). 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. 2019; Muto et al. 2019). 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 Gulf of Alaska 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). Males usually migrate only as far south as the Gulf of Alaska (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 Gulf of Alaska throughout the summer (Calkins 1986). The northern fur seals 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. Pups from the California stock also migrate to Washington, Oregon, and northern California after weaning (Lea et al. 2009).

Northern fur seals were seen throughout the North Pacific during surveys conducted during 1987–1990, including off Vancouver Island and in the western Gulf of Alaska (Buckland et al. 1993).

Tagged adult fur seals were tracked from the Pribilof Islands to the waters off Washington/Oregon/ California, with recorded movement throughout 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 Gulf of Alaska 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).

Bonnell et al. (1992) noted the presence of northern fur seals year-round off Oregon/Washington, with the greatest numbers (87%) occurring in January–May. Northern fur seals were seen as far out from the coast as 185 km, and numbers increased with distance from land; they were 5–6 times more abundant in offshore waters than over the shelf or slope (Bonnell et al. 1992). The highest densities were seen in the Columbia River plume (~46°N) and in deep offshore waters (>2000 m) off central and southern Oregon (Bonnell et al. 1992). The waters off Washington are a known foraging area for adult females, and concentrations of fur seals were also reported to occur near Cape Blanco, Oregon, at ~42.8°N (Pelland et al. 2014).

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 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 could be observed in the proposed survey area, in particular females and juveniles. However, adult males are generally ashore during the reproductive season from May–August, and adult females are generally ashore from June through November.

3.3.3.3 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. Hindell (2009) noted that traveling likely takes place at depths >200 m. 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). Bonnell et al. (1992) reported that northern elephant seals were distributed equally in shelf, slope, and offshore waters during surveys conducted off Oregon and Washington, as far as 150 km from shore, in waters >2000 m deep. Telemetry data indicate that they range much farther offshore than that (Stewart and DeLong 1995). Males may feed as far north as the eastern Aleutian Islands and the Gulf of Alaska, 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 Gulf of Alaska during foraging trips, and could potentially be passing through the area off Washington in May and August (migrating to and from molting periods) and November and February (migrating to and from breeding periods), but likely their presence there is transient and short-lived. Most elephant seal sightings at sea off Washington were made during June, July, and September; off Oregon, sightings were recorded from November through May (Bonnell et al. 1992). Northern elephant seal pups have been sighted at haulouts in the inland waters of Washington State (Jeffries et al. 2000), and at least three were reported to have been born there (Hayward 2003). Pupping has also been observed at Shell Island (~43.3°N) off southern Oregon, suggesting a range expansion (Bonnell et al. 1992; Hodder et al. 1998).

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). One northern elephant seal was sighted during the 2009 ETOMO survey west of the proposed survey area (Holst 2017). This species could be encountered during the proposed seismic survey.

3.3.3.4 Harbor Seal (*Phoca vitulina richardsi*)

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. 2019). Five stocks of harbor seals are recognized along the U.S. west coast: (1) Southern Puget Sound, (2) Washington Northern Inland Waters Stock, (3) Hood Canal, (4) Oregon/Washington Coast, and (5) California (Carretta et al. 2019). The Oregon/Washington stock occurs in the proposed survey area.

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 (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).

Harbor seals haul out on rocks, reefs, and beaches along the U.S. west coast (Carretta et al. 2019). Jeffries et al. (2000) documented several harbor seal rookeries and haulouts along the Washington coastline; it is the only pinniped species that breeds in Washington. Pupping in Oregon and Washington occurs from April–July (Brown 1988). Bonnell et al. (1992) noted that most harbor seals sighted off Oregon and Washington were ≤20 km from shore, with the farthest sighting 92 km from the coast. Menza et al. (2016) also showed the highest predicted densities nearshore. During surveys off the Oregon and Washington coasts, 88% of at-sea harbor seals occurred over shelf waters <200 m deep, with a few sightings near the 2000-m contour, and only one sighting over deeper water (Bonnell et al. 1992). Most (68%) at-sea sightings were recorded in September and November (Bonnell et al. 1992). Harbor seals were only seen in nearshore areas during surveys on the shelf and slope in 2011 and 2012 (Adams et al. 2014). Twelve sightings occurred in nearshore waters from R/V *Northern Light* during a survey off southern Washington during July 2012 (RPS 2012a). Harbor seals were also taken as bycatch east of southern Oregon in the west coast groundfish fishery during 2002–2009 (Jannot et al. 2011).

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 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.

3.3.3.5 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 2019f). 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. 2019). The Western DPS is listed as *endangered* and includes animals that occur in Japan and Russia (Muto et al. 2019); the Eastern DPS was delisted from *threatened* in 2013 (NMFS 2013a). Only individuals from the Eastern DPS could occur in the proposed survey area.

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. 2019). Breeding adults occupy rookeries from late-May to early-July (NMFS 2008a).

Non-breeding adults use haulouts or occupy sites at the periphery of rookeries during the breeding season (NMFS 2008a). 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 2008a). Females with pups generally stay within 30 km of the rookeries in shallow (30–120 m) water when feeding (NMFS 2008a). 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).

During surveys off the coasts of Oregon and Washington, Bonnell et al. (1992) noted that 89% of sea lions occurred over the shelf at a mean distance of 21 km from the coast and near or in waters <200 m deep; the farthest sighting occurred ~40 km from shore, and the deepest sighting location was 1611 m deep. Sightings were made along the 200-m depth contour throughout the year (Bonnell et al. 1992). During aerial surveys over the shelf and slope off Oregon and Washington, one Steller sea lion was seen on the Oregon shelf during January 2011, and two sightings totaling eight individuals were made on September 2012 off southern Oregon (Adams et al. 2014). During a survey off Washington/Oregon June–July 2012, two Steller sea lions were seen from R/V *Langseth* (RPS 2012b) off southern Oregon. Eight sightings of 11 individuals were made from R//V *Northern Light* during a survey off southern Washington during July 2012 (RPS 2012a). Steller sea lions were also taken as bycatch off southern Oregon in the west coast groundfish fishery during 2002–2009 (Jannot et al. 2011).

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.

3.3.3.6 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 Gulf of Alaska (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. 2019). Five genetically distinct geographic populations have been identified: (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 are coastal animals that often haul out on shore throughout the year, but peak numbers off Oregon and Washington occur during the fall (Bonnell et al. 1992). During aerial surveys off the coasts of Oregon and Washington during 1989–1990, California sea lions were sighted at sea during the fall and winter, but no sightings were made during June–August (Bonnell et al. 1992). Numbers off Oregon decrease during winter, as animals travel further north (Mate 1975 *in* Bonnell et al. 1992). King (1983) noted that sea lions are rarely found more than 16 km offshore. During fall and winter surveys off Oregon and Washington, mean distance from shore was ~13 km and most were observed in water <200 m deep; however, sightings were made in water as deep as 356 m (Bonnell et al. 1992). Weise et al. (2006) reported that males normally forage almost exclusively over the continental shelf, but during anomalous climatic conditions they can forage farther out to sea (up to 450 km offshore).

During aerial surveys over the shelf and slope off Oregon and Washington (Adams et al. 2014), California sea lions were seen during all survey months (January–February, June–July, September–October). Although most sightings occurred on the shelf, during February 2012, one sighting was made near the 2000-m depth contour, and during June 2011 and July 2012, sightings were made along the 200-m isobath off southern Oregon (Adams et al. 2014). During October 2011, sightings were made off the Columbia River estuary near the 200-m isopleth and on the southern Oregon shelf; during September 2012, sightings occurred in nearshore waters off Washington and in shelf waters along the coast of Oregon (Adams et al. 2014). Adams et al. (2014) reported sightings more than 60 km off the coast of Oregon. California sea lions were also taken as bycatch off Washington and Oregon in the west coast groundfish fishery during 2002–2009 (Jannot et al. 2011).

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.

3.3.4 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 (<35 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). 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).

Sea otters were translocated from Alaska to shallow coastal waters off the Olympic Peninsula of Washington; the population has increased from 59 reintroduced individuals in 1969–1970 to ~2058 in 2017 (Sato et al. 2018). The population ranges from Pillar Point in the Strait of Juan de Fuca to Cape Flattery, and south to Point Grenville (USFWS 2018). Although sea otters were also reintroduced to Oregon in the 1970s, the reintroduction was not successful (McAllister 2018). Sightings in Oregon are extralimital (Jeffries et al. 2019), and there is no resident sea otter population along the Oregon coast (Kone 2019). Nonetheless, at times sea otters are reported as far south as Newport, Depoe Bay, Yaquina Head, Cape Blanco, and Cape Arago, and Yaquina Head (USFWS 2018; Elakha Alliance 2020).

Sea otters occur in coastal areas of Washington typically in shallow (<30 m depth) water less than 4 km from shore (Laidre et al. 2009).

Sea otters were also 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). There is some limited interchange between sea otter populations in Washington and B.C. (USWFS 2018). Given that the survey is proposed to occur in water >60 m, sea otters are not expected to occur within the harassment zone of the airgun array

3.4 Sea Turtles

Four species of sea turtles have been reported in the waters of B.C., Washington, and Oregon: the leatherback (*Dermochelys coriacea*), green (*Chelonia mydas*), loggerhead (*Caretta caretta*) and olive ridley (*Lepidochelys olivacea*) turtles (McAlpine et al. 2004; CBC 2011a,b; Halpin et al. 2018). Reports of leatherbacks are numerous, and green turtles have been seen occasionally in the survey area compared to occurrences of loggerhead and olive ridley turtles, which are rare. 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.

All four species of turtles have also been documented off the coasts of Oregon and Washington (Buchanan et al. 2001; Dutton et al. 2009). However, green, loggerhead, and olive ridley sea turtles are considered accidental in Oregon (ODFW 2013). For Oregon, there are two occurrences of loggerheads from 2007–2017, and at least seven occurrences of olive ridleys from 2010–2018 (Oregonian 2012; Oregon Coast Aquarium 2019). Strandings have increased in recent years, particularly for olive ridley sea turtles, possibly due to warmer ocean conditions or El Niño (Boyer 2017). For Washington, there are eight records of loggerhead turtles from 1980–2017 (the most recent occurrence was November 2010; Sato 2017a) and few records of olive ridleys (e.g., Richardson 1997; Komo News 2015; Seattle Times 2017). 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 just south of the survey area off California 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 forage in pelagic and nearshore waters off the coasts of Washington, Oregon and California during the summer and fall when brown sea nettles (*Chrysaora fuscescens*) and moon jellies (*Aurelia labiata*) aggregate (Sato 2017b). Benson et al. (2011) identified the Columbia River Plume as an important foraging area off southern Washington/northern Oregon. Leatherback turtles satellite-tagged at western Pacific nesting beaches were observed to arrive along the coasts of California to Washington during April–July, and foraging behavior was recorded through late November (Benson et al. 2011). In Washington, 78 occurrences of leatherbacks were documented during 1975–2013 from the mouth of the Columbia River north to Cape Flattery; 70 occurrences occurred during July–October (Sato 2017b). Aerial surveys of California/Oregon/Washington waters suggest that most leatherbacks occur in continental slope waters and fewer occur over the continental shelf. Sightings off Oregon/Washington have been made 8–149 km offshore (Green et al. 1992, 1993; Bowlby et al. 1994; Buchanan et al. 2001). Bowlby et al. (1994) noted that most sightings (13 of 19) during their surveys occurred in waters 200–2000 m deep, with one sighting in waters >2000 m deep.

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 offshore of Vancouver Island (McAlpine et al. 2004; Pacific leatherback Turtle Recovery Team 2006; Spaven et al. 2009; Holst 2017; CBC 2018b). Seventy-seven of the 118 sightings summarized by Spaven et al (2009) occurred along the south coast of B.C.; most of these overlap with the proposed survey area and were recorded during 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 (Gregr et al. 2015). 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 each of green turtles for Oregon, Washington, and B.C., and two sightings for

Alaska; most sightings occurred in California (78%). Green turtles are considered rare in Washington, where 28 occurrences, mostly strandings, were documented between 1950 and 2017; the most recent occurrence was in November 2010 (Sato 2017a). There are at least three occurrences for Oregon from 2010–2017 (Oregonian 2012; Oregon Coast Aquarium 2019).

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

Four seabird species that are listed as threatened or endangered under the ESA or SARA could occur in or near the proposed survey area. The short-tailed albatross (*Phoebastria albatrus*) is listed as ***endangered*** under the ESA and SARA, the Hawaiian petrel (*Phoebastria albatrus*) is listed as ***endangered*** under the ESA (no SARA listing), the pink-footed shearwater (*Puffinus creatopus*) is listed as *endangered* under SARA (no ESA listing), and the marbled murrelet (*Brachyramphus marmoratus*) is listed as ***threatened*** under the ESA and SARA. Critical habitat has been designated for the marbled murrelet in Canada and in the US from Washington to California. An additional ESA-listed species, the western snowy plover (*Charadrius nivosus nivosus*), would be present on shorelines adjacent to proposed survey area, but does not occur in pelagic habitats, so it is not discussed further.

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 2015b; 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. However, in recent years, the Hawaiian petrel has been recognized to be a regularly occurring offshore species to the eastern Pacific in waters from southern California to B.C. In 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), although occurrences are likely more frequent than observations suggest owing to the minimal observer coverage at the distance from shore which these petrels typically frequent. The Hawaiian petrel could be encountered in small numbers in the proposed project area, but is more likely to occur along the southern transects.

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). 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.

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 2016b). Although terrestrial critical habitat has been identified in B.C., Washington, and Oregon, 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 occurs between late March and August, but the birds remain in the waters of that region 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). 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 about 28,000 breeding pairs, plus non-breeders (COSEWIC 2016b), or about 59,000 individuals (BirdLife International 2019c). It has been estimated that up to 20,000 pink-footed shearwaters 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 summer visitors, with numbers peaking in June–October (COSEWIC 2016b). Pink-footed shearwaters could be encountered within the proposed survey area.

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

3.6.1 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. There are several ESA-listed fish species or populations that occur off the coasts of Washington/Oregon including the ESUs of chinook (*Oncorhynchus tshawytscha*), chum (*O. keta*), coho (*O. kisutch*), and sockeye salmon (*O. nerka*), and DPSs of steelhead (Oncorhynchus mykiss), bull trout (*Salvelinus confluentus*), bocaccio (*Sebastes paucispinis*), yellow-eye rockfish (*S. ruberrimus*), Pacific eulachon (*Thaleichthys pacificus*), and green sturgeon (*Acipenser medirostris*) (Table 6).

TABLE 6. Fish "species" listed under the ESA that could occur in the proposed survey area off Washington and Oregon (NOAA 2019d).

Species	ESU or DPS	Status	Critical Habitat
Bocaccio	Puget Sound/Georgia Basin DPS	Endangered	Marine
Yelloweye Rockfish	Puget Sound/Georgia Basin DPS	Threatened	Marine
Pacific eulachon/smelt	Southern DPS	Threatened	Freshwater/estuarine
Green sturgeon	Southern DPS	Threatened	Marine/freshwater/estuarine
Chinook salmon	Sacramento River winter-run ESU	Endangered	Freshwater
	Upper Columbia River spring-run ESU	Endangered	Freshwater
	California Coastal ESU	Threatened	Freshwater
	Central Valley spring-run ESU	Threatened	Freshwater
	Lower Columbia River ESU	Threatened	Freshwater
	Puget Sound ESU	Threatened	Freshwater/marine
	Snake River fall-run ESU	Threatened	Freshwater
	Snake River spring/summer-run ESU	Threatened	—
	Upper Willamette River ESU	Threatened	Freshwater
	Upper Klamath-Trinity River ESU	Candidate	—
Chum salmon	Columbia River ESU	Threatened	Freshwater
	Hood Canal summer-run ESU	Threatened	Freshwater/marine
Coho salmon	Central California Coast ESU	Endangered	—
	Lower Columbia River ESU	Threatened	Freshwater
	Oregon Coast ESU	Threatened	Freshwater
	S. Oregon and N. California coasts ESU	Threatened	—
Sockeye salmon	Ozette Lake ESU	Threatened	Freshwater
	Snake River ESU	Endangered	—
Steelhead trout	Northern California Summer Population DPS	Candidate	—
	Southern California DPS	Endangered	Freshwater
	California Central Valley DPS	Threatened	Freshwater
	Central California Coast DPS	Threatened	Freshwater
	Northern California DPS	Threatened	Freshwater
	South-Central California Coast DPS	Threatened	Freshwater
	Lower Columbia River DPS	Threatened	Freshwater
	Middle Columbia River DPS	Threatened	Freshwater
	Puget Sound DPS	Threatened	Freshwater
	Snake River Basin DPS	Threatened	Freshwater
	Upper Columbia River DPS	Threatened	Freshwater
	Upper Willamette River DPS	Threatened	Freshwater
Bull trout	Coastal-Puget Sound	Threatened	Freshwater

Although the ***threatened*** giant manta ray (*Manta birostris*) and oceanic whitetip shark (*Carcharhinus longimanus*), and the ***endangered*** Eastern Pacific DPS of scalloped hammerhead shark (*Sphyrna lewini*) occur in the Northeast Pacific Ocean, their most northerly extent is California. No ESA-listed marine invertebrate species occur in the proposed survey area.

3.6.1.1 Salmonids

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.

The Coastal-Puget Sound DPS of bull trout is the only known anadromous population in U.S. waters, occurring throughout Puget Sound and the Olympic Peninsula south to the Quinault River Estuary. Bull trout have not been detected to use deep offshore waters or cross deep open-water bodies (e.g., coastal cutthroat trout) and appear to occupy marine waters for a shorter period of time than other anadromous salmonids (Goetz et al. 2013). Juveniles, sub-adults and adults generally occupy marine waters from early spring (March) to summer (late July), but some are known to overwinter in coastal waters. Fish that were radio-tagged in Skagit River in March and April 2006 entered Skagit Bay from March to May and returned upstream from May to late July (Hayes et al. 2011). Saltwater residency of these fish ranged from 36 to 133 days (avg. 75 days), and most were detected less than 14 km (avg. 8.5 km) from the Skagit River. These bull trout were associated with the shoreline and stayed an average of 0.32 +/- 0.27 km from shore and occupied shallow waters <4 m deep. However, Smith and Huff (2020) detected a tagged bull trout up to 10 km from shore. Goetz (2016) reported that marine residence averaged 62.8 days (SD=37.6 days) but ranged from four days to a maximum of four months.

3.6.1.2 Bocaccio

Bocaccio are distributed in coastal waters over rocky bottoms from the Gulf of Alaska to Baja California, Mexico down to depths of 478 m, but are most common between 50–250 m (NMFS 2008b). Larval and pelagic juvenile bocaccio tend to occur within surficial waters and have been found as far as 480 km offshore the west coast (NMFS 2014). According to COSEWIC (2013b), here are only two demographic clusters of bocaccio, and the B.C. population likely overlaps with U.S. populations centered on the central and southern coasts of California Bocaccio are most common from Oregon to California, and genetic analysis suggests three population regions including Haida Gwaii, Vancouver Island to Point Conception, and southwards of Point Conception (NMFS 2008b). Bocaccio are bycaught in commercial groundfish fisheries in B.C., and population biomass has declined by over 90% since the 1950s, and by 28% since 2002, with no signs of recovery (COSEWIC 2013b).

3.6.1.3 Yelloweye Rockfish

Yelloweye rockfish are found in coastal waters from the Alaskan Aleutian Islands down to Baja California. They are found in depths ranging from 15–549 m over hard, complex bottoms but are most common in waters 91–180 m (COSEWIC 2008; NMFS 2008b). COSEWIC (2008) divided the population into two Designatable Units (DUs) of "inside" and "outside" populations. The inside DU includes the Strait of Georgia, Johnstone Strait, and the Queen Charlotte Strait, and the outside DU includes waters from southwest Alaska to northern Oregon, including offshore B.C. and the north and central coast waters

(COSEWIC 2008). Yelloweye rockfish are exceptionally long-lived and individuals have been aged at 115 years in B.C. (COSEWIC 2008). Yelloweye rockfish are caught commercially in groundfish trawls and recreationally by hook and line.

3.6.1.4 Eulachon

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, and three DUs have been identified that include the Central Pacific Coast, Nass/Skeena Rivers, and the Fraser River (COSEWIC 2011). Eulachon spawn after three years, typically in coastal rivers that are associated with glaciers or snowpacks (COSEWIC 2011). To date, eulachon have been reported to spawn in at least 40 rivers in B.C. (Schweigert et al. 2012). Eulachon have an exceptionally high lipid content (approximately 20%) and are an important species in 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). However, they are taken commercially in Oregon (NOAA 2019g) and Washington (NMFS 2017).

3.6.1.5 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. Green sturgeon have been identified in large concentrations near Brooks Peninsula off the northwestern Vancouver Island during May–June and October–November (DFO 2019c). 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). 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 2019c). There are currently no directed fisheries for green sturgeon (DFO 2019c; NOAA 2019g); however, adults are bycaught in commercial groundfish trawls and in recreational fisheries (DFO 2019c).

3.6.2 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 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. In Washington and Oregon, there are four FMPs covering groundfish, coastal pelagic species, highly migratory species, and Pacific salmon. The entire western seaboard from the coast to the limits of the EEZ is EFH for one or more species for which EFH has been designated. The proposed project area encompasses several EFHs (Fig. 3).

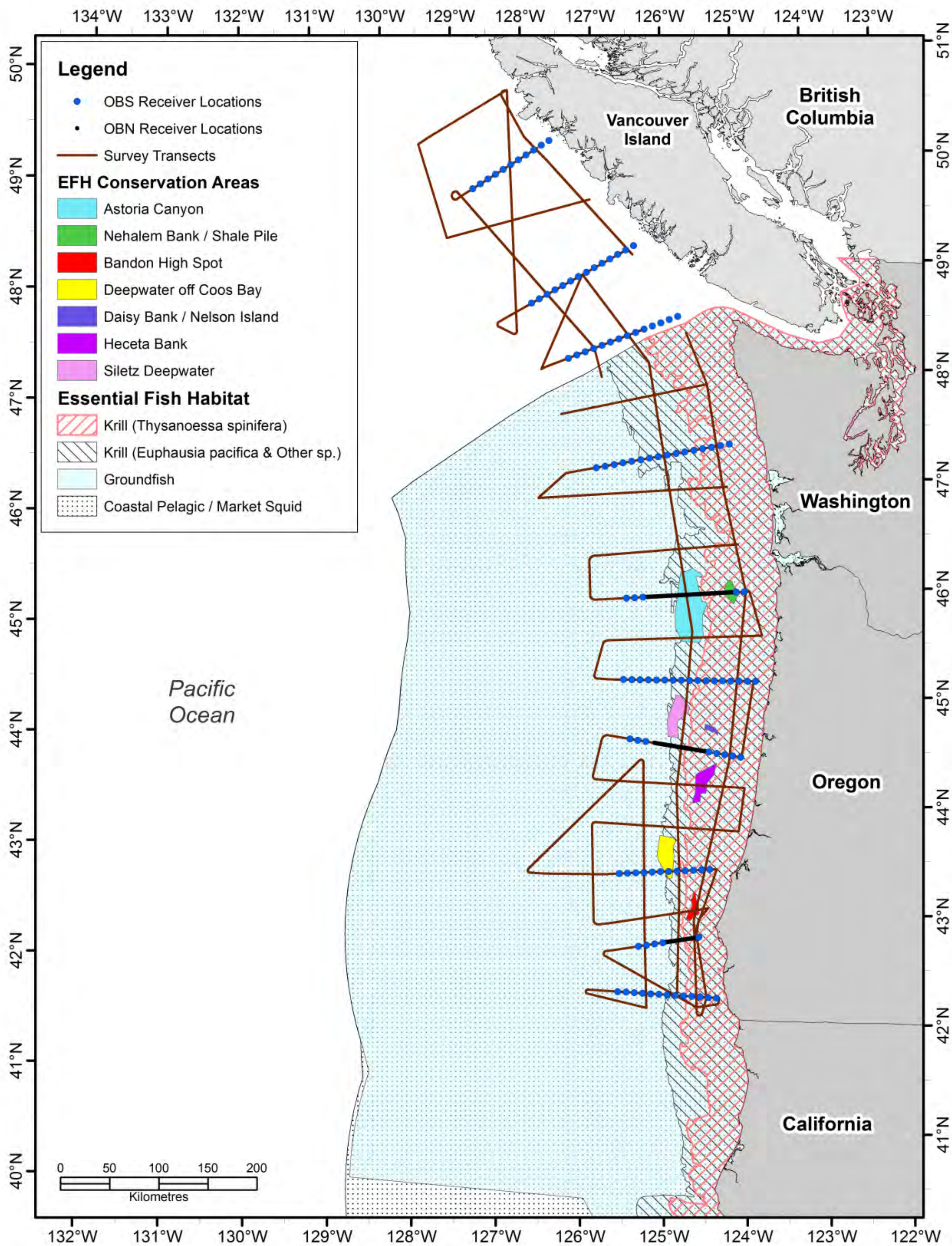


FIGURE 3. EFH in Washington and Oregon. Sources: NOAA 2018; NOAA WCR 2019; ODFW 2019b; USGS 2019.

Groundfish EFH.—The Pacific Coast Groundfish FMP manages more than 90 species (160 species/life stage combinations). The FMP provides a description of groundfish EFH for each of the species and their life stages (PFMC 2016a). When the EFH are taken together, the EFH for Pacific Coast groundfish includes all waters and substrate from the mean higher high water level or the upriver extent of saltwater intrusion along the coasts of Washington, Oregon, and California to within water depths <3500 m and seamounts in depths >3500 m (PMFC 2016a). In addition to the EFH parameters mentioned above, there are seven distinct EFH Conservation Areas within the proposed project area that are closed to bottom trawl fishing gear (Fig. 3) (NOAA 2018; NOAA WCR 2019; ODFW 2019b; USGS 2019).

Coastal Pelagic Species EFH.—The FMP for Pacific coast Coastal Pelagic Species (CPS) includes four finfish (Pacific sardine, Pacific [chub] mackerel, northern anchovy, and jack mackerel), market squid and all euphausiids (krill) species that occur in the west coast EEZ (PFMC 2016b). EFH for these species is defined both through geographic boundaries and by sea-surface temperature ranges. Because of similarities in their life histories and similarities in their habitat requirements, the four CPS finfish are treated as a single species complex for the purposes of EFH. Market squid are also treated in this same complex because they are similarly fished above spawning aggregations. The geographic boundary of EFH for CPS finfish and market squid is defined to be all marine and estuarine waters from the shoreline along the coasts of California, Oregon, and Washington offshore to the limits of the EEZ and above the thermocline where sea surface temperatures range between 10°C and 26°C; the southern extent of the EFH is the U.S.-Mexico boundary (see Fig. 3). The northern boundary of the range of CPS finfish is the position of the 10°C isotherm which varies both seasonally and annually (PFMC 2016b). EFH for krill (*Thysanoessa spinifera*) extends from the shoreline outwards to a depth of 1000 m, while EFH for *Euphausia pacifica* and other krill species in the area extends from the shoreline to ~2000-m depth (NOAA 2018).

Pacific Coast Salmon EFH.—The FMP for Pacific coast salmon includes the coast-wide aggregate of natural and hatchery salmon species that is contacted by salmon fisheries in the EEZ off the coasts of Washington, Oregon, and California (PFMC 2016c). The PFMC manages the fisheries for coho, chinook, and pink (odd-numbered years) salmon and has defined EFH for these three species. Pacific coast salmon EFH includes marine areas within the EEZ, from the extreme high tide line in nearshore and tidal submerged environments within state territorial waters out to the full extent of the EEZ, along with estuarine and all currently or historically occupied freshwater habitat within the internal waters of Washington, Oregon, Idaho, and California north of Point Conception (PFMC 2016c).

Highly Migratory Species EFH.—The FMP for the U.S. west coast fisheries for highly migratory species includes dorado/dolphinfish and important species of tunas (North Pacific albacore, yellowfin, bigeye, skipjack, and northern bluefin), billfish/swordfish (striped marlin and swordfish), and sharks (common thresher, shortfin mako/bonito and blue) which are harvested by west coast fisheries (PFMC 2016d). EFH for each life stage of these species is described in the FMP (PFMC 2016d); collectively the highly migratory species EFH extends outwards from near shore (~10 m water depth) to the limit of the EEZ off of Washington, Oregon, and California (NOAA 2018).

3.6.3 Habitat Areas of Particular Concern

Habitat Areas of Particular Concern (HAPCs) are a subset of EFH that provide important ecological functions, are especially vulnerable to degradation, or include habitat that is rare (NOAA 2019h). There are several HAPCs within or near the proposed survey area for groundfish (Fig. 4). There are no HAPCs designated at this time for highly migratory species (PFMC 2016d).

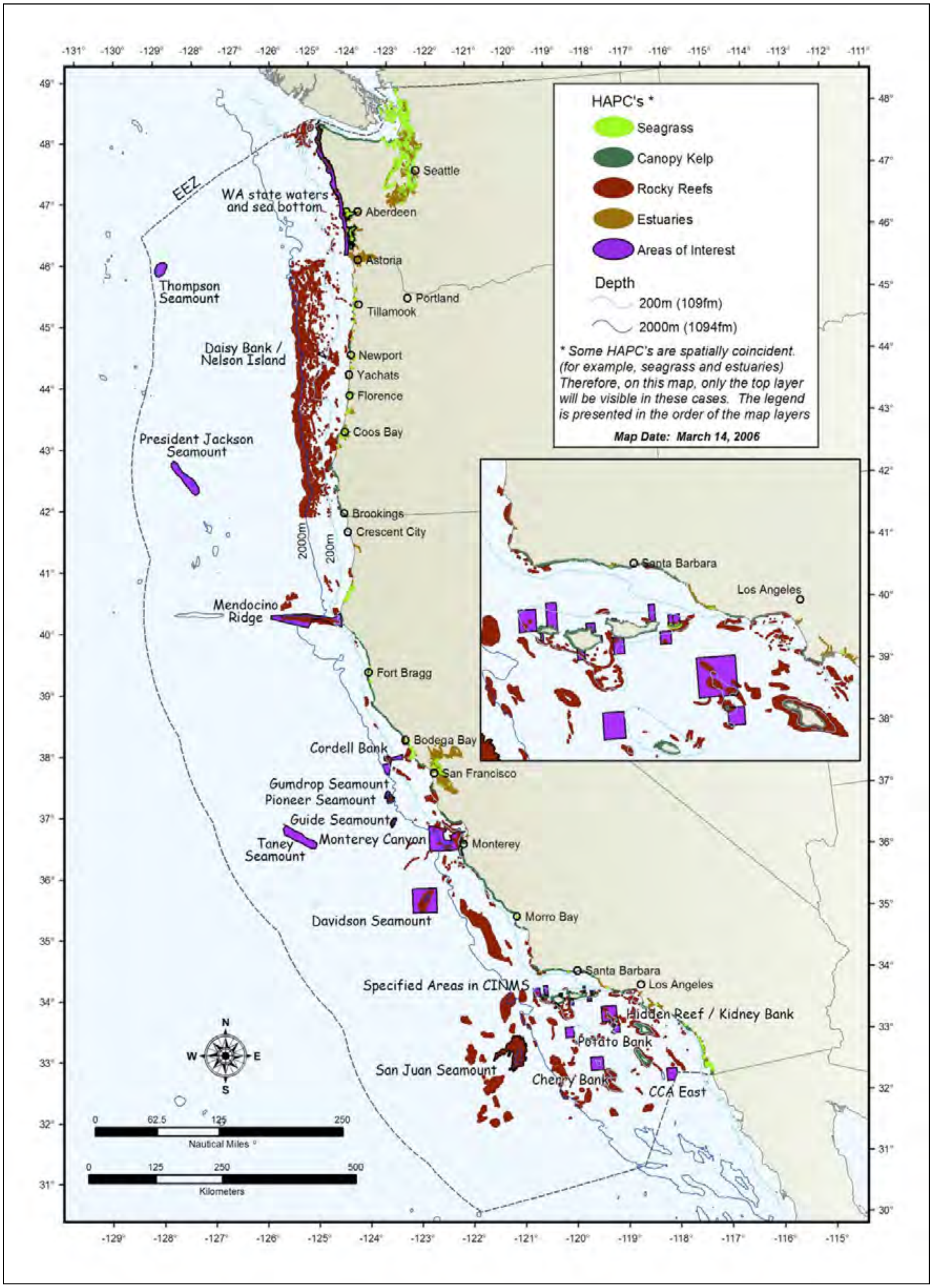


FIGURE 4. Groundfish HAPC in Washington, Oregon, and California. Source: PFMC (2016a).

Rocky Reefs HAPC.—The rocky reefs HAPC includes waters, substrates, and other biogenic features associated with hard substrate (bedrock, boulders, cobble, gravel, etc.) to mean higher high water level. The HAPC occurs primarily in Oregon waters 200–2000 m deep, including in the proposed survey area (see Fig. 4). The rocky reefs HAPC in Washington are mostly scattered in <200 m depth, including in the northern portion of the OCNMS (PFMC 2016a).

Daisy Bank/Nelson Island HAPC.—Daisy Bank area of interest HAPC is a highly unique geological feature that occurs in Federal waters west of Newport, Oregon (44°38'N) and appears to play a unique and potentially rare ecological role for groundfish and large invertebrate sponge species. The bank supports more than 600,000 juvenile rockfish per km^2. Daisy Bank also supports more and larger lingcod and large sponges than other nearby banks (*in* PFMC 2016a). It is located within the survey area (see Fig. 4).

Washington State Waters HAPC.—The Washington State Waters HAPC encompasses all waters and sea bottom in state waters shoreward from the 5.6 km boundary of the territorial sea shoreward to mean higher high-water level. The HAPC encompasses a variety of habitats important to groundfish, including other HAPCs such as rocky reef habitat supporting juvenile rockfish (primarily north of 47.2°N). Sandy substrates within state waters (primarily south of 47.2°N) are important habitat for juvenile flatfish. A large proportion of this area occurs within the OCNMS (PFMC 2016a). This HAPC is adjacent to the survey area (see Fig. 4).

Thompson and President Jackson Seamounts HAPC.—Seamounts have relatively high biodiversity; up to a third of species occurring on these features may be endemic (de Forges et al. 2000 *in* PFMC 2016a). Currents generated by seamounts retain rockfish larvae and zooplankton, a principal food source for rockfish (Genin et al. 1988, Mullineaux and Mills 1997, Haury et al. 2000, and Dower and Perry 2001 *in* PFMC 2016a). Deep-sea corals also occur on seamounts (Monterey Bay National Marine Sanctuary 2005 *in* PFMC 2016a). The Thompson Seamount HAPC has an area of ~430 km^2 and is closed to all bottom contact gear (Oren and DeVogelaere 2014). The HAPC is west of the survey area (see Fig. 4).

3.6.4 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 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 2020b). In addition, several other fish species, as well as the Olympia oyster, are listed as *special concern*.

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, 2020a). 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, 2020a). 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 2020b). 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 2020b). From 1996–2018, only 37 confirmed or reliable basking shark sightings were recorded in Canadian Pacific waters (DFO 2020b). 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, 2020b).

3.6.5 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, including adjacent to the proposed survey area (Fig. 5). 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. 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 2018d). 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 2018d). Slope species are found at depths of 100–2000 m, and include the Pacific Ocean perch, *S. alutus* (DFO 2018d). 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).

3.7 Fisheries

3.7.1 Commercial Fisheries

The commercial Oregon and Washington fisheries harvest at least 170 species, including fish such as salmon, rockfish, flatfish, sharks, and tuna; crustaceans; mollusks; and other invertebrates (NOAA 2019g; ODFW 2019c). The highest landings (in metric tons) occur during July and August (NOAA 2017). In order of descending catch weight, the primary fish species recorded during 2014 in the Oregon, Washington, and Vancouver Coast and Shelf Marine Ecoregion included North Pacific hake (583.19 t), shrimp (63.46 t), Pacific cupped oyster (55.53 t), dungeness crab (29.13 t), chum salmon (11.06 t), coho salmon (8.44 t), pink salmon (2.89 t), Alaska pollock (1.8 t), and redfishes (1.42 t). Other species accounted for 174.48 t of the total catch (Sea Around Us 2016a). North Pacific hake has been the primary species caught since the 1960s, dropping off between the 1980s and 1990s, but landings have steadily increased to present day levels (Sea Around Us 2016a). The most common gear type used in the ecoregion as well as in the U.S. west coast fishery in 2014 was pelagic trawls (Sea Around Us 2016a,b). 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 traps, in addition to hand harvesting for bivalve species (DFO 2019b).

3.7.2 Recreational Fisheries

Most marine recreational fisheries on the U.S. west coast occur within non-federal (shore to 5.6 km off the coast) waters, but some effort also occurs in federal waters (5.6 km to the extent of the EEZ); anglers fish from shore, private boats, and commercial passenger fishing vessels (NOAA 2019i). Species typically taken during recreational fisheries on the west coast include highly migratory species (albacore and other tunas, striped marlin, common thresher shark, shortfin mako shark), salmon (Chinook, coho), steelhead, groundfish (rockfish, lingcod scorpionfish, greenling, flatfish, sharks), halibut, coastal pelagic species (Pacific sardine, northern anchovy, market squid, Pacific mackerel), various state-managed species (barracuda, bass, bonito, sturgeon, surfperches), and invertebrates (abalone, lobster, crab, clams, oysters) (NOAA 2019i). During 2016, 1.2 million anglers took 5.2 million saltwater fishing trips, supporting $3 billion in sales on the U.S. west coast (NOAA 2019i).

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
Bull trout[3] (*Salvelinus confluentus*) South Coast B.C. population			S1			X	4	B.C. to Washington
Marine Invertebrates								
Northern Abalone (*Haliotis kamtschatkana*) Pacific Ocean population	S1			X			100	Alaska to Baja California, Mexico
Olympia Oyster (*Ostrea lurida*) Central Coast population			S1			X	50	Gale Passage, B.C., to Baja California, Mexico
Johnstone Strait population			S1			X	50	
Queen Charlotte population			S1			X	50	
Strait of Georgia population			S1			X	50	
Strait of Juan de Fuca population			S1			X	50	
West Coast Vancouver Island population			S1			X	50	

[1] Government of Canada (2021d). E = Endangered; T = Threatened; SC = Special Concern; S1 = Schedule 1.
[2] DFO (2019a).
[3] Hayes et al. (2011).

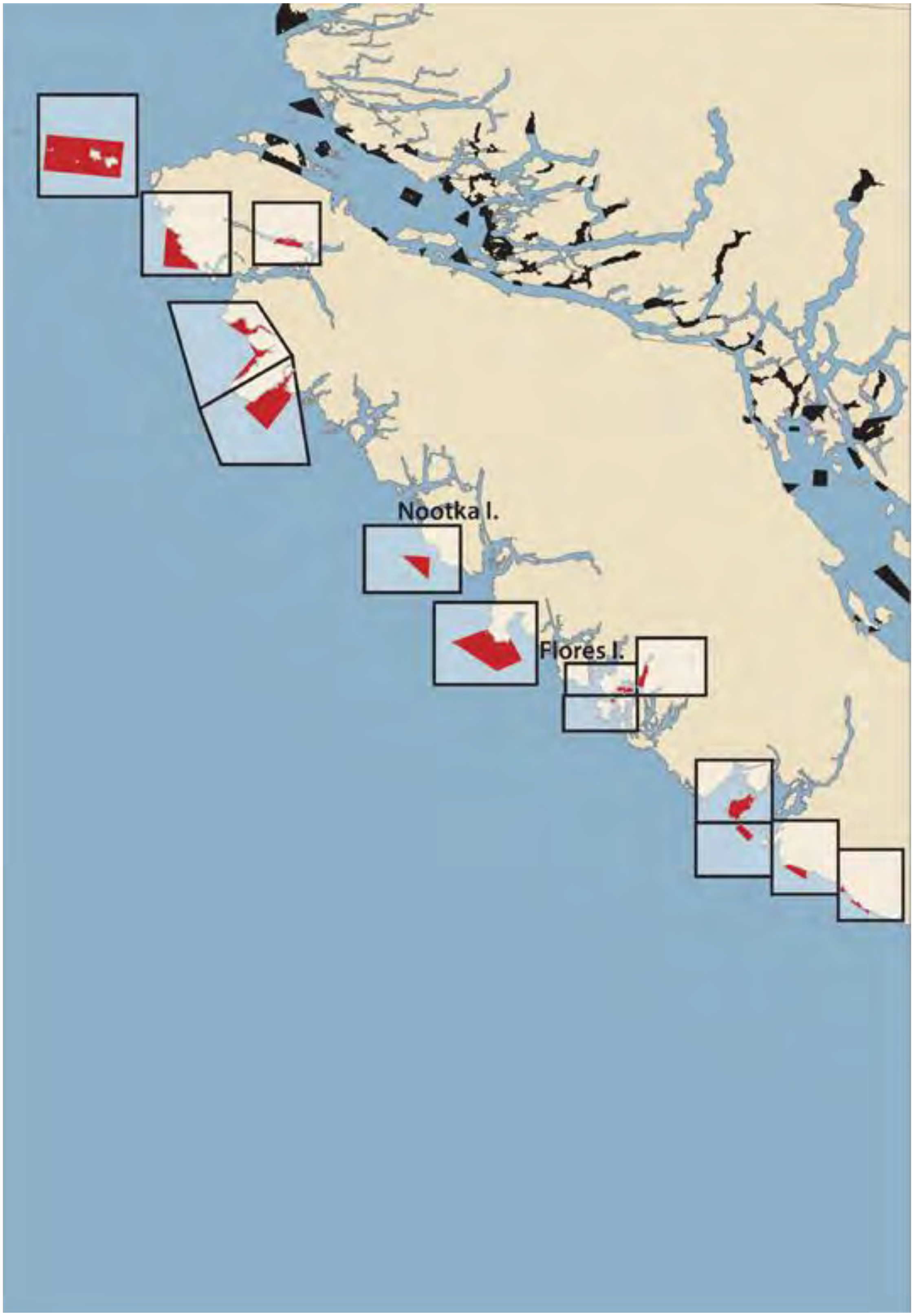


FIGURE 5. Rockfish Conservation Areas adjacent to the proposed project area. Source: DFO (2015b)

Recreational oceanic salmon fisheries off Oregon are open from March–November (location- and species-dependent); during 2018, there were 63,829 angler trips for this fishery (ODFW 2019d). Recreational groundfish taken off Oregon for which catch quotas are set include black rockfish, blue and deacon rockfishes, cabezon, canary rockfish, kelp and rock greenlings, "minor nearshore rockfishes" (China, copper, black-and-yellow, brown, calico, gopher, grass, kelp, olive, treefish, and quillback), and yelloweye rockfish; these species are primarily fished during spring and summer, with peak catches typically during July and August (ODFW 2019e). Pacific halibut are also caught during both nearshore and offshore recreational fisheries off Oregon, with the season running from May–October, with peak catches occurring from May–August (ODFW 2019f).

Recreational fisheries off Washington include salmon (Chinook, coho, chum, pink, sockeye, jacks), marine fish (bottomfish [e.g., rockfish, lingcod, sole, flounder], forage fish [e.g., herring, smelt], tunas and mackerels, Pacific halibut), and shellfish (e.g., clams, oysters, shrimp, crab) (Kraig and Scalici 2017). The recreational fishing season varies by species and location, but generally runs from May–October with peaks during mid-summer to early-fall (Kraig and Scalici 2017). The main species that contribute to the recreational fishery in B.C. include coho and chinook salmon, and Pacific halibut (MaPP 2015; DFO 2020c). Other finfish species are also caught recreationally, in addition to bivalves, crabs, and other invertebrates (DFO 2020c). In 2010, 1260 t were taken in the recreational fishery (Ainsworth 2015).

3.7.3 Tribal and First Nation Fisheries

The coast and nearshore areas are of cultural and economic importance to indigenous people of the Pacific Northwest. Since time immemorial, exercising fishing, hunting, and gathering for commercial, ceremonial, and subsistence purposes throughout the Pacific Northwest has been essential to Indigenous people in the region. Tribes in Washington State have treaties with the federal government that include fishing rights within "Usual and Accustomed Fishing and Hunting Areas" (U&A). These treaty rights have been confirmed and interpreted under the Boldt Decision[4] and other subsequent court cases[5] to include the right of Treaty Tribes to harvest up to 50% of all fisheries resources that reside in and/or pass through their U&A. These decisions also establish Treaty Tribes in Washington as legal co-managers of fisheries resources,[6] with similar regulations at the Federal level[7]. Treaty Tribes in the region have sophisticated fisheries management and research capacity. Part of the proposed survey off the Washington coast occurs within the U&A areas of the Hoh Tribe, Makah Tribe, Quileute Tribe, and Quinault Nation. Treaty Tribes' commercial and ceremonial/subsistence fisheries in this region are extensive and include but are not limited to: salmon, halibut, groundfish, flatfish, whiting, and Dungeness crab. Tribes also harvest shellfish such as clams, crab, oysters, and shrimp, and many other species as part of treaty fisheries (NWIFC 2019). Treaty fisheries play an integral role in the economy, nutritional security, and culture of the Treaty Tribes within the study area.

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[4] *United States v. Washington*, 384 F. Supp. 312 (W.D. Wash. 1974), aff'd, 520 F.2d 676, 684-687 (9th Cir. 1975).

[5] *E.g.*, *Washington v. Washington State Commercial Passenger Fishing Vessel Association*, 443 U.S. 658, 685-687 (1979) (salmon); *U.S. v. Washington*, 459 F. Supp. 1020, 1065 (W.D. Wash. 1978) (herring); *U.S. v. Washington*, No. C85-1606R, Subproceeding No. 92-1 (W.D. Wash. Dec. 29, 1993) (halibut); *U.S. v. Washington*, 873 F. Supp. 1422, 1445, n.30 (W.D. Wash. 1994), aff'd in part and rev'd in part, 157 F. 3d 630, 651-652 (9th Cir. 1998) (shellfish); *U.S. v. Washington*, No. 9213, Subproceeding 96-2 (Nov. 4, 1996) (Pacific whiting).

[6] *See generally United States v. Washington*, 384 F. Supp. 312 (W.D. Wash. 1974), aff'd, 520 F.2d 676 (9th Cir. 1975).

[7] *See*, *e.g.*, 50 C.F.R. § 660.50(d)(2).

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 indigenous communities in FSC fisheries due to their nutritional, cultural, and spiritual significance, but marine mammals, birds, and plants are also taken (Weatherdon et al. 2016). Small quantities of sockeye salmon are principally harvested for subsistence purposes on the west coast Vancouver Island in areas including Clayoquot Sound, Barkley Sound, and Nitinat Inlet (DFO 1999). Halibut as well as herring roe are also harvested (Ainsworth 2015). Under the AAROM (Aboriginal Aquatic resource and Oceans Management) program, DFO supports indigenous groups as they "develop, grow and maintain aquatic resource and oceans management departments" (DFO 2020c). Domestic fishing areas for the Maa-nulth First Nation are located within the proposed study off Vancouver Island. Artisanal fisheries occur for butter clams, lingcod, and abalone; in 2010, subsistence fishing totaled 3690 t, and artisanal landings totaled 2160 t (Ainsworth 2015).

3.8 Aquaculture

In Oregon, the only marine species that is harvested is the Pacific oyster which makes up 44% of the number of farms within the state, valued at $10 million (ODA 2015). There is significant room to diversify and expand the current practices, and to explore possibilities of farming other marine invertebrate species such as the Manila clam, purple varnish clam, mussel, abalone, sea cucumber, and sea urchin (ODA 2015). Classified commercial shellfish growing areas in Oregon include Clatsop beaches, Tillamook Bay, Netarts Bay, Yaquina Bay, Umpqua Triangle, Umpqua River, Coos Bay, and South Slough (ODA 2019).

In 2011, shellfish farming in Washington state contributed $270 million to the economy (Washington Sea Grant 2015). Shellfish aquaculture production regions along the coast include the Strait of Juan de Fuca, Grays Harbor, Willapa Bay, and Puget Sound. The most important farmed species are the Pacific, eastern, and Kumamoto oysters, Olympia oyster, Manila clam, mussels, and geoduck (Washington Sea Grant 2015). The Pacific oyster makes up 38% of the total production of aquaculture in Washington, followed by geoduck (27%) and the Manila clam (19%) (Washington Sea Grant 2015). In 2017, a sea cage site owned by Cooke Aquaculture near Cypress Island, Puget Sound, failed and released 240,000 Atlantic salmon (non-native) into the surrounding waters. Since then, House Bill 2957 was passed by Washington Legislature which stated that all remaining Atlantic salmon pens will be phased out by 2022, and new commercial non-native finfish aquaculture is prohibited (Washington State Department of Ecology 2019).

In 2016, there were 41 licensed marine finfish and 63 licensed shellfish aquaculture facilities on the west coast of Vancouver Island (DFO 2020d). During 2010–2015, finfish aquaculture production generated $454 million (77, 209 t) and shellfish aquaculture generated $21 million (9146 t) for B.C. (VIEA 2017). Most marine finfish aquaculture licenses are issued for Atlantic salmon, chinook, coho, and sockeye salmon, and to a lesser degree, sablefish, steelhead trout, sturgeon, and tilapia (DFO 2017c; VIEA 2019). The majority of finfish aquaculture facilities are located around northern and western Vancouver Island, particularly in Clayoquot Sound. Shellfish aquaculture licenses are issued for Pacific oysters, Manila clams, geoduck, blue and Gallo mussels, and Japanese scallops (BCSGA 2019). On the west coast of Vancouver Island in Barkley Sound several kelp species are farmed and harvested commercially. These species include giant kelp, bull kelp, kombu, and sugar kelp (Canadian Kelp 2019; VIEA 2019).

3.9 Shipwrecks and SCUBA Diving

There are at least 17 shore-accessible SCUBA diving sites along the Oregon coast (ShoreDiving 2019). Wreck dives are popular along the Olympic Peninsula of Washington. Although the Columbia River Bar is nicknamed the *Graveyard of the Pacific* with ~2000 shipwrecks (TheOregonCoast.info 2019), the survey area is located >50 km from the mouth of the Columbia River and would occur in water depths

>60 m, outside the range for recreational SCUBA diving. The West Coast Trail, originally the Dominion Lifesaving Trail, runs for 75 km along the southwest coast of Vancouver Island, and was built to facilitate the rescue of survivors of more than 484 shipwrecks along this stretch of coastline (West Coast Trail Guide 2019). The locations of 25 shipwrecks are included in the West Coast Trail Guide, though there are not visible remains of all 25 wrecks (West Coast Trail Guide 2019). Scuba diving makes up <5% of visitor motivations to travel to Vancouver Island North as tourism is centrally driven by other nature-based activities (Vancouver Island North Tourism Plan 2015). The majority of dive operators (41%) are located on southern Vancouver Island, and 10% are located on northern Vancouver Island and Haida Gwaii (Ivanova 2004). Most diving trips occur during the summer, but diving on the west coast takes place throughout the year (Ivanova 2004). Alberni-Clayoquot is a popular diving area on the west coast of Vancouver Island.

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 $\mu Pa^2 \cdot s$, decreased at $CSEL_{10\text{-min}}$ >127 dB re 1 $\mu Pa^2 \cdot s$, and whales were nearly silent at $CSEL_{10\text{-min}}$ >160 dB re 1 $\mu Pa^2 \cdot s$. 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).

Kavanagh et al. (2019) analyzed more than 8000 hr of cetacean survey data in the northeastern Atlantic Ocean to determine the effects of the seismic surveys on cetaceans. They found that sighting rates of baleen whales were significantly lower during seismic surveys compared with control surveys. 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 2019j). In a hearing to examine the Bureau of Ocean Energy Management's 2017–2022 OCS Oil and Gas Leasing Program (http://www.energy.senate.gov/public/index.cfm/hearings-and-business-meetings?ID =110E5E8F-3A65-4BEC-9D25-5D843A0284D3), 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.

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 (USN 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. (2018) 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), and physical presence of vessels, not just ship noise, has been shown to disturb the foraging activity of blue whales (Lesage et al. 2017). 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). 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. Reducing ship speed drastically reduced the overall risk of ship strikes (Wiley et al. 2016; Leaper et al. 2019). 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 in U.S. waters and for 60 min before and during ramp ups in Canadian waters; 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 designated EZ; and power downs (or if necessary shut downs) when sea turtles or listed seabird species are detected in or about to enter the 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.

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 but exclude potential takes in Canadian Territorial Waters.

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.

Extensive systematic aircraft- and ship-based surveys have been conducted for marine mammals in offshore waters of Oregon and Washington (e.g., Bonnell et al. 1992; Green et al. 1992, 1993; Barlow 1997, 2003; Barlow and Taylor 2001; Calambokidis and Barlow 2004; Barlow and Forney 2007; Forney 2007; Barlow 2010). Ship surveys for cetaceans in slope and offshore waters of Oregon and Washington were conducted by NMFS/SWFSC in 1991, 1993, 1996, 2001, 2005, 2008, and 2014 and synthesized by Barlow (2016); these surveys were conducted up to ~556 km from shore from June or August to November or December. These data were used by SWFSC to develop spatial models of cetacean densities for the CCE. Systematic, offshore, at-sea survey data for pinnipeds are more limited; the most comprehensive studies are reported by Bonnell et al. (1992) based on systematic aerial surveys conducted in 1989–1990. In B.C., several systematic surveys have been conducted in coastal 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; however, little effort occurred off the west coast of Vancouver Island during late spring/summer (Ford et al. 2010a).

The U.S. Navy primarily used SWFSC spatial models to develop a marine species density database for the Northwest Training and Testing Study Area (USN 2019a), which encompasses the U.S. portion of the proposed survey area; if no density spatial modeling was available, other data sources were used (USN 2019a). The USN marine species density database is at this time the most comprehensive density data set available for the CCE. However, GIS data layers are currently unavailable for the database; thus, in this analysis the USN data were used only for species for which density data were not available from an alternative spatially-explicit model (e.g., minke, sei, gray, false killer, killer, and short-finned pilot whales, *Kogia* spp., and pinnipeds). As recommended by NMFS, spatially-explicit density data from the NOAA CetSound website (NOAA 2019k) were used for most other species (i.e., humpback, blue, fin, sperm, Baird's beaked, and other small beaked whales; bottlenose, striped, short-beaked common, Pacific white-sided, Risso's, and northern right whale dolphins; and Dall's porpoise). CetMap (https://cetsound.noaa.gov/cda) provides output from habitat-based density models for cetaceans in the CCE. As CetMap provides output from habitat-based density models for cetaceans in the CCE (Becker et al. 2016) in the form of GIS layers; these were used to calculate takes in the survey area. As CetMap did not have a spatially-explicit GIS density layer for the harbor porpoise, densities from Forney et al. (2014) were used for that species. Densities used in the analysis are shown in Table B-1 of Appendix B.

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 8 shows the 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 Appendix B for more details). These are based on revised seismic transects (as shown in Fig. 1) and changes made to the mitigation radii after the Draft EA was released. When seasonal densities were available, the calculated exposures were based on late spring/summer densities, which were deemed to be most representative of the proposed survey timing. It should be noted that the exposure estimates assume that the proposed surveys would be completed in their entirety. 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 2013b). 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 2013b).

The number of marine mammals that could be exposed to airgun sounds with received levels ≥160 dB re 1 μPa_{rms} (Level B) for marine mammals on one or more occasions have been calculating based on 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. The area expected to be ensonified 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 (see Appendix B). 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.

After elimination of several transect lines in shallow water, NSF expects no takes of sea otters as no regularly-used sea otter habitat would be expected to be ensonified during the proposed survey. However, USFWS estimated that there could be 13 sea otter takes during the proposed surveys (see Appendix D). As all sea otter habitat in B.C. that was estimated to be ensonified occurred within Canadian Territorial Waters, no takes were calculated for B.C.

TABLE 8. Estimates of the possible numbers of individual 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 late spring/summer 2021. Takes for Canadian Territorial Waters are not included here. Species in italics are listed under the ESA as *endangered* or *threatened*.

	Calculated Take		Regional Population	Level B + Level A as	Requested Take
Species	Level B[1]	Level A[2]	Size	% of Pop.[3]	Authorization[4]
LF Cetaceans					
North Pacific right whale	*0*	*0*	*400*	*0*	*0*
Humpback whale[5]	*111*	*28*	*10,103*	*1.4*	*139*
Blue whale	*40*	*11*	*1,496*	*3.4*	*51*
Fin whale	*94*	*1*	*18,680*	*0.5*	*95*
Sei whale	*30*	*2*	*27,197*	*0.1*	*32*
Minke whale	96	7	20,000	0.5	103
Gray whale	43	1	26,960	0.2	44
MF Cetaceans					
Sperm whale	*72*	*0*	*26,300*	*0.3*	*72*
Baird's beaked whale	84	0	2,697	3.1	84
Small beaked whale[6]	242	0	6,318	3.8	242
Bottlenose dolphin[7]	1	0	1,924	0	**13**
Striped dolphin[7]	7	0	29,211	0	**46**
Short-beaked common dolphin[7]	112	0	969,861	0	**179**
Pacific white-sided dolphin	6,084	9	48,974	12.4	6,093
Northern right-whale dolphin	4,318	2	26,556	16.3	4,320
Risso's dolphin	1,664	5	6,336	26.3	1,669
False killer whale[8]	N.A.	N.A.	N.A.	N.A.	**5**
Killer whale[9]	73	0	918	8.0	73
Short-finned pilot whale[7]	20	0	836	2.4	**29**
HF Cetaceans					
Pygmy/dwarf sperm whale	125	5	4,111	3.2	130
Dall's porpoise	9,762	488	31,053	33.0	10,250
Harbor porpoise	7,958	283	53,773	15.3	8,241
Otariid Seals					
Northern fur seal	4,416	8	620,660	0.7	4,424
Guadalupe fur seal[10]	2,033	15	34,187	6.0	*2,048*
California sea lion	888	1	257,606	0.3	889
Steller sea lion	7,255	249	77,149	9.7	7,504
Phocid Seal					
Northern elephant seal	2,735	19	179,000	1.5	2,754
Harbor seal	3,865	22	129,732	3.0	3,887
Fissiped					
Northern Sea Otter[11]	N.A.	N.A.	2,928	0.4	13
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 is Level A plus Level B calculated takes, used by NMFS as proxy for number of individuals exposed. [4]Requested take authorization (Level A + Level B) expressed as % of population off California/Oregon/Washington, Eastern North Pacific, or U.S. stock (see Table 5). [5]All takes are assumed to be from the ESA-listed Central America and Mexico DPSs. [6] Requested take includes 7 Blainville's, 84 Stejneger's, 84 Cuvier's, and 67 Hubbs' beaked whales (see Appendix B). [7]Requested take increased to mean group size (Barlow 2016). [8]Requested take increased to mean group size (Mobley et al. 2000). [9]Includes individuals from all stocks; NMFS calculated that there would be 10 takes of killer whales from the southern resident stock (see Appendix C). [10]This is an overestimate, as Guadalupe fur seals are not expected to occur in Canadian waters. [11]Takes calculated by USFWS (see Appendix D).

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 detected animals approaching or inside the EZs), are also given in Table 8. 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.

Although the % of the population estimated to be ensonified during the surveys are large for Risso's dolphin (26.3%) and Dall's porpoise (~33.0%), these are likely overestimates. As noted above, densities derived from past surveys may not be representative of the densities that would be encountered during the proposed seismic surveys because of considerable year-to-year variability in oceanographic conditions. If densities from Barlow (2016) are used, the calculations result in takes of 14.8% of the population for Risso's dolphin, and 17.1% of the Dall's porpoise population; depending on the oceanographic conditions during the survey, these estimates may be more representative. In addition, the individuals are wide-ranging, and it is likely that some individuals would be ensonified multiple times instead of many different individuals being exposed during the survey. Also, only two sightings of 10 Risso's dolphins were seen during the L-DEO surveys off Washington/Oregon late spring/summer 2012 (RPS 2012a,b,c).

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 2019b,c).

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 8). The proposed activities are likely to adversely affect ESA-listed species for which takes are being requested (Table 9). However, the relatively short-term exposures are unlikely to result in any long-term negative consequences for the individuals or their populations.

TABLE 9. ESA determination for marine mammal species expected to be encountered during the proposed surveys in the Northeast Pacific Ocean during late spring/summer 2021.

Species	ESA Determination		
	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)			√
Sei Whale			√
Fin Whale			√
Blue Whale			√
Gray Whale (Western North Pacific Population)	√		
Sperm Whale			√
Killer Whale (Southern Resident DPS)			√
Steller Sea Lion (Western DPS)	√		
Guadalupe Fur Seal			√

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, 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 10).

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

TABLE 10. ESA determination for sea turtle species expected to be encountered during the proposed surveys in the Northeast Pacific Ocean during late spring/summer 2021.

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

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.

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Substrate vibrations caused by sounds may also affect the epibenthos, but sensitivities are largely unknown (Roberts and Elliott 2017). Nonetheless, several studies have found that substrate-borne vibration and sound elicit behavioral responses in crabs (e.g., Roberts et al. 2016) and mussels (Roberts et al. 2015). Solan et al. (2016) also reported behavioral effects on sediment-dwelling invertebrates during sound exposure. 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 $\mu Pa^2 \cdot s$ SEL. Increases in alarm responses were seen at SELs >147–151 dB re 1 $\mu Pa^2 \cdot s$; 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 μPa^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 1μPa_{0-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 $\mu Pa^2 \cdot s$. 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 11), and their fisheries, including commercial, recreational, and subsistence fisheries. Additionally, no mortality of fish or marine invertebrates are expected in marine reserves along the coast of Oregon, as the injury threshold distances would not enter the reserves that are at least 2 km away. In decades of seismic surveys carried out 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. During a similar survey conducted in the region in

TABLE 11. ESA determination for DPSs or ESUs of fish species expected to be encountered during the proposed surveys in the Northeast Pacific Ocean during late spring/summer 2021.

Species	ESA Determination		
	No Effect	May Affect – Not Likely to Adversely Affect	May Affect – Likely to Adversely Affect
Bocaccio (Puget Sound/Georgia Basin DPS)		√	
Yelloweye Rockfish (Puget Sound/Georgia Basin DPS)		√	
Steelhead Trout (Various DPSs)		√	
Bull trout (Coastal Puget Sound DPS)		√	
Chinook Salmon (Various ESUs)		√	
Chum Salmon (Various ESUs)		√	
Coho Salmon (Various ESUs)		√	
Sockeye Salmon (Various ESUs)		√	
Pacific Eulachon (Southern DPS)		√	
Green Sturgeon (Southern DPS)		√	
Giant Manta Ray	√		
Oceanic Whitetip Shark	√		
Scalloped Hammerhead Shark (Eastern Pacific DPS)	√		

the past (Marine Geophysical Surveys by R/V *Marcus G. Langseth* in the Northeastern Pacific Ocean, June–July 2012), there were no observed significant impacts. In addition, no adverse effects on EFH or HAPC are expected given the short-term nature of the study (~40 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 farther 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. If an injury threshold of 202 dB SEL is assumed, then the radius around the airgun array within which diving birds could sustain injury is 84 m. However, no activities would occur within 8 km from shore, where most marbled murrelets are found. In addition, 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 (500 m for power down, 100 m for shut down). Given the proposed activities and their limited occurrence in the proposed project area, impacts would not be anticipated to be significant or likely to adversely affect most seabird species, including short-tailed albatross and Hawaiian petrel (Table 12). Based on an analysis and consultation with USFWS, the marbled murrelet is likely to be adversely affected, but the proposed activities are not likely to jeopardize the continued existence of the marbled murrelet. 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 12. ESA determination for seabird species expected to be encountered during the proposed surveys in the Northeast Pacific Ocean during late spring/summer 2021.

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

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 Tribal & First Nation Fisheries, Cultural Resources, and Their Significance

The coast and nearshore areas are of cultural importance to indigenous peoples for fishing (including subsistence and commercial), 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. Less than 2 days of survey operations are planned within all U&A fisheries, with some areas affected for only a few hours. Interactions between the proposed surveys and fishing operations in the study area are expected to be limited. Although fishing 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 Notice to Mariners and direct radio communication with subsistence fishers during the surveys. When finalized, NSF would provide survey start date and route plans within the U&A fisheries to tribal points of contact and give notice three days in advance of planned operations within U&A fisheries.

Additionally, there are thousands of shipwrecks along the coast of the Pacific Northwest from Oregon to B.C. However, the proposed activities are of short duration (~40 days), and most of the shipwrecks (and dive sites) are located in shallower water outside of the project area. Conflicts would be avoided through communication with dive operators during the surveys. Furthermore, OBSs and OBNs 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. Models of cumulative effects that incorporate all threats to resident killer whales are better at predicting demographic rates of population than individual threat models (Lacy et al. 2017; Murray et al. 2019).

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, Current, and Future Research Activities

Scripps Institution of Oceanography (SIO) conducted low-energy seismic surveys for ~4–7 days off the coast of Oregon/Washington during September 2007, July 2009, and September 2017. During July 2008, UTIG conducted a low-energy seismic survey for ~6 days off the coast of Oregon. In June–August 2004 and August–October 2005, the riserless drilling vessel *JOIDES Resolution* conducted coring off OR. Seismic surveys using a 36-airgun array were conducted in the EVH MPA, to the north of the proposed survey area, by R/V *Langseth* during summer 2009, and off the coast of Oregon/Washington during June–July 2012.

NSF funded the Cascadia Initiative (CI), an ambitious onshore/offshore seismic and geodetic experiment that took advantage of an amphibious array to study questions ranging from megathrust earthquakes, to volcanic arc structure, to the formation, deformation, and hydration of the Juan De Fuca and Gorda Plates (Toomey et al. 2014). CI involved a plate-scale seismic experiment that encompassed components of the Cascadia subduction zone as well as the underthrusting Juan de Fuca Plate. The onshore seismic component of the amphibious array consisted of the EarthScope USArray Transportable Array and the offshore seismic component consisted of OBSs. Over four field seasons from 2011–2014, oceanographic expeditions and OBSs deployments and recoveries were conducted in the region to collect data in support of the research objectives. As noted previously, an onshore research effort is also currently under consideration for NSF funding which 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 Cascadia region.

During May–June 2018, SIO conducted vibracoring and CHIRP profiles off the Oregon coast, and retrieved seafloor receivers collecting magnetotelluric and passive seismic data offshore OR utilizing R/V *Roger Revelle*. SIO deployed geodetic transponders from R/V *Roger Revelle* along the Cascadia Subduction Zone off Oregon during June 2018, which were later retrieved. During June–August 2018, SIO conducted a cabled array survey offshore Oregon using the remote operated vehicle (ROV) *Jason* and R/V

Roger Revelle. As a component of this survey, a shallow profiler was installed and an ROV was deployed from R/V *Thompson* to turn instruments and/or moorings during July/August 2018. R/V *Sally Ride* was used by SIO to conduct biological sampling to assess mesozooplankton food webs off Oregon and northern California during July 2018, and deploy coastal surface moorings off Oregon and Washington during September–October 2018. SIO utilized two vessels to conduct sampling for a primary production study in the waters off the Northwest Pacific during August–September 2018, and collected atmospheric, water column and surficial sediment samples along 152ºW from Alaska to Tahiti using R/V *Roger Revelle* during September–October and October–November 2018.

The Northwest Fisheries Science Center conducts the West Coast Groundfish Bottom Trawl Survey from May to October every year, covering the area twice (NOAA 2021b). The survey takes place from Cape Flattery to the U.S./Mexico border (NOAA 2021b). These surveys are conducted to assess 90 commercially fished stocks to ensure sustainable fisheries (NOAA 2021b).

The Oregon State University will be conducting a whale study off the coast of Oregon that is funded by the U.S. Office of Naval Research. The study will include the deployment of two hydrophones – one off Otter Rock Marine Reserve and the other just to the southwest of Newport. All activities associated with the study would occur within 16 km from shore. In addition, the PacWave development route and area is also located within 16 km from shore off Oregon. PacWave is an open ocean wave energy test facility located off Newport.

NSF has funded a research project focused on (1) measuring particle motion and pressure from the survey and (2) behavioral responses of important marine species: rockfishes (*Sebastes* spp.), Dungeness crab, and longnose skate. The study, to be carried out by researchers from Oregon State University, would occur concurrently with the seismic survey off the coast of Oregon.

The U.S. portion of the proposed survey area is the site of numerous other recent studies including of fluid seeps along the margin, and recent (2018 and 2019) as well as future high-resolution seismic studies by the USGS as part of their multi-year hazard assessment studies for the Pacific Northwest. There are also ongoing studies using the Ocean Observatories Initiative (OOI) regional cable underwater volcanic observatory, including nodes at Axial Seamount, Juan de Fuca Plate, Hydrate Ridge, and on the Oregon shelf. In addition to having an active volcano which erupted in 1998, 2011, and 2015, Axial Seamount has several hydrothermal fields (OOI 2018). Numerous geophysical, chemical, and biological sensors, as well as cameras, are deployed there, which provide real-time information on seismic events via a cabled array (OOI 2018).

Drilling as a component of the Deep Sea Drilling Project (DSDP) and Ocean Drilling Program (ODP) was undertaken during 1971, 1992, and 2002 off Oregon (IODP 2019). Drilling was also conducted off B.C. and Washington during several ODP legs from 1991–1996, and in 2010, as a component of the IODP (IODP 2019). In addition, the IODP is proposing to drill at locations to be sited on the proposed seismic lines (IODP 2019).

In addition, Ocean Networks Canada hosts NEPTUNE (North East Pacific Time-series Underwater Networked Experiments), an underwater fiber-optic cabled observatory network in the waters of B.C. This network consists of a 840-km loop of fibre optic cable with five nodes, located at Folger Passage (near Barkley Sound), Barkley Canyon, Clayoquot Sound, Cascadia Basin, and Endeavour Ridge (Ocean Networks Canada 2019a). Instrumentation at each node includes acoustic doppler current profilers, current meters, hydrophones, rotary sonars, bottom pressure recorders, video cameras, temperature probes, oxygen sensors, and LED lights (Ocean Networks Canada 2019b).

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 2018e). 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 2019d). At the Endeavour MPA, research projects, mainly by foreign vessels (4–7 per year) and Canadian Coast Guard (1–2 per year) vessels are undertaken (Conley 2006). The SWFSC conducts regular marine mammal surveys off the U.S. coast, including off Oregon/Washington. 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 the OOI, that are planned to occur in the proposed project area during late spring/summer 2021.

4.1.6.2 Naval Activities

In summer 2012, the U.S. Navy conducted a test sponsored by the Naval Sea Systems Command, who is responsible for the research, development, and construction of Navy systems. They tested a towed array with an active acoustic source and a passive receiver. The primary test took place during both a north and south ship transit between San Diego, CA, and Puget Sound, WA, in the Pacific Northwest, when the ship was >12 nmi (~22 km) from the coast of the U.S. The Rose Festival Fleet Week occurs annually during October, for which visiting U.S. Navy ships (e.g., destroyers and mine countermeasure ships) and fleet-related elements (e.g., submarines) transit to Portland, OR (PRFF 2019). Seafair annually hosts visiting vessels from the U.S. Navy, U.S. Coast Guard, and Royal Canadian Navy during Fleet Week and the Boeing Maritime Celebration during July/August on the Seattle, WA, waterfront (Seafair 2018). Navy vessels may transit within or near the proposed survey area during any given year while travelling to west coast Fleet Week ports, depending on a ship's originating location. Other Navy activities may have been or may be conducted in this region in the future as this area is included in the U.S. Navy's Northwest Training and Testing Area, which extends up to 250 nmi offshore; however, we are not aware of any specific activities that are planned to occur in the proposed survey area during late spring/summer 2021.

4.1.6.3 Vessel Traffic

Several major ports are located on the northwestern coast of the U.S., including Seattle, Tacoma, and Portland, as well as Vancouver, B.C., and major shipping lanes originate there. 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 June–July 2019 (USCG 2019). At least 150 vessels occurred within the proposed survey area when live vessel traffic information (MarineTraffic 2019) was accessed on 1 October 2019; vessels mainly consisted of fishing vessels, but also included pleasure crafts, cruise ships, cargo vessels, tankers, and tugs. The total transit time by R/V *Langseth* (~40 days) would be minimal relative to the number of other vessels operating in the proposed survey area during late spring/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.—According to Lewison et al. (2014), the northwest coast of the U.S. has relatively high bycatch rates for marine mammals. Between 1990 and 1996, an average of 456 cetaceans and 160 pinnipeds were killed or seriously injured per year in the California/Oregon driftnet fishery. As a result of regulatory action to reduce cetacean bycatch in 1997, bycatch was reduced to a yearly average of 105 cetaceans (8 odontocete species and fin, minke, and gray whales) and 77 pinnipeds (California sea lion and northern elephant seal) during the 1997–2006 period (Moore et al. 2009). Before 2000, high bycatch of harbor porpoises, southern sea otters, and pinnipeds (California sea lion, harbor seals, and elephant seals) occurred in the set gillnet fishery for California halibut. The bycatch likely led to the decline of the harbor porpoise. Restrictions applied between 2000 and 2002 effectively closed most of the fishery (Moore et al. 2009). In 2009, based on observed bycatch, the estimated total bycatch in the California/Oregon large-mesh drift gillnet fishery for thresher sharks and swordfish was 7 short-beaked common dolphins, 15 Pacific white-sided dolphins, and 37 California sea lions (Carretta and Enriquez 2010).

Three fisheries had marine mammal takes in the non-Pacific hake groundfish fisheries from 2002–2005 (NMFS 2008c). An estimated 250 marine mammals were killed in the limited-entry bottom trawl fishery; bycatch estimates included 227.6 California sea lions, 11.5 Steller sea lions, 7.5 Pacific white-sided dolphins, and 3.1 harbor porpoises (NMFS 2008c). Bycatch in the limited-entry sablefish fishery was estimated at 29 California sea lions. Eight California sea lions were also killed in the non-sablefish endorsed fishery during the same period (NMFS 2008c). A number of pinnipeds were also caught in the west coast Pacific hake fishery; estimated bycatch for 2002–2006 included 2.5 harbor seals, 8.3 Steller sea lions, 6.9 California sea lions, and 3.4 elephant seals (NMFS 2008c). During 2007–2009, bycatch totals for the U.S. west coast groundfish fishery included 19 California sea lions, 12 Steller sea lions, 12 northern elephant seals, 5 harbor seals, 1 Risso's dolphin, 1 bottlenose dolphin, and 1 sperm whale (Jannot et al. 2011). The extent of bycatch is unknown in some fisheries that receive little or no observer coverage. In 2005, ~87 short-beaked common dolphins were killed in squid purse seines; an estimated 5196 other marine mammals were caught but released alive across all other observed California purse seine fisheries (Carretta and Enriquez 2006). In 2005, the bycatch for the Northwest Region (including Oregon) for the sablefish-endorsed fixed gear, groundfish bottom trawl, and mid-water hake trawl fisheries was estimated at 37 animals, including 33.7 California sea lions, 2.4 Steller sea lions, and 1.2 harbor seals (NMFS 2011b). From 2010–2014, Carretta et al. (2016) reported 85 large whales and 116 small cetaceans entangled in fishing gear for the U.S. west coast; there were 180 cases of pinniped injuries and mortalities in the hook and line fishery.

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 by-catch Pacific white-sided dolphins, harbor porpoises, and Dall's porpoises (Stacey et al. 1997; Williams et al. 2008).

Sea turtles.—According to Lewison et al. (2014) and Roe et al. (2014), the northwest coast of the U.S. has relatively low bycatch rates for sea turtles. Finkbeiner et al. (2011) reported that between 1990 and 2007, the annual mean bycatch for sea turtles in the California/Oregon driftnet fishery was 30 individuals before regulations came into effect, and <10 after regulations were put in place. Moore et al. (2009) reported that an average of 14 leatherbacks were killed annually in the California/Oregon drift gillnet fishery before regulations were implemented to reduce bycatch in 1997 and 2001. There was no bycatch reported for 2005 (NMFS 2011b). One sea turtle (a leatherback in 2008) was killed or injured in the west coast groundfish fishery in 2002–2009 off California (Jannot et al. 2011). Carretta and Enriquez (2010) reported one leatherback caught and released alive in 2009.

***Seabirds*.—**According to Lewison et al. (2014), the northwest coast of the U.S. has relatively low bycatch rates for seabirds. Net fisheries for salmon in Puget Sound have killed thousands of birds annually, mostly murres and auklets (Moore et al. 2009). Annual seabird bycatch in the set net fishery for California halibut during 1990–2001 ranged from 308–3259; most bycatch consisted of common murres, loons, grebes, and cormorants (Moore et al. 2009). Closure of the central California fishery in depths <110 m in 2002 reduced bycatch to an estimated 61 seabirds in 2003 (Moore et al. 2009). The estimated take of seabirds in the non-Pacific hake fisheries during 2002–2005 totaled 575, half of which were common murres. Other species caught included Leach's storm petrel, Brandt's cormorant, black-footed albatross, western gull, and brown pelican (NMFS 2008c). Jannot et al. (2011) reported takes of 11 seabird species in the west coast groundfish fishery during 2002–2009, including marbled murrelets and short-tailed albatross; in 2009, northern fulmars made up most of the bycatch. The estimated take of seabirds in the Pacific hake fisheries during the same period was 50 birds, including seven black-footed albatrosses, five common murres, 23 northern fulmars, two sooty shearwaters, and 13 unidentified seabirds (NMFS 2008c). In 2005, the bycatch for the Northwest Region (including Oregon) was estimated at 106 birds for the west coast groundfish limited entry non-trawl, groundfish bottom trawl, and mid-water hake trawl fisheries, including 58.8 black-footed albatross, 35.6 brown pelicans, 3.8 gulls, 2 sooty shearwaters, 2 northern fulmars, 2 common murres, and 2 unidentified seabirds (NMFS 2011b). 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 Tourism

Various companies offer whale and dolphin watching off the coast of Oregon and Washington. Whale watching can occur in this area year-round (Oregon Coast Visitors Association 2019). The main focus of the whale watch industry is the southward gray whale migration from mid-December through January and their northbound migration from March–June (Oregon Coast Visitors Association 2019). However, some whales are resident off Oregon in the summer and can be seen there from June through November (Oregon Coast Visitors Association 2019). There are at least 11 whale watching boat charters along the coast of Oregon, including at Newport and Depoe Bay; whale watching flights are also carried out by at least six companies (Oregon Coast Visitors Association 2019). Whale watching also takes place in Washington State, but most of the excursions occur near the San Juan Islands and inshore of the proposed project area. Whalewatch operations also occur in B.C. waters, including in the Strait of Juan de Fuca and off the west coast of Vancouver Island, from ports such as Port Renfrew, Tofino, and Ucluelet.

4.1.6.6 Whaling and Sealing

There is limited whaling and sealing by indigenous groups in the Pacific Northwest. In the U.S., the Makah Tribe has historically hunted gray whales; in recent times, a gray whale was successfully hunted on 17 May 1999 (NOAA 2015). NOAA has recently released a proposed rule to allow a limited hunt for gray whales by the Makah Tribe (NOAA 2019l). NOAA is currently considering a plan to cull sea lions on the Columbia River in order to benefit salmonid populations; under this plan, federal employees as well as indigenous tribes would remove sea lions (NOAA 2019m). In Canada, various First Nations harvest seals and sea lions, and some indigenous groups are advocating pinniped culls to benefit salmonid stocks.

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; NMFS, however, requires NSF to request 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 has been 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 have also been assessed in the document. The Draft EA was used to support the ESA Section 7 consultation process with NMFS and USFWS and other regulatory processes, such as the EFH and CZMA. Due to their involvement with the Proposed Action, the USGS also agreed to be a Cooperating Agency. The Draft EA was also used as supporting documentation for an IHA application submitted by L-DEO to NMFS and USFWS, under the U.S. MMPA, for "taking by harassment" (disturbance) of small numbers of marine mammals, for the proposed seismic survey. NSF sent notices to potential interested parties and posted the Draft EA on the NSF website for a 30-day public comment period from 7 February 2020 to 7 March 2020; comments were received from three entities (Center for Biological Diversity, Oregon Department of Fish and Game, a private individual) and are addressed in Appendix E. NSF sent letters to tribal contacts to notify the tribes 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. NSF discussed the project with a point of contact from the Quinault Nation. NSF understands a letter was sent from the Makah Tribe to NSF highlighting some points of concern about the project; however, the letter was unfortunately not received by the agency. NSF has coordinated with a point of contact on the matter.

NSF coordinated with NMFS to complete the Final EA prior to issuance of an IHA 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 also coordinated with DFO. NSF, the researchers, and L-DEO coordinated with the Navy and fishers to avoid space-use conflicts and/or security matters.

(a) Endangered Species Act (ESA)

The Draft EA was used during the ESA Section 7 consultation process with NMFS and USFWS. On 22 November 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*** Hawaiian petrel and short-tailed albatross, and the ***threatened*** marbled murrelet. On 11 January 2020, USFWS provided a letter of concurrence (Appendix F) that the proposed activity "may affect" but was not likely to "adversely affect" the Hawaiian petrel and short-tailed albatross, but did not concur for marbled murrelet, requesting additional information related to this species. In subsequent discussions with USFWS, they also identified that the Proposed Action could have potential effects on bull trout. On 24 March 2020, NSF provided additional information to USFWS on marbled murrelet and bull trout and held subsequent discussions on these species. NSF notified USFWS on 29 May 2020 that the proposed survey would be deferred until spring/summer 2021 due to COVID impacts and unfinalized federal regulatory processes, including the USFWS processes. On 5 June 2020, NSF requested the consultation efforts be continued and concluded in a timely manner despite the deferral; an extension of the consultation period was not requested or agreed upon. NSF contacted USFWS on numerous subsequent occasions to request a status update and to complete the consultation; however, USFWS demonstrated no progress in concluding the consultation. A meeting with both agency management staff was held to address the matter on 26 February 2021. On 12 April 2021, USFWS issued a Biological Opinion on these species to NSF noting that the proposed action may affect, but is not likely to adversely affect the bull trout and its critical habitat, and that the proposed actions is likely to adversely affect but is not likely to jeopardize the continued existence of the marbled murrelet (Appendix F). Mitigation measures for ESA-listed seabirds would include power downs, and if necessary, shut downs for diving or foraging seabirds within the EZ.

On 8 November 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. NMFS conducted tribal outreach efforts consistent with *Secretarial Order (#3206): American Indian Tribal Rights, Federal-Tribal Trust Responsibilities, and the Endangered Species Act*, to help inform their consultation on this action. Letters were sent to tribes with potential interest in the consultation. On 17 February 2021, NMFS held a webinar to discuss the project, including participation from representatives of tribes, NSF, and OCNMS. Per the request of the tribal representative attendees, an additional meeting focused on potential tribal fisheries interactions was held on 6 April 2021; NSF participated in the meeting.

On 3 March 2021, NOAA received a letter from the Makah Tribal Council outlining their general support of the project but making several requests, including that NSF (1) notify Makah Fisheries Management when the survey start date is finalized with route plans and anticipated dates of surveys within the Makah U&A fishing area, as well as three days in advance of reaching the Makah U&A; (2) adopt the enhanced mitigation measure to restrict seismic survey operations to daylight hours and include a second observer vessel within the Makah U&A fishing area regardless of depth to better ensure that ESA-listed marine mammals are identified and avoided; and (3) identify opportunities to monitor for acoustic impacts associated with the seismic surveys and make this data available to Makah Fisheries Management. NOAA, with input from NSF, provided a response to the Makah Tribe on 21 April 2021. The Makah Tribe also requested government to government consultation with NOAA; however, later it was communicated that a consultation meeting with NOAA Fisheries was not needed.

As previously noted, NSF had enhanced coordination with NMFS during the consultation process. 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 8 November 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 7 April 2019, NMFS issued in the Federal Register a notice of intent to issue an IHA for the survey and a 30-day public comment period. Public comments were received from three entities during that process, including the Center for Biological Diversity, Ecojustice, and Deep Green Wilderness; NMFS considered the comments and will provide responses as required per the IHA process. As previously noted, NSF had enhanced coordination with NMFS and USFWS during the IHA application process. Based on this enhanced coordination, NSF anticipates that an IHA will be issued for the proposed activity. As part of its decision-making process for the Proposed Action, NSF will take into consideration the IHA issued by NMFS and the results of the entire environmental review process.

The Draft EA was also used as supporting documentation for an IHA application submitted on 20 December 2019 by L-DEO 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. NSF had additional dialog and correspondence with USFWS regarding the IHA application, including providing additional supplemental information. After discussions with USFWS staff, NSF agreed to eliminate survey tracklines near sea otter habitat, including most activities within the 100 m isobath. NSF notified USFWS on 29 May 2020 that the proposed survey would be deferred until spring/summer 2021 due to COVID impacts and unfinalized federal regulatory processes, including the USFWS IHA process. On 5 June 2020, NSF requested the IHA application continue to be processed in a timely manner despite the deferral. On 1 March 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 D). Public comments were received from three entities during that process, including from the Marine Mammal Commission; USFWS considered the comments and will provide responses as required per the IHA process. USFWS issued an IHA for the proposed activity on 20 April 2021 (Appendix D). As part of its decision-making process for the Proposed Action, NSF has taken into consideration the IHA issued by USFWS and the results of the entire environmental review process.

(c) Coastal Zone Management Act (CZMA)

On 20 December 2019, NSF submitted a determination that the Proposed Action was consistent to the maximum extent practicable with the enforceable policies of Oregon's Coastal Zone Management Program. On 4 March 2020, the Oregon Department of Land Conservation and Development confirmed presumed concurrence with the NSF determination that the proposed activity is consistent to the maximum extent practicable with the enforceable policies of Oregon's CZM Program (Appendix G). During this process, some concerns were raised related to potential space-use conflicts with fishers; however, as noted in Section 4.1.2.4 and 4.1.5, NSF anticipates limited space-use conflict with fishers. Outreach efforts and coordination with members of the fishing industry have occurred to help further reduce any potential space-use conflicts. For example, the researchers have prepared and plan to distribute flyers and digital maps of the proposed tracklines and OBS/OBN deployments to the fishing community to avoid conflicts, including fishing gear stores in Oregon coastal towns. During operations, the vessels would communicate with other ocean users via Notice to Mariners and radio communications. Researchers engaged with the commercial fishing community through organizations like the Oregon Fishermen's Cable Committee (OFCC) and the Scientists and Fishermen Exchange (SAFE) Program from Oregon Sea Grant. As a result of researcher participation in OFCC virtual meetings, the survey vessel operator is exploring whether Automatic Identification System (AIS) can be added to the streamer tail buoy.

On 8 January 2020, NSF submitted a determination that the Proposed Action was consistent to the maximum extent practicable with the enforceable policies of Washington's Coastal Zone Management Program. On 23 March 2020, the State of Washington Department of Ecology, pursuant to the Coastal Zone Management Act of 1972 as amended, concurred with NSF's determination that the proposed work is consistent with Washington's CZMP, and that NSF demonstrated that the proposed action is consistent with the CZMP's enforceable policies found in Washington's Ocean Resource's Management Act and the Ocean Management Guidelines, which call for no long-term significant impacts to Washington's coastal zone resources or uses (Appendix G).

(d) National Marine Sanctuary Act/Olympic Coast National Marine Sanctuary

On 19 December 2019, LDEO submitted a permit application to OCNMS for activities that would occur within the Sanctuary. A Sanctuary Resource Statement (SRS) was submitted to the Office of National Marine Sanctuaries (ONMS) on 16 March 2020 by NSF and NMFS. After the survey originally scheduled for 2020 was deferred, the permit was updated for the spring/summer 2021 timeframe and resubmitted to OCNMS on 15 June 2020. As part of the permit process, OCNMS also sought input on the application from the Hoh, Makah, Quileute, and Quinault Tribes. On 19 May 2020, Quileute Tribe submitted comments on the permit application to OCNMS. In particular, the Tribe stated that they did not support the abandonment of any equipment in the marine environment, including the OBS anchors. No OBSs or anchors would be deployed within the Quileute Tribal U&A Fisheries. Based on this input, however, NSF modified the originally proposed plan to use within the Sanctuary steel anchors for the OBSs to concrete anchors, which while still cannot be retrieved, should degrade faster and mainly to sand.

NSF contacted OCNMS on multiple occasions to inquire about the status of the SRS and permit. After requesting additional information in January 2021, a revised SRS was submitted on 22 January 2021. ONMS found, on 27 January 2021, that the SRS was sufficient to make an injury determination. In their final determination dated 12 March 2021, ONMS made two alternative recommendations to further minimize injury and protect sanctuary resources: (1) limit operations in OCNMS to daylight hours only regardless of depth, and (2) use of the secondary support vessel aiding in marine mammal observations throughout the entire sanctuary (Appendix H). On 19 March 2021, NSF notified OCNMS the alternative recommendations were accepted and understood no further consultation with OCNMS was necessary prior to conducting the Proposed Action. OCNMS issued the permit on 2 April 2021 (Appendix H).

(e) Essential Fish Habitat (EFH)

EFH and HAPCs were identified to occur within the proposed survey area. Although NSF anticipated no significant impacts to EFH and HAPC, as the Proposed Action may affect EFH and HAPC, in accordance with the Magnuson-Stevens Fishery Conservation and Management Act, NSF requested consultation with NMFS on 14 November 2019. In discussions with NMFS, it was determined to incorporate the EFH process into the ESA consultation.

(f) Canadian Department of Fisheries and Oceans

An application for a Species at Risk permit application was submitted on 19 December 2019. After discussion with DFO staff, the Species at Risk application was revised and resubmitted along with a Fisheries Act Request for Review on 18 December 2020. After consultation with DFO, all proposed transect lines and their associated 160-dB ensonified area were moved out of Canadian critical habitat for southern resident killer hales. On 6 April 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 (Appendix J). 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 "Measurement measures to protect southern resident killer whales", and the "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 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 our understanding of the Cascadia Subduction Zone, providing new constraints on earthquake and tsunami potential in this heavily populated region of the Pacific Northwest. would not be collected. The No Action Alternative would not meet the purpose and need for the proposed activity.

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APPENDIX A: DETERMINATION OF MITIGATION ZONES

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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; all models used a 12-m tow depth. This 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 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 results are summarized below.

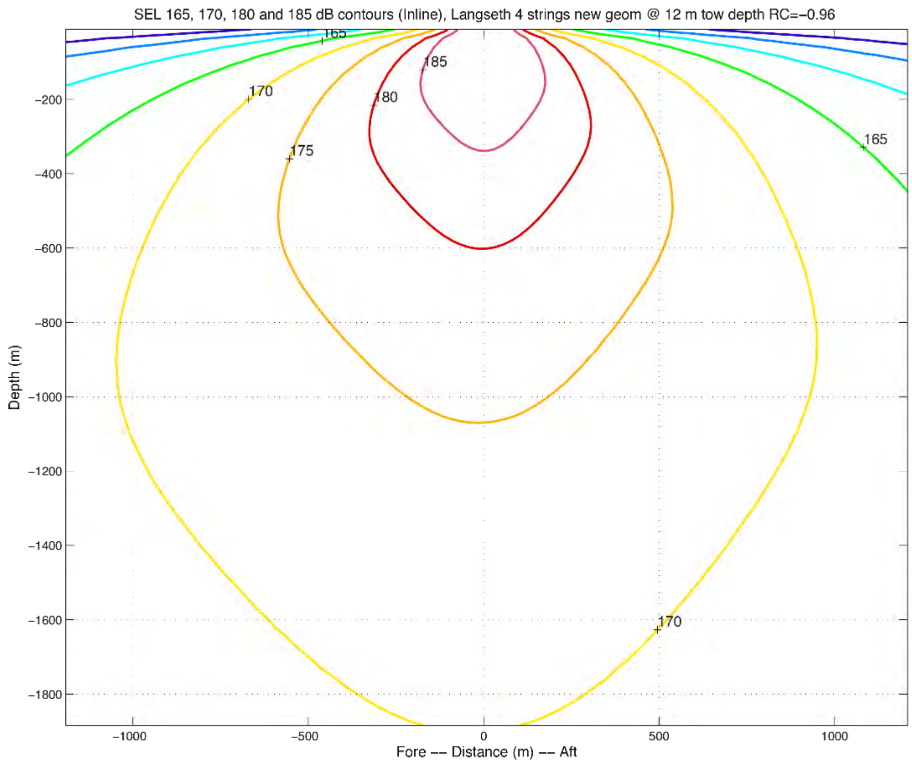
In deep and intermediate-water depths, comparisons at short ranges between sound levels for direct arrivals recorded by the calibration hydrophone and model results for the same array tow depth are in good agreement (Fig. 12 and 14 in Appendix H of the PEIS). Consequently, isopleths falling within this 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[8] 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 12-m tow depth in deep water (Fig. A-3). 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 field measurements obtained for the 36-airgun array was used. 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-3) and 7244 for the 36-airgun array at 6-m tow depth (Fig. A-2), 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-3) and 1284 m for the 36-airgun array at 6-m tow depth (Fig. A-2), 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-3) and 126.3 m for the 36-airgun array at 6-m tow depth (Fig. A-2), 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.

[8] 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).



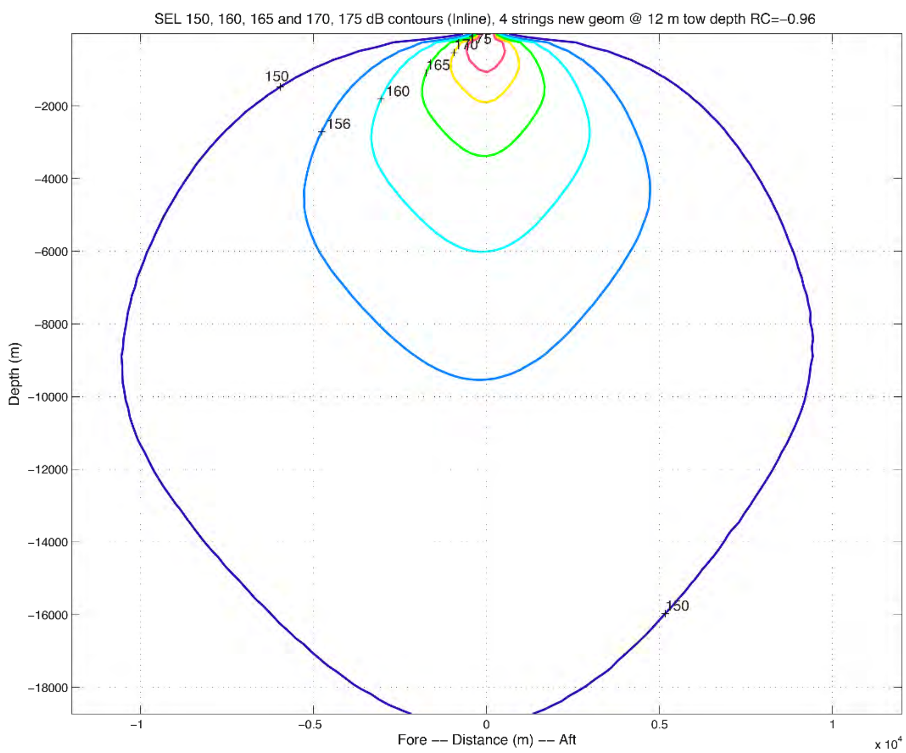


FIGURE A-1. Modeled deep-water received sound exposure levels (SELs) from the 36-airgun array at a 12-m tow depth planned for use during the proposed surveys in the Northeast Pacific Ocean. Received rms levels (SPLs) are expected to be ~10 dB higher. For example, the radius to the 150-dB SEL isopleth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

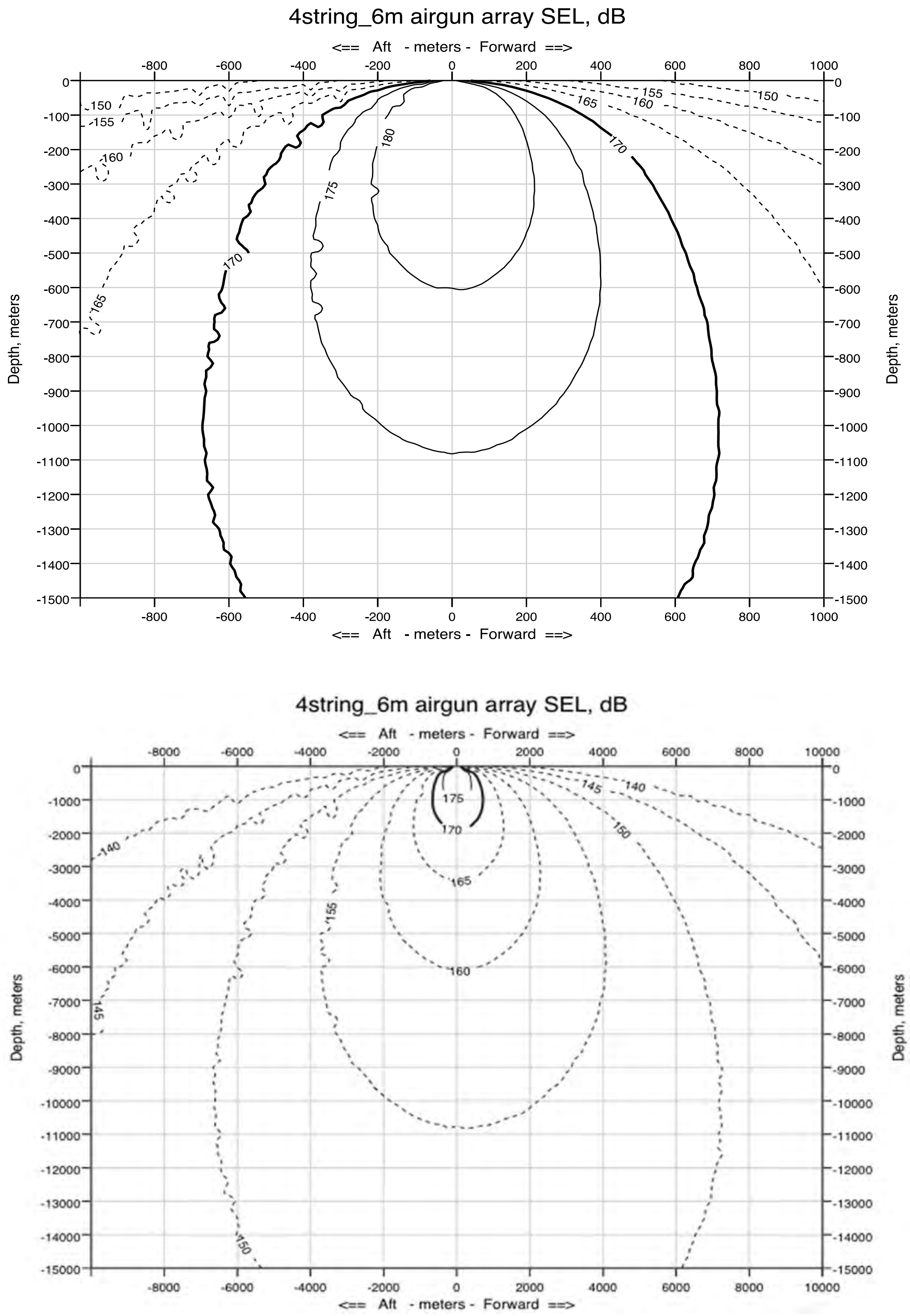


Figure A-2. Modeled deep-water received sound exposure levels (SELs) from the 36-airgun array at a 6-m tow depth used during the GoM calibration survey. Received rms levels (SPLs) are expected to be ~10 dB higher. For example, the radius to the 150 dB SEL isopleth is a proxy for the 160-dB rms isopleth. The upper plot is a zoomed-in version of the lower plot.

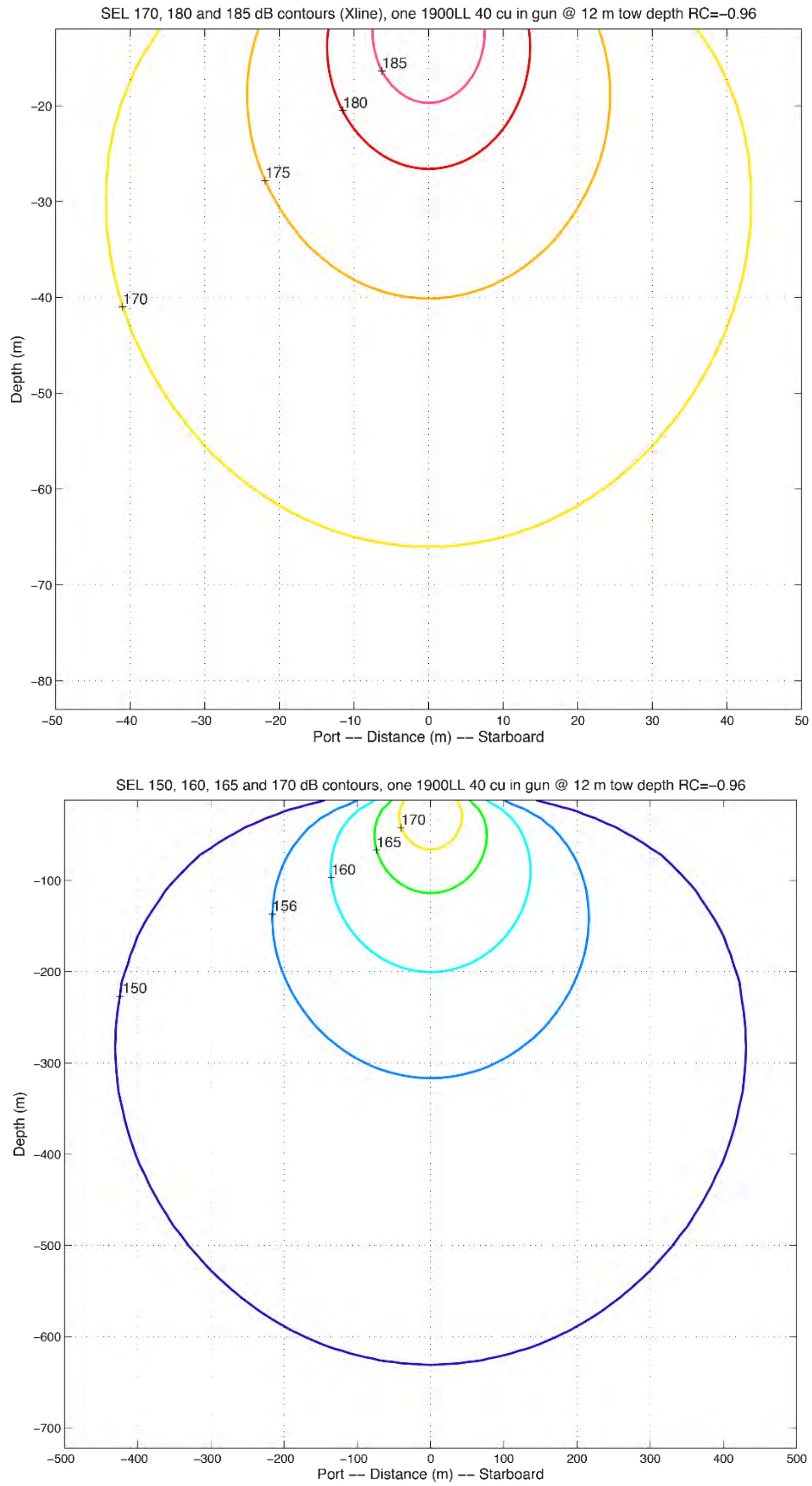


FIGURE A-3. Modeled deep-water received SELs from a single 40-in^3 airgun towed at a 12-m depth, which is planned for use as a mitigation airgun during the proposed surveys in the Northeast Pacific Ocean. Received rms levels (SPLs) are expected to be ~10 dB higher. For example, the radius to the 150-dB SEL isopleth is a proxy for the 160-dB rms isopleth. The upper plot is a zoomed-in version of the lower plot.

Table A-1 shows the distances at which the 160-dB and 175-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 criteria (Level B) that is used by NMFS to estimate anticipated takes for marine mammal. The 175-dB level is used by NMFS, based on data from the USN (2017), to determine behavioral disturbance for turtles. A recent retrospective analysis of acoustic propagation of *Langseth* sources in a coastal/shelf environment from the Cascadia Margin off Washington suggests that predicted (modeled) radii (using an approach similar to that used here) for *Langseth* sources were 2–3 times larger than measured in shallow water, so in fact, as expected, were very conservative (Crone et al. 2014). 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 the *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[9] have confirmed that the L-DEO model generated conservative EZs, resulting in significantly larger EZs than required by National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS).

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 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 (USN 2017) were also used here. The new 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

[9] 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-13. 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.

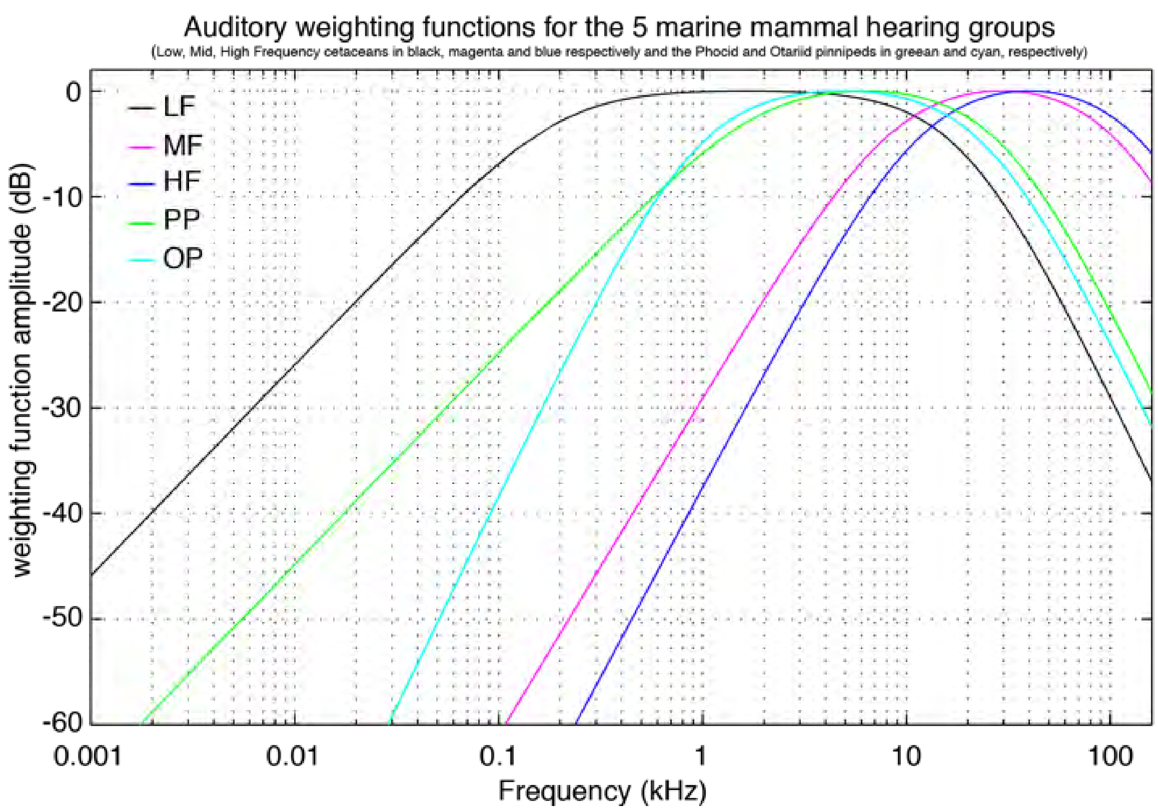


FIGURE A-4. Auditory weighting functions for five marine mammal hearing groups from the NMFS Technical Guidance Spreadsheet.

(Tolstoy et al. 2009). 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 17.3 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 a new 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).

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 single 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 function)	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.

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

TABLE A-3. Results for single shot 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	Source : 4 string 36 element 6600 cu.in of the R/V Langseth at a 12 m towed depth. Shot inteval of 37.5 m. Source velocity of 4.2 knots
Please include any assumptions	
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)	17.35573	37.5 m/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	1.14485E+22	1.10682E+22	1.17581E+22	1.10682E+22	9.29945E+21	9.12026E+21

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 Turtles**
SEL_{cum} Threshold	183	185	155	185	203	204
PTS SEL_{cum} Isopleth to threshold (meters)	**426.9**	**0.0**	**1.3**	**13.9**	**0.0**	**20.5**

WEIGHTING FUNCTION CALCULATIONS

Weighting Function Parameters	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds	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).

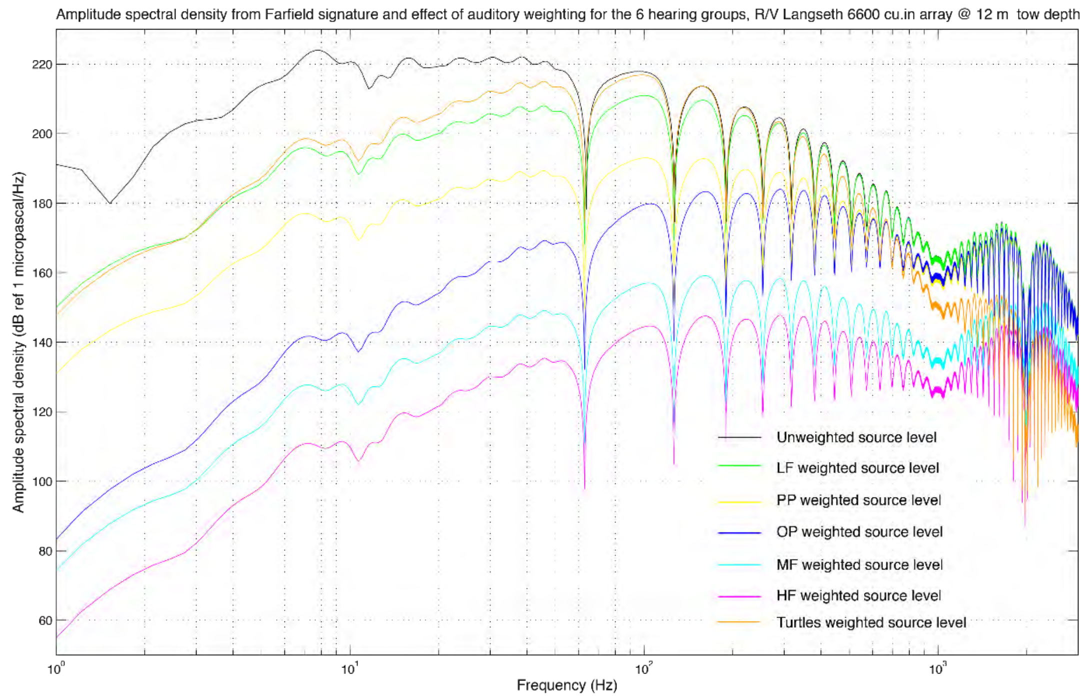


FIGURE A-5. Modeled amplitude spectral density of the 36-airgun array farfield signature. Amplitude spectral density before (black) and after (colors) applying the auditory weighting functions for LF, MF, and HF cetaceans, Phocid Pinnipeds (PP), Otariid Pinnipeds (OP), and Sea Turtles. Modeled spectral 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.

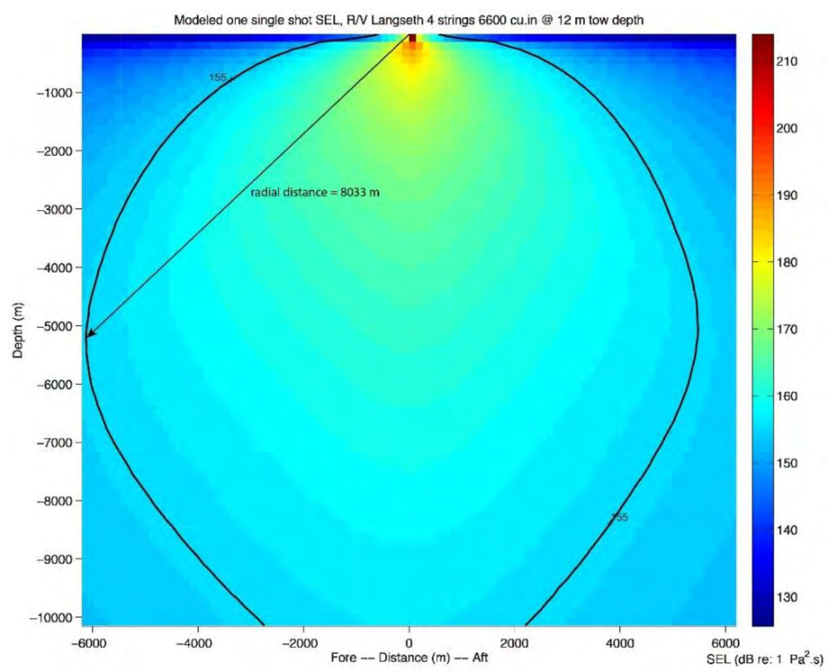


FIGURE A-6. Modeled received sound levels (SELs) in deep water from the 36-airgun array. The plot provides the radial distance from the geometrical center of the source array to the 155-dB SEL isopleth (8033 m). Radial distance allows us to determine the modified farfield SEL using a propagation of $20\log_{10}$(radial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

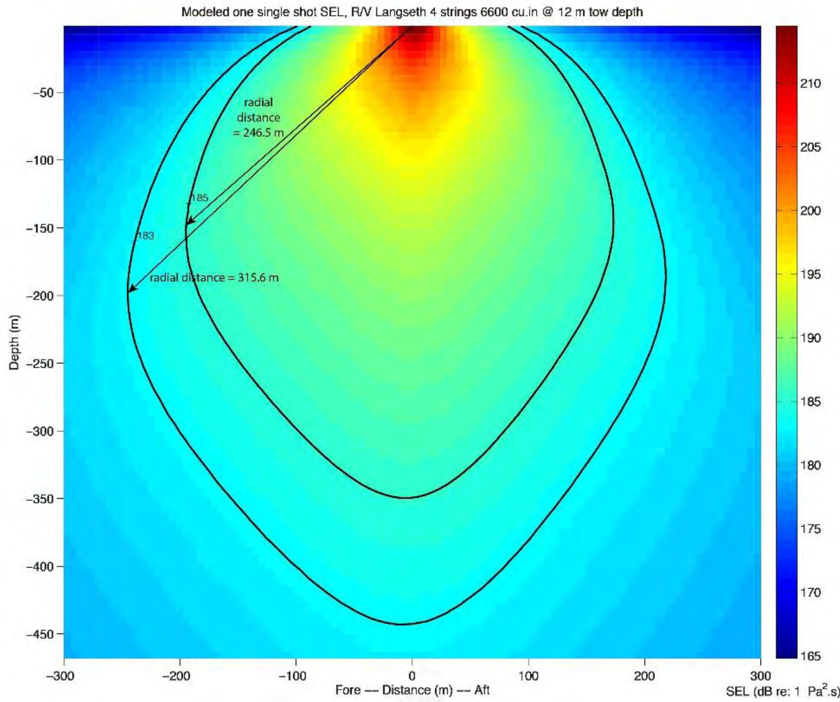


FIGURE A-7. Modeled received sound levels (SELs) in deep water from the 36-airgun array. The plot provides the radial distance from the geometrical center of the source array to the 183–185-dB SEL isopleths (315.6 and 246.5 m, respectively).

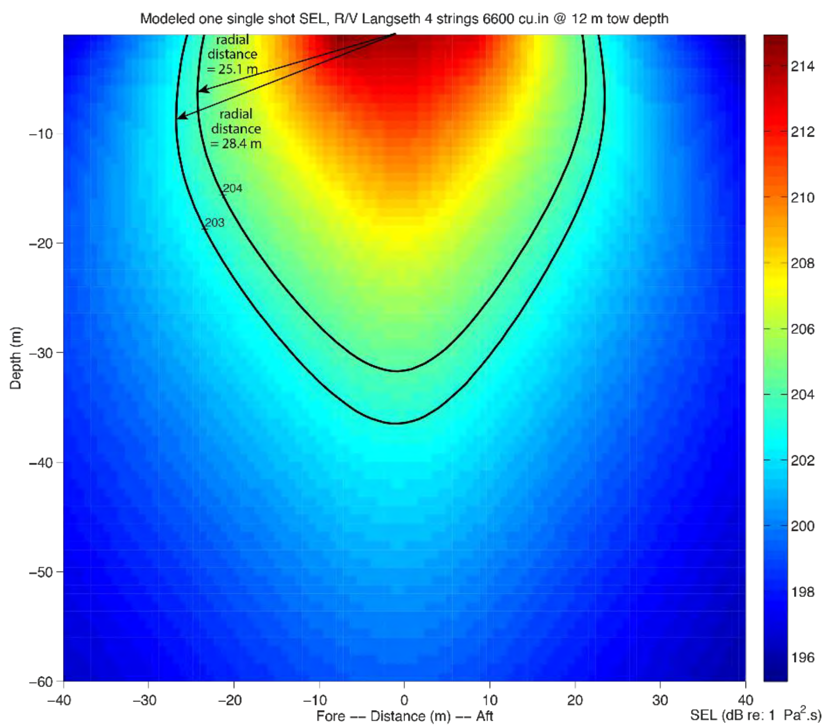


FIGURE A-8. Modeled received sound levels (SELs) in deep water from the 36-airgun array. The plot provides the radial distance from the geometrical center of the source array to the 203-dB and 204-dB SEL isopleth (28.4 m and 25.1 m, respectively).

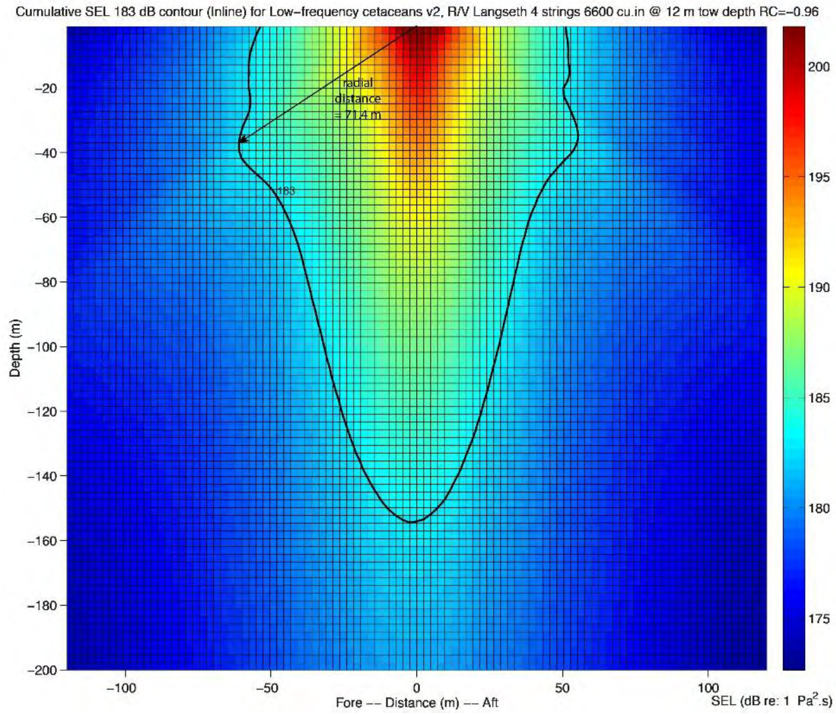


FIGURE A-9. Modeled received sound exposure levels (SELs) from the 36-airgun array at a 12-m tow depth, after applying the auditory weighting function for the LF cetaceans hearing group following the NMFS Technical Guidance. The plot provides the radial distance to the 183-dB SEL_{cum} isopleth for one 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
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.

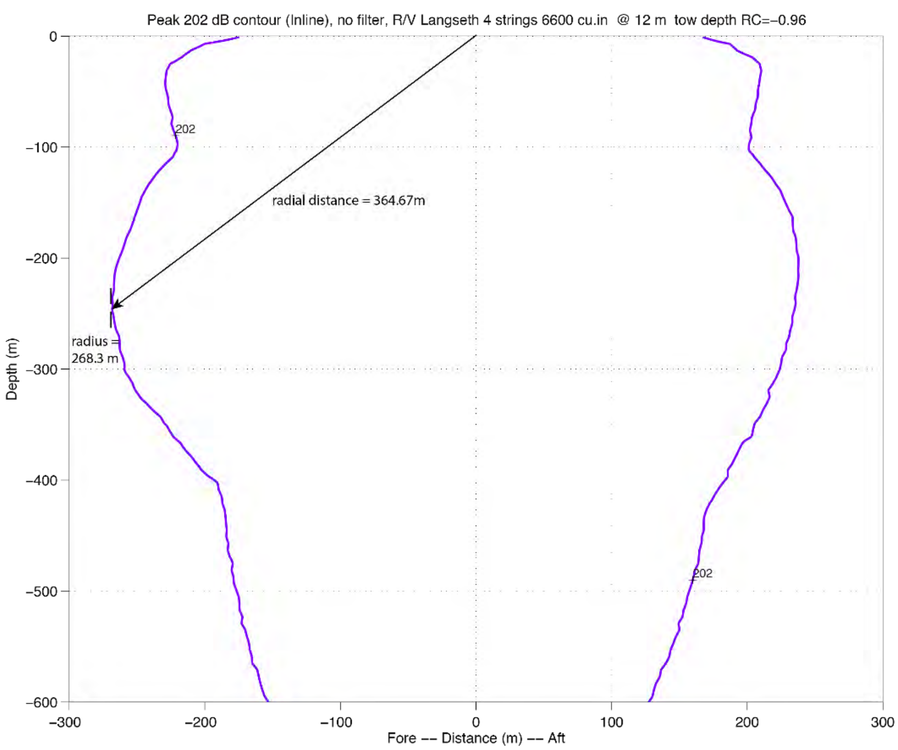


FIGURE A-10. Modeled deep-water received Peak SPL from the 36-airgun array at a 12-m tow depth. The plot provides the distance to the 202-dB Peak isopleth.

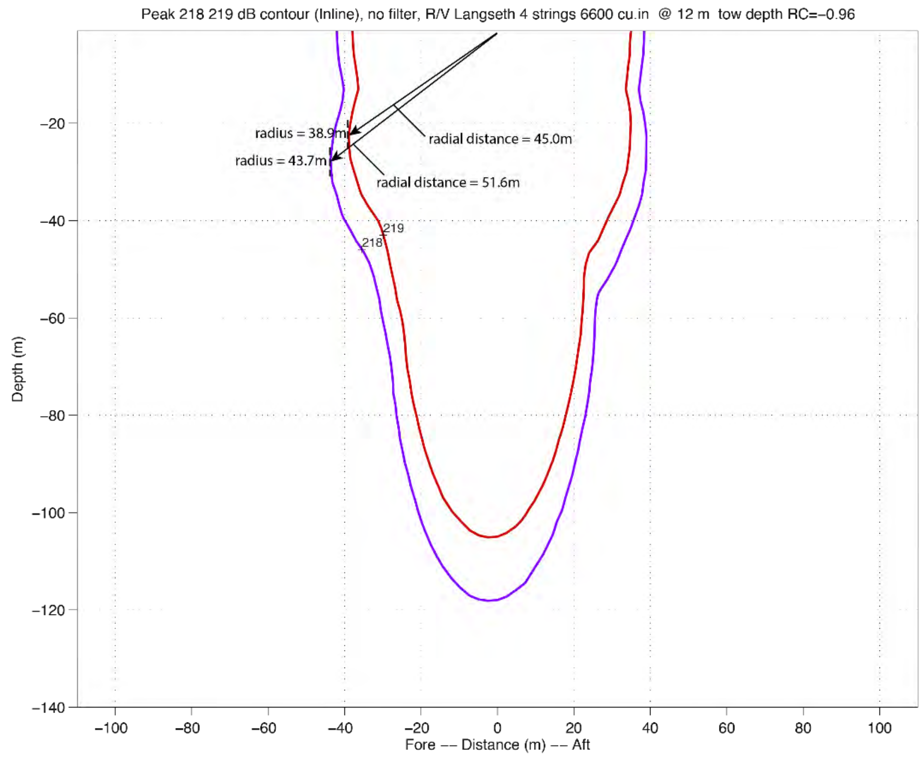


FIGURE A-11. Modeled deep-water received Peak SPL from the 36-airgun array at a 12-m tow depth. The plot provides the distances to the 218- and 219-dB Peak isopleths.

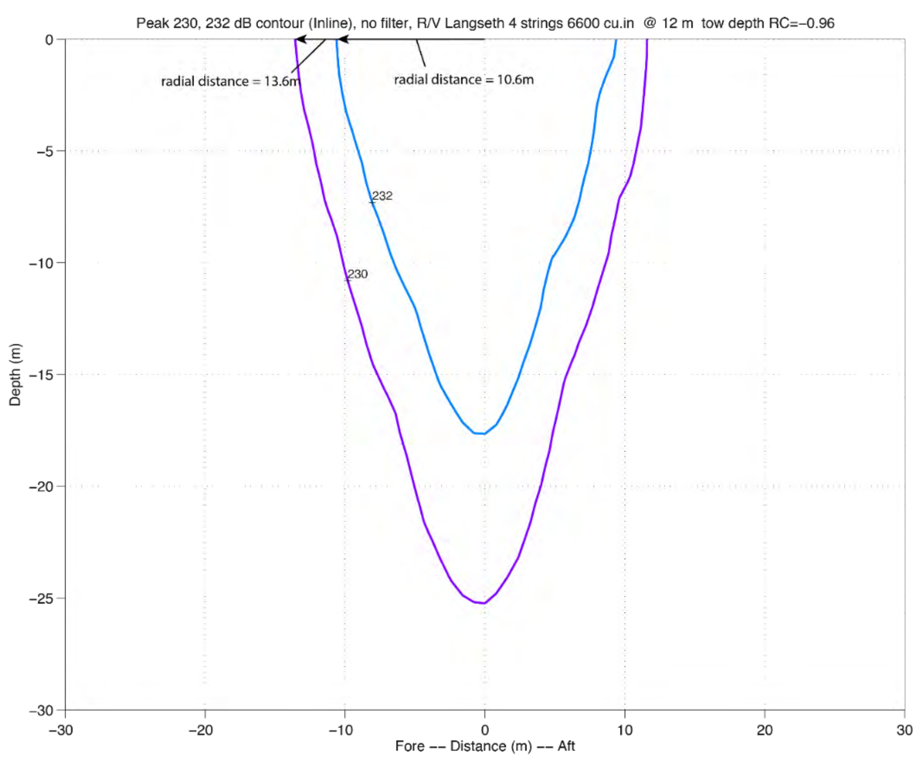


FIGURE A-12. Modeled deep-water received Peak SPL from the 36-airgun array at a 12-m tow depth. The plot provides the distances to the 230- and 232-dB Peak isopleths.

TABLE A-5. Level A threshold distances for different marine mammal hearing groups and sea turtles for the 36-airgun array. As required by 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 Turtles
PTS SEL_{cum}	**426.9**	0	1.3	13.9	0	**20.5**
PTS Peak	38.9	**13.6**	**268.3**	**43.7**	**10.6**	10.6

TABLE A-6. Results for single shot SEL source level modeling for the 40 in^3 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.

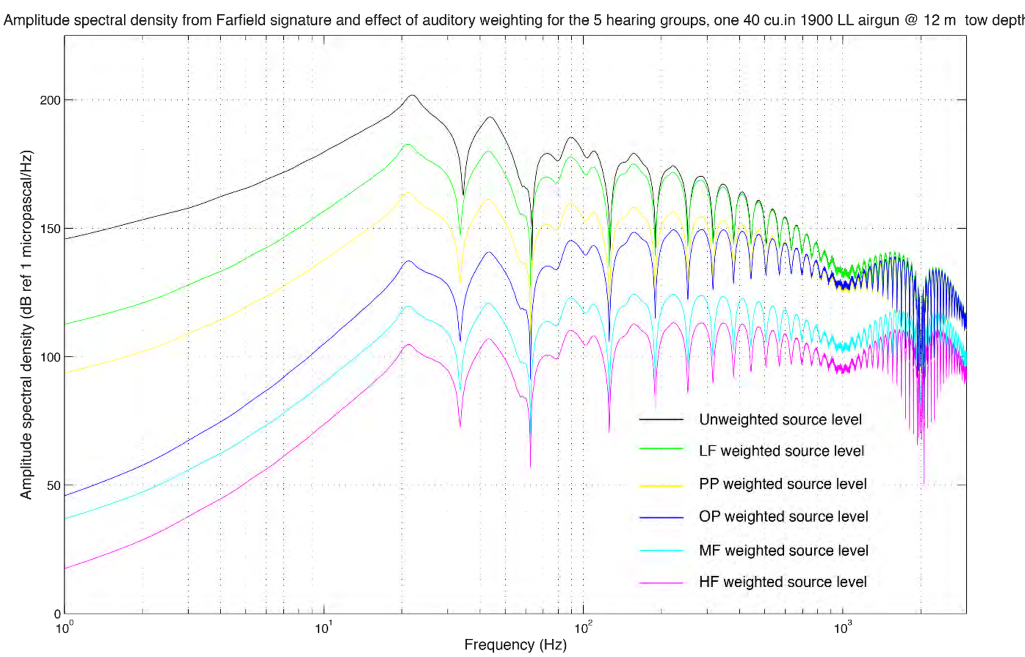


FIGURE A-13. Modeled amplitude spectral density of the 40-in^3 airgun farfield signature. Amplitude spectral density before (black) and after (colors) applying the auditory weighting functions for LF, MF, and HF cetaceans, Phocid Pinnipeds (PP), and Otariid Pinnipeds (OP). Modeled spectral levels are 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 single shot 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
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.

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)	17.35572762	37.5/2.16067

†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	1.14717E+19	1.12211E+19	1.57528E+19	1.12211E+19	9.89617E+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
SEL_{cum} Threshold	183	185	155	185	203
PTS SEL_{cum} Isopleth to threshold (meters)	**0.5**	**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).

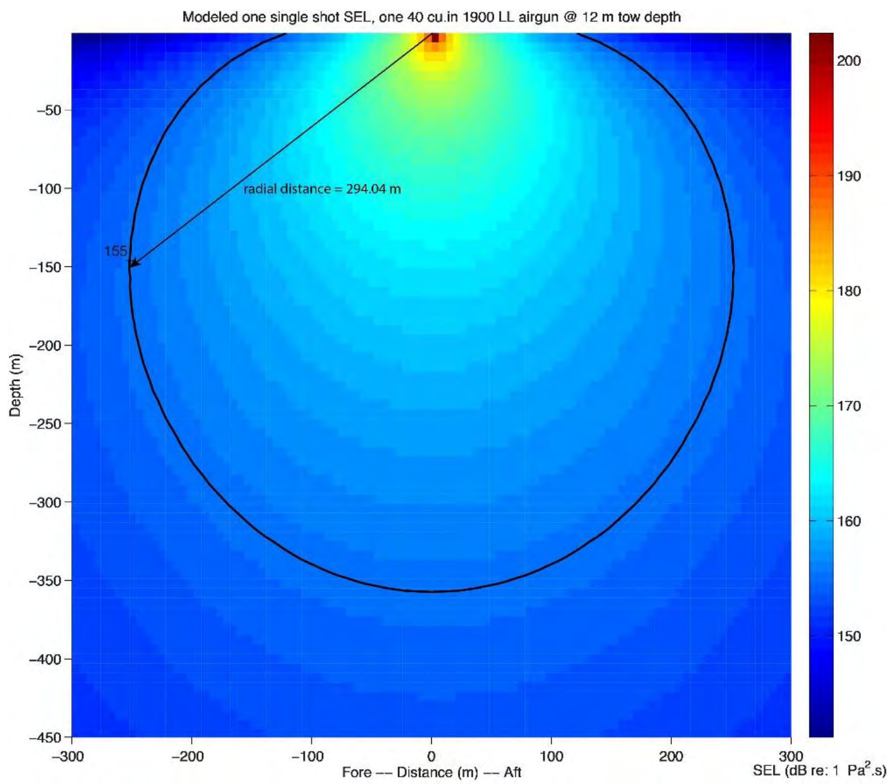


FIGURE A-14. Modeled received sound levels (SELs) in deep water from one 40-in³ airgun at a 12-m tow depth. The plot provides the distance from the geometrical center of the source array to the 155-dB SEL isopleth (294.04 m).

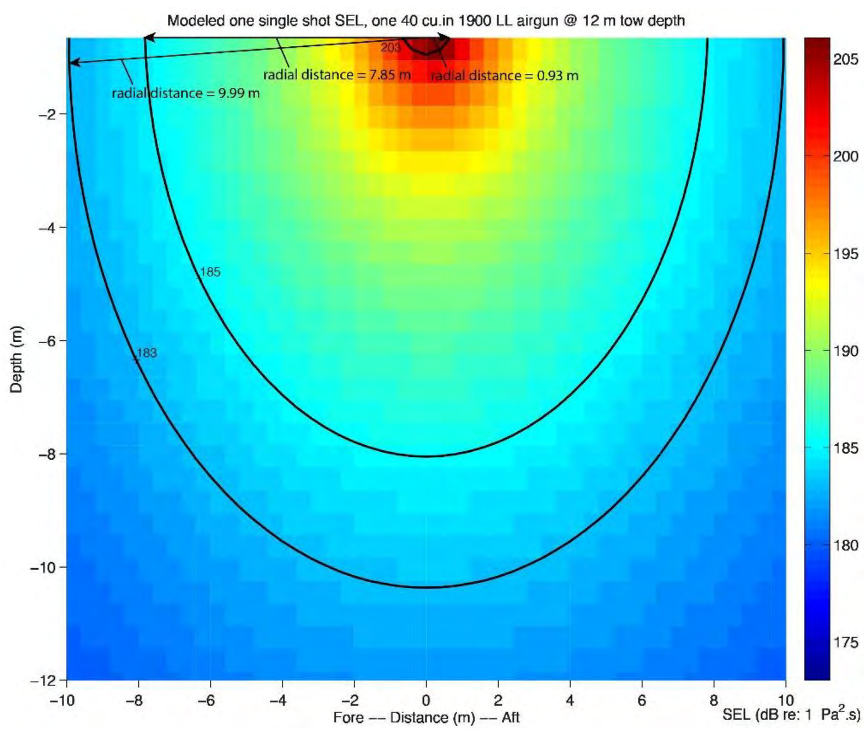


FIGURE A-15. Modeled received sound levels (SELs) in deep water from one 40-in³ airgun at a 12-m tow depth. The plot provides the distance from the geometrical center of the source array to the 183–185 dB and 203 dB SEL isopleths.

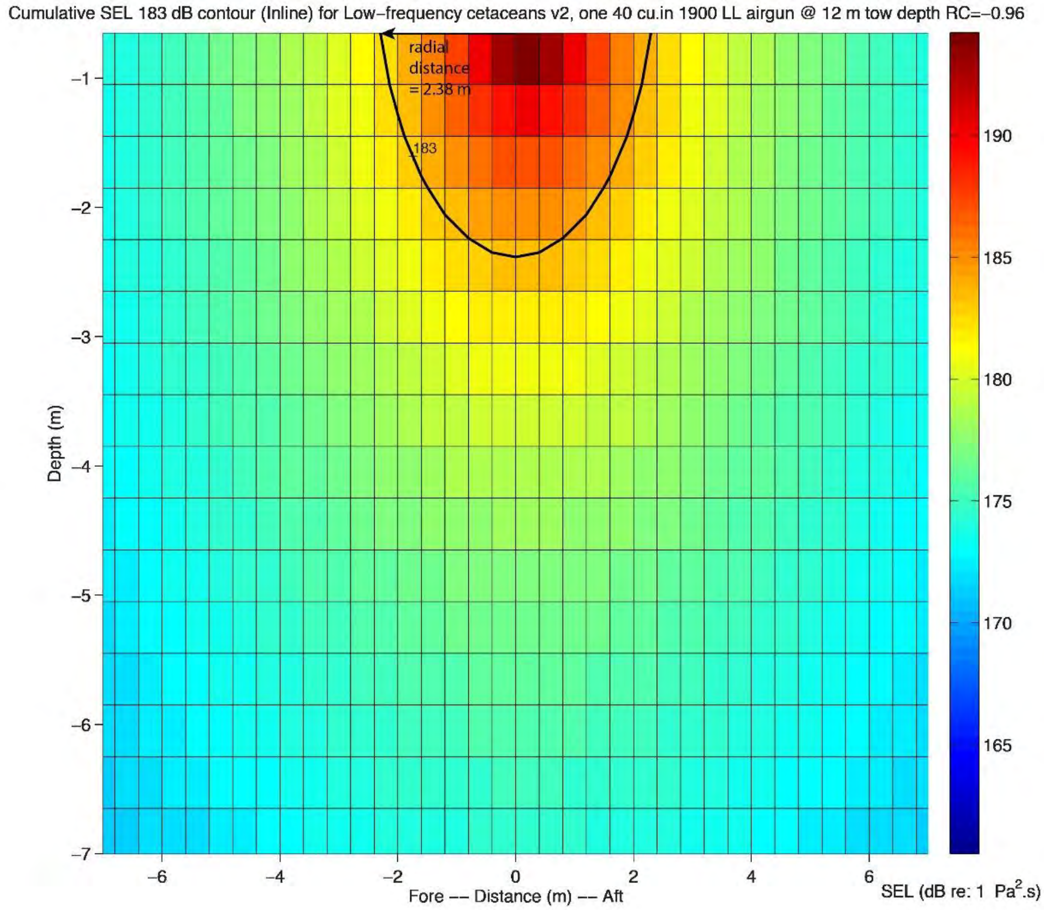


FIGURE A-16. Modeled received sound exposure levels (SELs) from one 40-in^3 mitigation at a 12-m tow depth, after applying the auditory weighting function for the LF cetaceans hearing group following the NMFS Technical Guidance. The plot provides the radial distance to the 183-dB SEL_{cum} isopleth for 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-in^3 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
Peak Threshold	**219**	**230**	**202**	**218**	**232**
PTS Peak Isopleth (Radius) to Threshold (m)	1.76	0.51	12.5	1.98	0.40

N.A. means not applicable or not available.

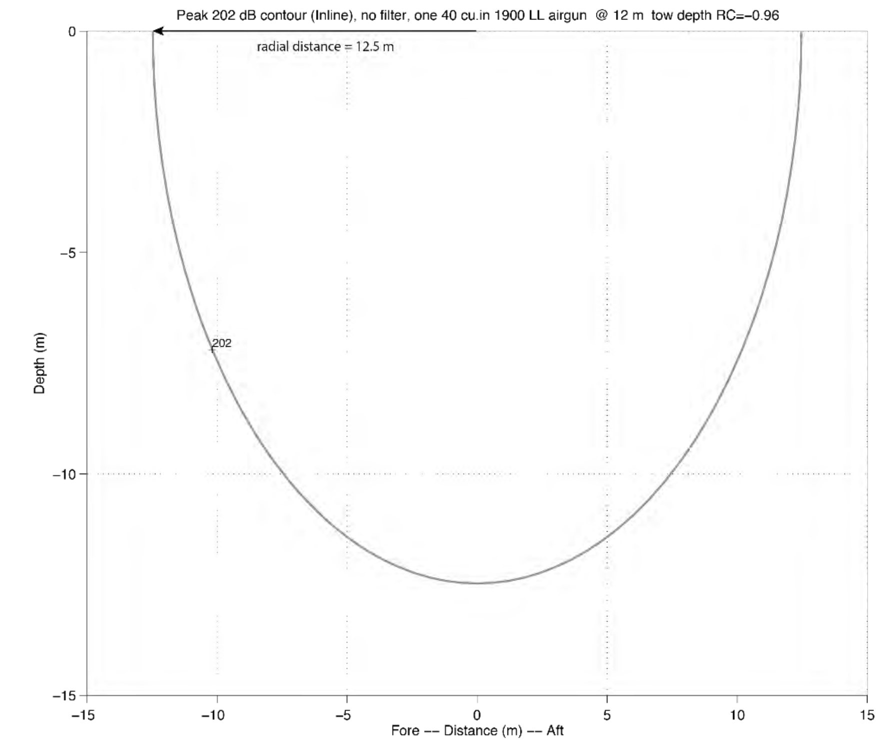


FIGURE A-17. Modeled deep-water received Peak SPL from one 40 in^3 airgun at a 12-m tow depth. The plot provides the radial distance from the source geometrical center to the 202-dB Peak isopleth.

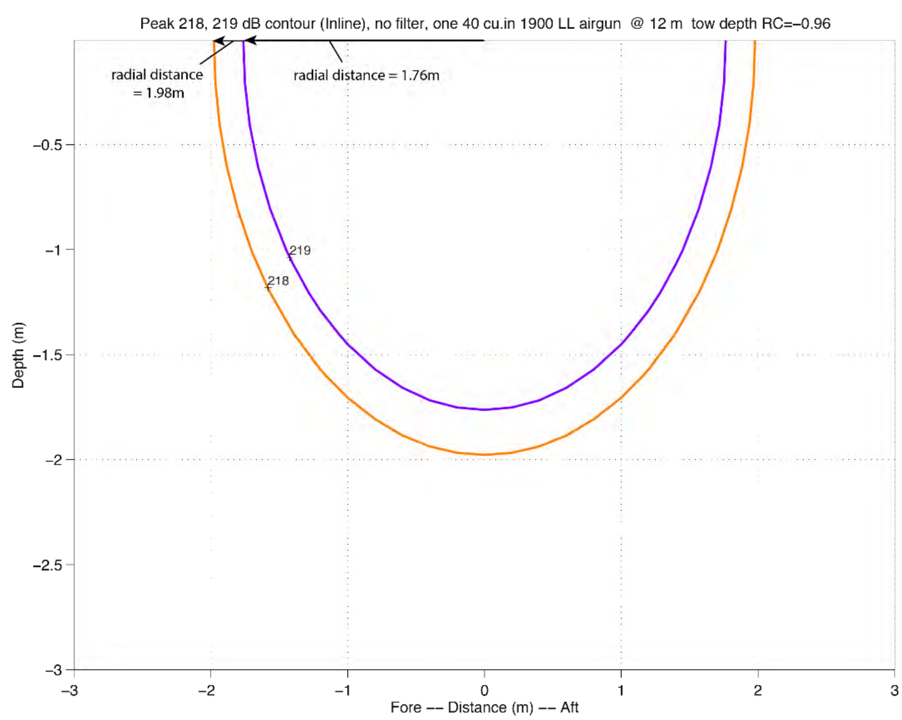


FIGURE A-18. Modeled deep-water received Peak SPL from one 40 in^3 airgun at a 12-m tow depth. The plot provides the radial distances from the source geometrical center to the 218 and 219-dB Peak isopleths.

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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).

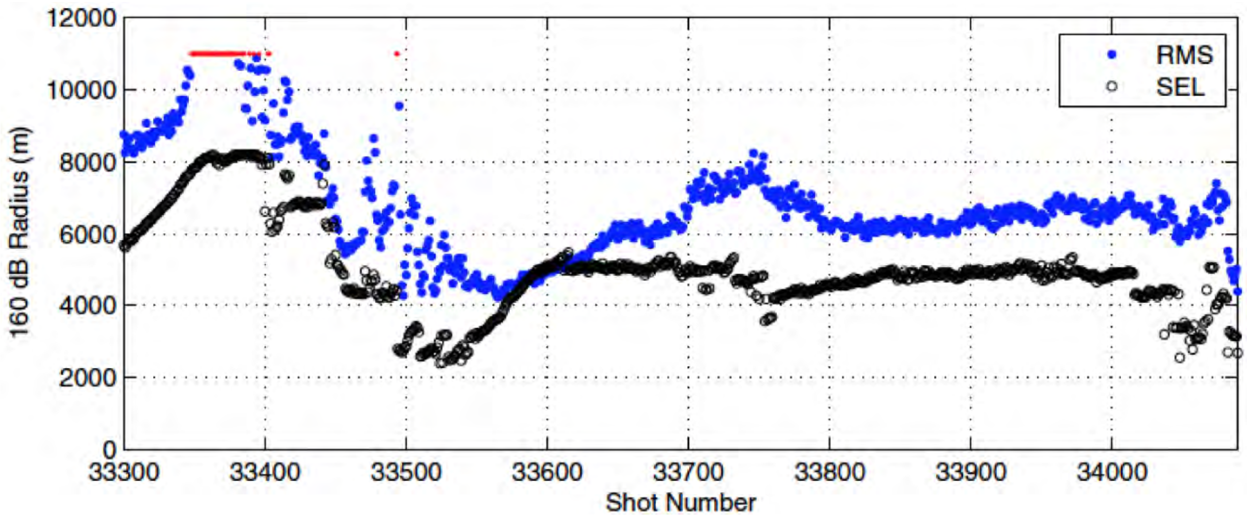

FIGURE 1. Measured radius distances to the 160 dB radii for both SEL and RMS along line A/T collected in 2012 at Cascadia with R/V *Langseth* 6600 in^3 airgun array towed at a depth of 9 m (Fig. 12 from Crone et al. 2014). This line extends across the shelf from ~50m water depth (Shot 33,300), 100m water 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 2020 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 in^3).

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: METHODS FOR MARINE MAMMAL DENSITIES, ENSONIFIED AREAS, AND TAKE CALCULATIONS

APPENDIX B: MARINE MAMMAL DENSITIES, ENSONIFIED AREAS, AND TAKE CALCULATIONS

The U.S. Navy primarily used SWFSC spatial models to develop a marine species density database for the Northwest Training and Testing Study Area (USN 2019), which encompasses the U.S. portion of the proposed survey area; if no density spatial modeling was available, other data sources were used (USN 2019a). The USN marine species density database is currently the most comprehensive density data set available for the CCE. However, GIS data layers are currently unavailable for the database; thus, in this analysis the USN data were used only for species for which density data were not available from an alternative spatially-explicit model (e.g., minke, sei, gray, false killer, killer, and short-finned pilot whales, *Kogia* spp., pinnipeds, and leatherback sea turtle). For these species, GIS was used to determine the areas expected to be ensonified in each density category. The densities (Table B-1) were then multiplied by the ensonified areas (Table B-2) to determine Level A and Level B takes (Tables B-3 and B-4).

As recommended by NMFS, spatially-explicit density data from the NOAA CetSound website (NOAA 2019k) were used for most other species (i.e., humpback, blue, fin, sperm, Baird's beaked, and other small beaked whales; bottlenose, striped, short-beaked common, Pacific white-sided, Risso's, and northern right whale dolphins; and Dall's porpoise). CetMap (https://cetsound.noaa.gov/cda) provides output habitat-based density models for cetaceans in the CCE. As CetMap provides output from habitat-based density models for cetaceans in the CCE (Becker et al. 2016) in the form of GIS layers; these were used to calculate takes in the survey area. The density estimates were available in the form of a GIS grid with each cell in the grid measuring ~7 km east-west by 10 km north-south. This grid was intersected with a GIS layer of the areas expected to be ensonified to >160 dB SPL within the three water depth categories (<100 m, 100–1000 m, >1000 m). The densities from all grid cells overlapping the ensonified areas within each water depth category were averaged to calculate a zone-specific density for each species (Table B-1). These densities were then multiplied by the total area (for the U.S. and non-territorial waters of Canada) within each water depth category expected to be ensonified above the relevant threshold levels to estimate Level A and Level B takes (Tables B-3 and B-4). As CetMap did not have a spatially-explicit GIS density layer for the harbor porpoise, densities from Forney et al. (2014) were used for that species for the portions of the survey area that occurred within the 200-m isobath (Table B-1).

The requested take for false killer whales was increased to mean group size provided by Mobley et al. (2000), as no density information was available for Oregon, Washington, or B.C. The requested takes for small beaked whales were assigned to various species as follows: assuming that Cuvier's beaked whale and Stejneger's beaked whale are expected to occur in similar numbers in the survey area as Baird's beaked whale, the same take as determined for Baird's beaked whale was assigned to the other two beaked whale species (i.e., 86 individuals each). As Blainville's beaked whale is unlikely to occur in the survey area, it was allotted a take of 7 individuals or the maximum group size as reported by Jefferson et al. (2015). The remaining takes (71) were assigned to Hubbs' beaked whale, which is expected to be rare in the survey area.

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TABLE B-1. Marine mammal densities expected to occur in the proposed survey area in the Northeast Pacific Ocean.

Species	Category	Estimated Density (#/km²): Density (not by water depth)	Shallow water <100 m	Intermediate water 100-1000 m	Deep water >1000 m	Source	Comments
LF Cetaceans							
North Pacific right whale			*0*	*0*	*0*		Not provided but near zero
Humpback whale			*0.005240*	*0.004020*	*0.000483*	Becker et al. (2016)	Summer/fall
Blue whale			0.002023	0.001052	0.000358	Becker et al. (2016)	Annual densities
Fin whale			*0.000202*	*0.000931*	*0.001381*	Becker et al. (2016)	Annual densities
Sei whale			*0.000400*	*0.000400*	*0.000400*	USN (2019a)	Annual densities
Minke whale			*0.001300*	*0.001300*	*0.001300*	USN (2019a)	Annual densities
Gray whale							
	1: 0-10 km from shore	0.015500				USN (2019a)	Density for summer (July-November)
	2: 10-47 km from shore	0.001000				USN (2019a)	Density for summer (July-November)
MF Cetaceans							
Sperm whale			*0.000059*	*0.000156*	*0.001302*	Becker et al. (2016)	Annual densities
Baird's beaked whale			0.000114	0.000300	0.001468	Becker et al. (2016)	Annual densities
Small beaked whale			0.000788	0.001356	0.003952	Becker et al. (2016)	Annual densities
Bottlenose dolphin			0.000001	0.000001	0.000011	Becker et al. (2016)	Annual densities
Striped dolphin			0.000000	0.000002	0.000133	Becker et al. (2016)	Annual densities
Short-beaked common dolphin			0.000508	0.001029	0.001644	Becker et al. (2016)	Annual densities
Pacific white-sided dolphin			0.051523	0.094836	0.070060	Becker et al. (2016)	Annual densities
Northern right-whale dolphin			0.010178	0.043535	0.062124	Becker et al. (2016)	Annual densities
Risso's dolphin			0.030614	0.030843	0.015885	Becker et al. (2016)	Annual densities
False killer whale			N.A.	N.A.	N.A.		
Killer whale (Offshore waters)			0.000920	0.000920	0.000920	USN (2019b)	Annual densities
Short-finned pilot whale			0.000250	0.000250	0.000250	USN (2019a)	Annual densities
HF Cetaceans							
Pygmy/dwarf sperm whale			0.001630	0.001630	0.001630	USN (2019a)	Annual densities
Dall's porpoise			0.145077	0.161061	0.113183	Becker et al. (2016)	Summer/fall
Harbor porpoise							
	1: North of 45N	0.624000				Forney et al. (2014)	Annual density north of 45N, within 200-m isobath
	2: South of 45N	0.467000				Forney et al. (2014)	Annual density south of 45N, within 200-m isobath
Otariid Seals							
Northern fur seal*							
	1: up to 70 km from shore	0.010912				USN (2019a)	Density for July
	2: 70-130 km from shore	0.129734				USN (2019a)	Density for July
	3: >130 km from shore	0.009965				USN (2019a)	Density for July
*Guadalupe fur seal**							
	1: within 200-m isobath	*0.023477*				USN (2019a)	Density for summer (other densities lower)
	2: 200-m isobath to 300 km	*0.026260*				USN (2019a)	Density for summer (other densities lower)
California sea lion							
	1: 0-40 km from shore	0.028800				USN (2019a)	Density for August (density zero during June and July)
	2: 40-70 km from shore	0.003700				USN (2019a)	Density for August (density zero during June and July)
	3: 70-450 km from shore	0.006500				USN (2019a)	Density for August (density zero during June and July)
Steller sea lion*							
	1: within 200-m isobath	0.480489				USN (2019a)	Average densities for OR/WA for summer
	2: 200-m isobath to 300 km	0.003581				USN (2019a)	Average densities for OR/WA for summer
Phocid Seals							
Northern elephant seal*			0.034600	0.034600	0.034600	USN (2019a)	Density for summer
Harbor seal							
	1: within 30 km from shore	0.342400				USN (2019a)	Annual density within 30 km from WA/OR shore
Turtle							
Leatherback Turtle			0.000114	0.000114	0.000114	USN (2019a)	Annual density

*Densities adjusted for most recent population size.
N.A. is not applicable.

TABLE B-2. Areas expected to ensonified during the proposed survey in the Northeast Pacific Ocean.

Survey Zone		Criteria	Daily Ensonified Area (km²)	Total Survey Days	Total Ensonified Area (km²)	Relevant Isopleth (m)
Shallow <100 m		160 dB	96.8	37	3,580.7	12650
Intermediate 100-1000 m		160 dB	636.8	37	23,562.4	9468
Deep >1000 m		160 dB	1417.3	37	52,438.7	6733
	Overall	**Level B**	**2150.9**	**37**	**79,581.9**	
		Level A				
All zones		LF Cetacean	144.2	37	5,334.5	426.9
All zones		MF Cetacean	4.6	37	171.4	13.6
All zones		HF Cetacean	90.9	37	3,364.0	268.3
All zones		Otariid	3.6	37	133.6	10.6
All zones		Phocid	14.9	37	550.5	43.7
All zones		Sea Turtle	7.0	37	258.3	20.5

TABLE B-3. Take estimates for the proposed survey area in the Northeast Pacific Ocean for the harbor porpoise and species with densities from USN (2019a,b).

	Estimated Density (#/km²)				Level B 160 dB Ensonified Area (km²)			Level A Ensonified Area (km²)			Level B Takes							
Species	Shallow <100 m / Category 1	Intermediate 100-1000 m / Category 2	Deep >1000 m / Category 3	Regional Population Size	Shallow <100 m / Category 1	Intermediate 100-1000 m / Category 2	Deep >1000 m / Category 3	Category 1	Category 2	Category 3	Shallow <100 m / Category 1	Intermediate 100-1000 m / Category 2	Deep >1000 m / Category 3	Level B Takes (All)	Just Level B Takes	Level A Takes	% of Pop. (Total Takes)	Requested Level A+B Take Authorization
LF Cetaceans																		
North Pacific right whale	*0*	*0*	*0*	400	3,581	23,562	52,439	5,335			0	0	0	0	0	0	0.00	0
Sei whale	*0.0004000*	*0.0004000*	*0.0004000*	27,197	3,581	23,562	52,439	5,335			1	9	21	32	30	2	0.12	32
Minke whale	0.0013000	0.0013000	0.0013000	20,000	3,581	23,562	52,439	5,335			5	31	68	103	96	7	0.52	103
Gray whale	0.0155000	0.0010000		26,960	1,433	21,376		1	1,416		22	21	0	44	43	1	0.16	44
MF Cetaceans																		
False killer whale	N.A.	N.A.	N.A.	N.A.	3,581	23,562	52,439	171			N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	**5**
Killer whale	0.0009200	0.0009200	0.0009200	918	3,581	23,562	52,439	171			3	22	48	73	73	0	7.98	73
Short-finned pilot whale	0.0002500	0.0002500	0.0002500	836	3,581	23,562	52,439	171			1	6	13	20	20	0	2.38	**29**
HF Cetaceans																		
Pygmy/dwarf sperm whale	0.0016300	0.0016300	0.0016300	4,111	3,581	23,562	52,439	3,364			6	38	85	130	125	5	3.16	130
Harbor porpoise	0.6240000	0.4670000		53,773	7,469	7,667		264	253		4,661	3,580	0	8,241	7,958	283	15.33	8,241
Otariid Seals																		
Northern fur seal	0.0109117	0.1297339	0.0099653	620,660	31,886	30,068	17,628	48	55	30	348	3,901	176	4,424	4,416	8	0.71	4,424
Guadalupe fur seal	*0.0234772*	*0.0262595*		34,187	15,136	64,446		516	113		355	1,692	0	2,048	2,033	15	5.99	2,048
California sea lion	0.0288000	0.0037000	0.0065000	257,606	18,356	13,530	47,696	28	20	86	529	50	310	889	888	1	0.35	889
Steller sea lion	0.4804893	0.0035811		77,149	15,136	64,446		516	113		7,273	231	0	7,504	7,255	249	9.73	7,504
Phocid Seal																		
Northern elephant seal	0.0345997	0.0345997	0.0345997	179,000	3,581	23,562	52,439	551			124	815	1,814	2,754	2,735	19	1.54	2,754
Harbor seal	0.3424000			129,732	11,351			63			3,887	0	0	3,887	3,865	22	3.00	3,887
Sea Turtle																		
Leatherback Turtle	0.0001140	0.0001140	0.0001140		985.5	7,810.4	16,244.5	258.3						3	3	0		3

N.A. means not available. * Requested take for the false killer whale is based on mean group size (Mobley et al. 2000). For different categories, see density table (Table B-1).

TABLE B-4. Take estimates for the proposed survey area in the Northeast Pacific Ocean for the species with densities from Becker et al. (2016).

Species	Estimated Density (#/km²) Shallow <100 m / Category 1	Estimated Density (#/km²) Intermediate 100-1000 m / Category 2	Estimated Density (#/km²) Deep >1000 m / Category 3	Regional Population Size	Level B 160 dB Ensonified Area (km²) Shallow <100 m / Category 1	Level B 160 dB Ensonified Area (km²) Intermediate 100-1000 m / Category 2	Level B 160 dB Ensonified Area (km²) Deep >1000 m / Category 3	Level A Ensonified Area (km²) Category 1	Level A Ensonified Area (km²) Category 2	Level A Ensonified Area (km²) Category 3	Level B Takes Shallow <100 m / Category 1	Level B Takes Intermediate 100-1000 m / Category 2	Level B Takes Deep >1000 m / Category 3	Level B Takes (All)	Just Level B Takes	Level A Takes	% of Pop. (Total Takes)	Requested Level A+B Take Authorization
LF Cetaceans																		
Humpback whale	*0.0052405*	*0.0040200*	*0.0004830*	10,103	3,581	23,562	52,439	5,335			19	95	25	139	111	28	1.37	139
Blue whale	*0.0020235*	*0.0010518*	*0.0003576*	1,496	3,581	23,562	52,439	5,335			7	25	19	51	40	11	3.39	51
Fin whale	*0.0002016*	*0.0009306*	*0.0013810*	18,680	3,581	23,562	52,439	5,335			1	22	72	95	94	1	0.51	95
MF Cetaceans																		
Sperm whale	*0.0000586*	*0.0001560*	*0.0013023*	26,300	3,581	23,562	52,439	171			0	4	68	72	72	0	0.27	72
Baird's beaked whale	*0.0001142*	*0.0002998*	*0.0014680*	2,697	3,581	23,562	52,439	171			0	7	77	84	84	0	3.13	84
Small beaked whale	*0.0007878*	*0.0013562*	*0.0039516*	6,318	3,581	23,562	52,439	171			3	32	207	242	242	0	3.83	242
Bottlenose dolphin	*0.0000007*	*0.0000011*	*0.0000108*	1,924	3,581	23,562	52,439	171			0	0	1	1	1	0	0.03	**13**
Striped dolphin	*0.0000000*	*0.0000025*	*0.0001332*	29,211	3,581	23,562	52,439	171			0	0	7	7	7	0	0.02	**46**
Short-beaked common dolphin	*0.0005075*	*0.0010287*	*0.0016437*	969,861	3,581	23,562	52,439	171			2	24	86	112	112	0	0.01	**179**
Pacific white-sided dolphin	*0.0515230*	*0.0948355*	*0.0700595*	48,974	3,581	23,562	52,439	171			184	2,235	3,674	6,093	6,084	9	12.44	6,093
Northern right-whale dolphin	*0.0101779*	*0.0435350*	*0.0621242*	26,556	3,581	23,562	52,439	171			36	1,026	3,258	4,320	4,318	2	16.27	4,320
Risso's dolphin	*0.0306137*	*0.0308426*	*0.0158850*	6,336	3,581	23,562	52,439	171			110	727	833	1,669	1,664	5	26.35	1,669
HF Cetaceans																		
Dall's porpoise	0.1450767	0.1610605	0.1131827	31,053	3,581	23,562	52,439	3,364			519	3,795	5,935	10,250	9,762	488	33.01	10,250
Otariid Seals																		
Northern fur seal	0.0109117	0.1297339	0.0099653	620,660	31,886	30,068	17,628	48	55	30	348	3,901	176	4,424	4,416	8	0.71	4,424
Guadalupe fur seal	*0.0234772*	*0.0262595*		34,187	15,136	64,446		516	113		355	1,692	0	2,048	2,033	15	5.99	2,048
California sea lion	0.0288000	0.0037000	0.0065000	257,606	18,356	13,530	47,696	28	20	86	529	50	310	889	888	1	0.35	889
Steller sea lion	0.4804893	0.0035811		77,149	15,136	64,446		516	113		7,273	231	0	7,504	7,255	249	9.73	7,504

APPENDIX C: NMFS CALCULATIONS OF SOUTHERN RESIDENT KILLER WHALE TAKES

APPENDIX C: NMFS CALCULATIONS OF SOUTHERN RESIDENT KILLER WHALE TAKES

In order to calculate estimated take, NMFS used the proposed seismic tracklines and overlaid them on density plots for Southern Resident killer whales created and provided by the U.S. Navy (USN 2019). Table C-1 shows the estimated ensonified areas within killer whale habitat, and Table C-2 shows the estimated takes.

TABLE C-1. Estimates of ensonified area within killer whale habitat and the killer whale density expected to occur there.

Pod	Density (animals/km^2)	Ensonified Area (km^2)
K/L	0	5,888
	0.000001 - 0.002803	15,470
	0.002804 - 0.005615	342
	0.005616 - 0.009366	0
	0.009367 - 0.015185	0
J	0	6,427
	0.000001 - 0.001991	5,556
	0.001992 - 0.005010	0
	0.005011 - 0.009602	0

TABLE C-2. Southern Resident Killer Whale takes as estimated by NMFS.

J pod			K/L pods			Total all pods US	Total all pods Canada	Total all areas
US	Canada territorial	Total	US	Canada territorial	Total			
1.27	0.24	1.51	8.01	0.6	8.61	9.28	0.84	10.12

Literature Cited

USN. 2019. U.S. Navy Marine Species Density Database Phase III for the Northwest Training and Testing Study Area. NAVFAC Pacific Technical Report. Naval Facilities Engineering Command Pacific, Pearl Harbor, HI. 262 p.

APPENDIX D: USFWS MMPA IHA & FEDERAL REGISTER NOTICE

United States Department of the Interior

FISH AND WILDLIFE SERVICE
911 NE 11th Avenue
Portland, Oregon 97232-4181

In Reply Refer to:
FWS/IR09/IR12/IHA-21-01

INCIDENTAL HARASSMENT AUTHORIZATION
(IHA-21-01)

The National Science Foundation and Lamont-Doherty Earth Observatory (NSF/L–DEO) are hereby authorized by the U.S. Fish and Wildlife Service (Service) under section 101(a)(5)(D) of the Marine Mammal Protection Act (MMPA; 16 U.S.C. 1371 (a)(5)(D)) to harass northern sea otters incidental to a marine geophysical survey along the coasts of Washington and Oregon, when adhering to the following terms and conditions.

1. This Incidental Harassment Authorization (IHA) is valid for a period of one year from the date of issuance.

2. This IHA is valid only for marine geophysical survey activity as specified in NSF/L–DEO's IHA application and draft environmental assessment, as subsequently modified in the Service's Federal Register notice (86 FR 12019, March 1, 2021) and the Service's final environmental assessment and Finding of No Significant Impact (FONSI); specifically using an airgun array towed behind the R/V *Langseth* and other sound emitting equipment abord the R/V *Langseth* and R/V *Oceanus* with characteristics specified in the IHA application along the Cascadia Subduction Zone off the coasts of Washington and Oregon.

3. General Conditions

   (a) A copy of this IHA shall be in the possession of NSF/L–DEO, the vessel operator, the lead Protected Species Observer (PSO) and any other relevant designees of NSF/L–DEO operating under the authority of this IHA. These personnel shall understand, be fully aware of, and be capable of full implementation of the terms and conditions of the IHA at all times during project work.

   (b) Operators shall allow Service personnel or the Service's designated representative to visit project work sites to monitor impacts to sea otters at any time throughout project activities so long as it is safe to do so. ''Operators'' are all personnel operating under the applicant's authority, including all contractors and subcontractors.

(c) Authorized incidental take is limited to a total of 13 northern sea otters. Take may be Level A harassment, Level B harassment, or combination. Authorized take shall be limited to significant injury associated with permanent threshold shifts and disruption of behavioral patterns that may be caused by geophysical surveys and support activities conducted by NSF/L–DEO in Washington and Oregon, from approximately May 20 to July 31, 2021. It is possible the proposed project timeframe could be delayed. However, as noted below, the authorization is valid for up to one year from the signature date.

(d) The taking by death of northern sea otter is prohibited and may result in the modification, suspension, or revocation of this IHA.

(e) The taking of sea otters whenever the required conditions, mitigation, monitoring, and reporting measures have not been fully implemented, as required by this IHA, is prohibited. Failure to follow measures specified herein may result in the modification, suspension, or revocation of this IHA.

(f) NSF/L–DEO or the vessel operator shall conduct briefings between PSOs and vessel crew prior to the start of all seismic operations, and when new personnel join the work, in order to explain responsibilities, communication procedures, northern sea otter monitoring protocol, and operational procedures.

4. Mitigation Measures

The holder of this Authorization is required to implement the following mitigation measures:

(a) Within the waters offshore of Washington between Tatoosh Island and the Quillayute River mouth, survey transects shall remain 21 km (13 mi) from shore or seaward of 100-m (328-ft) depth contour, whichever is greater. Survey transects shall remain seaward of the 100-m (328-ft) depth contour between the mouths of the Quillayute River and Grays Harbor. Waters less than 100-m depth contour offshore of Washington between Tatoosh Island and Grays Harbor constitute the area of highest sea otter densities within the proposed action.

(b) While the R/V *Langseth* is surveying in waters 200 m (656 ft) deep or less off the coast of Washington, survey operations shall occur in daylight hours only (*i.e.*, from 30 minutes prior to sunrise through 30 minutes following sunset) to ensure that observers are able to visually observe the entire 500-m (1,640-ft) Exclusion Zone (EZ) and beyond to implement shutdown procedures.

(c) If possible, while the R/V *Langseth* is surveying in waters 1,000 m (3,280 ft) deep or less off the coast of Washington, survey operations shall occur in daylight hours only (*i.e.*, from 30 minutes prior to sunrise through 30 minutes following sunset) to ensure that PSOs are able to visually observe the entire 500-m (1,640-ft) EZ and beyond to implement shutdown procedures.

(d) Vessel-Based Visual Observation

(i) NSF/L–DEO shall use at least five dedicated, trained, Service-approved PSOs. The PSOs shall 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 northern sea otters and mitigation requirements.

(ii) At least one of the visual PSOs aboard the vessel shall have a minimum of 90 days at-sea experience working in those roles, respectively, 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 protected species observation team. The lead PSO shall serve as primary point of contact for the vessel operator and ensure all PSO requirements per the IHA are met. To the maximum extent practicable, the experienced PSOs shall be scheduled to be on duty with those PSOs with appropriate training but who have not yet gained relevant experience.

(iii) 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 visual PSOs shall 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). Visual monitoring of the exclusion and buffer zones shall begin no less than 30 minutes prior to ramp-up and shall continue until 1 hour after use of the acoustic source ceases or until 30 minutes past sunset. Visual PSOs shall coordinate to ensure 360° 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.

(iv) During use of the airgun (*i.e.*, anytime the acoustic source is active, including ramp-up), occurrences of northern sea otters within the buffer zone (but outside the exclusion zone) shall be communicated to the operator to prepare for the potential shutdown of the acoustic source. Visual PSOs shall 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 northern sea otters by crew members shall be relayed to the PSO team. During good conditions (*e.g.*, daylight hours; Beaufort sea state (BSS) 3 or less), visual PSOs shall 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 4 consecutive hours followed by a break of at least 1 hour between watches and may conduct a maximum of 12 hours of observation per 24-hour period.

(e) Exclusion zone and buffer zone

(i) PSOs shall establish and monitor a 500-m (1,640-ft) exclusion zone and 1,000-m (3,280-ft) buffer zone. The exclusion zone encompasses the area at and below the sea surface out to a radius of 500 m from the edges of the acoustic source (rather than being based on the center of the array or around the vessel itself). The buffer zone encompasses the area at and below the sea surface from the edge of the 0–500-m (1,640-ft) exclusion zone, out to a radius of 1,000 m (3,280 ft) from the edges of the airgun array (500–1,000 m [1,640–3,280 ft]). PSOs shall monitor up to 1,000 m and enumerate any incidental take that occurs.

(f) Pre-clearance and Ramp-up

(i) A ramp-up procedure shall be followed at all times as part of the activation of the acoustic source, except as described under 4(f)(ix).

(ii) The operator shall notify a designated PSO of the planned start of ramp-up as agreed upon with the lead PSO; the notification time should not be less than 60 minutes prior to the planned ramp-up in order to allow the PSOs time to monitor the exclusion and buffer zones for 30 minutes prior to the initiation of ramp-up (pre-clearance).

(iii) Ramp-ups shall be scheduled so as to minimize the time spent with the source activated prior to reaching the designated run-in.

(iv) One of the PSOs conducting pre-clearance observations shall be notified again immediately prior to initiating ramp-up procedures and the operator shall receive confirmation from the PSO to proceed.

(v) Ramp-up shall not be initiated if any northern sea otter is within the exclusion or buffer zone. If a sea otter is observed within the 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 zone or until an additional 15-minute time period has elapsed with no further sightings.

(vi) Ramp-up shall begin by activating a single airgun of the smallest volume in the array and shall 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 shall not be less than 20 minutes. The operator shall provide information to the PSO documenting that appropriate procedures were followed.

(vii) Visual PSOs shall monitor the exclusion and buffer zones during ramp-up, and ramp-up shall cease and the source shall be shut down upon observation of a northern sea otter within the exclusion zone. Once ramp-up has begun, observations of northern sea otters within the buffer zone do not require shutdown, but such observation shall be communicated to the operator to prepare for the potential shutdown.

(viii) Ramp-up may occur at times of poor visibility if appropriate visual monitoring has occurred with no detections in the 30 minutes prior to beginning ramp-up. Acoustic source activation may occur only at times of poor visibility where operational planning cannot reasonably avoid such circumstances.

(ix) 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 northern sea otters have occurred within the applicable exclusion zone. For any longer shutdown, pre-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 visual observation was maintained, pre-clearance watch of 30 minutes is not required.

(x) 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-clearance of 30 minutes.

(g) Shutdown

(i) Any PSO on duty has the authority, and shall be required, to delay the start of survey operations or to call for shutdown of the acoustic source if a northern sea otter is detected within the 500-m exclusion zone.

(ii) The operator shall also 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 a northern sea otter appears within or enters the 500-m exclusion zone, the acoustic source shall be shut down. When shutdown is called for by a PSO, the acoustic source shall be immediately deactivated.

(iv) Following a shutdown, airgun activity shall not resume until the northern sea otter(s) has been visually observed exiting the 500-m (1,640-ft) exclusion zone or it has not been seen within the 500-m (1,640-ft) exclusion zone for 15 minutes.

(v) L–DEO shall implement shutdown if a sea otter approaches the Level A or Level B harassment zones if the level of authorized incidental take has been met.

5. Monitoring Requirements

The holder of this Authorization is required to conduct northern sea otter monitoring during survey activity. Monitoring shall be conducted in accordance with the following requirements:

(a) The operator shall provide PSOs with bigeye binoculars (*e.g.*, 25×150; 2.7-view angle; individual ocular focus; height control) of appropriate quality (*i.e.*, Fujinon or equivalent) solely for PSO use. These shall 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 shall 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 sea otters.

(c) Visual Protected Species Observer (PSO) Qualifications

(i) PSOs shall be independent, dedicated, trained visual PSOs and shall be employed by a third-party observer provider.

(ii) PSOs shall have no 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 (northern sea otters and those under the jurisdiction of NMFS) and mitigation requirements (including brief alerts regarding maritime hazards).

(iii) NSF and L–DEO are responsible for providing appropriate training to PSOs to ensure ability to observe and identify a sea otter.

(iv) NSF/L–DEO shall submit to the Service for review and approval PSO resumes including relevant training course information that identifies the name and qualifications (*i.e.*, experience, training completed, or educational background) of the instructor(s), the course outline or syllabus, and course reference material as well as a document stating successful completion of the course (passing a written and/or oral examination with 80 percent or greater).

(v) PSOs shall 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.

(vi) The educational requirements may be waived if the PSO has acquired the relevant skills through alternate experience. Requests for such a waiver shall be submitted to the Service and shall include written justification. Requests shall be granted or denied (with justification) by the Service within 1 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 shall use consistent data collection forms, whether hard copy or electronic. PSOs shall record detailed information about any implementation of mitigation requirements, including the distance of sea otters 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 shall be recorded:

a. Vessel names (source vessel and other vessels associated with survey) and call signs.

b. PSO names and affiliations.

c. Dates of departures and returns to port with port name.

d. Date and participants of PSO briefings.

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).

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-clearance, ramp-up, shutdown, testing, shooting, ramp-up completion, end of operations, streamers, etc.).

(iii) Upon visual observation of any northern sea otter, the following information shall 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 and estimated distance of northern sea otter relative to the vessel at initial sighting.

h. Estimated number of animals (high/low/best).

i. Detailed behavior observations (*e.g.*, grooming; actively moving away from vessel; diving; note any observed changes in behavior).

j. Animal's closest point of approach and/or closest distance from any element of the acoustic source.

k. Platform activity at time of sighting (*e.g.*, deploying, recovering, testing, shooting, data acquisition, other).

l. Description of any actions implemented in response to the sighting (*e.g.*, delays, shutdown, ramp-up) and time and location of the action.

6. Reporting

(a) NSF/L–DEO shall submit a final report to the Service within 90 after completion of work or expiration of the IHA, whichever comes sooner. The final report shall include the following:

(i) Summary of the operations conducted and sightings of sea otters near the operations.

(ii) Full documentation of methods, results, and interpretation pertaining to all monitoring, including factors influencing visibility and detectability of sea otters.

(iii) Summary of dates and locations of seismic operations and all northern sea otter sightings (dates, times, locations, activities, associated seismic survey activities).

(iv) Estimates of the number and nature of northern sea otter exposures that occurred above the harassment threshold based on PSO observations.

(v) Geo-referenced time-stamped vessel transect lines for all time periods during which airguns were operating. Transect lines 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).

(vi) GIS files shall be provided in ESRI shapefile format and include the UTC date and time, latitude in decimal degrees, and longitude in decimal degrees. All coordinates shall be referenced to the GCS_North_American_1983 geographic coordinate system.

(vii) All raw observational data.

(viii) Certification from the lead PSO as to the accuracy of the report.

a. The lead PSO may submit statement directly to the Service concerning implementation and effectiveness of the required mitigation and monitoring.

(b) Reporting Injured or Dead Northern Sea Otters

(i) Reporting of Injured or Dead Northern Sea Otter - In the event that personnel involved in survey activities covered by the authorization discover an injured or dead northern sea otter, the NSF/L–DEO shall report the incident to the Washington Fish and Wildlife Office's sea otter stranding coordinator (1-877-326-8837) as soon as feasible, but no later than within 48 hours. The report shall include the following information:

a. Time, date, and location (latitude/longitude) of the discovery.

b. Condition of the animal(s) (including carcass condition if the animal is dead).

c. Observed behaviors of the animal(s), if alive.

d. If available, photographs or video footage of the animal(s).

e. General circumstances under which the animal was discovered.

(ii) Vessel Strike - In the event of a ship strike of a northern sea otter by any vessel involved in the activities covered by the authorization, NSF/L–DEO shall report the incident to Washington Fish and Wildlife Office's sea otter stranding coordinator (contact information above) as soon as feasible. The report shall include the following information:

a. Time, date, and location (latitude/longitude) of the incident.

b. Vessel's speed during and leading up to the incident.

c. Vessel's course/heading and what operations were being conducted (if applicable).

d. Status of all sound sources in use.

e. 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.

f. Environmental conditions (*e.g.*, wind speed and direction, Beaufort sea state, cloud cover, visibility) immediately preceding the strike.

g. Description of the behavior of the northern sea otter immediately preceding and following the strike.

h. Estimated fate of the animal (*e.g.*, dead, injured but alive, injured and moving, blood or tissue observed in the water, status unknown, disappeared).

i. To the extent practicable, photographs or video footage of the animal(s).

(iii) *Additional Information Requests*—If the Service determines that the circumstances of any northern sea otter stranding found in the vicinity of the activity suggest investigation of the association with survey activities is warranted (example circumstances noted below), and an investigation into the stranding is being pursued, the Service shall submit a written request to the IHA-holder indicating that the following initial available information shall be provided as soon as possible, but no later than 7 business days after the request for information.

a. Status of all sound source use in the 48 hours preceding the estimated time of stranding and within 50 km (31 mi) of the discovery/notification of the stranding by the Service.

b. If available, description of the behavior of any sea otters(s) observed preceding (*i.e.*, within 48 hours and 50 km [31 mi]) and immediately after the discovery of the stranding.

c. Examples of circumstances that could trigger the additional information request include, but are not limited to, the following:

   1. Necropsies with findings of pathologies that are unusual for northern sea otters.

   2. Stranded animals with findings consistent with blast trauma.

d. 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, the Service may provide additional information requests, in writing, regarding the nature and location of survey operations prior to the time period above.

7. This Authorization may be modified, suspended or withdrawn if the holder fails to abide by the conditions prescribed herein, or if the Service determines the authorized taking is having more than a negligible impact on the northern sea otter stock in Washington and Oregon.

8. Renewals - On a case-by-case basis, the Service may issue a one-year IHA renewal with an expedited public comment period (15 days) when 1) another year of identical or nearly identical activities as described in the Specified Activities section is planned or 2) the activities would not be completed by the time the IHA expires and a second IHA would allow for completion of the activities beyond that described in the Dates and Duration section, provided all of the following conditions are met:

   (a) A request for renewal is received no later than 60 days prior to expiration of the current IHA.

   (b) The request for renewal shall include the following:

(i) An explanation that the activities to be conducted beyond the initial dates either are identical to the previously analyzed activities or include changes so minor (e.g., reduction in transects) that the changes do not affect the previous analyses, incidental take estimates, or mitigation and monitoring requirements.

(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.

(iii) Upon review of the request for renewal, the status of the northern sea otter, and any other pertinent information, the Service determines that there are no more than minor changes in the activities, the mitigation and monitoring measures remain the same and appropriate, and the original findings remain valid.

9. All reports or inquiries shall be submitted to "Attention: Washington Fish and Wildlife Office's Sea Otter Stranding Coordinator" at WashingtonFWO_Admin@fws.gov.

Acting Hugh Morrison — Digitally signed by Hugh Morrison Date: 2021.04.20 16:56:39 -07'00'

Regional Director, Interior Regions 9 and 12
U.S. Fish and Wildlife Service

April 20, 2021

Date

for purposes of publication in the **Federal Register**.

Aaron Santa Anna,

Federal Register Liaison for the Department of Housing and Urban Development.

[FR Doc. 2021–04074 Filed 2–26–21; 8:45 am]

BILLING CODE 4210–67–P

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

[Docket No. FR–7040–N–04; OMB Control No. 2535–0107]

60-Day Notice of Proposed Information Collection: Public Housing Financial Management Template

AGENCY: Office of the Assistant Secretary for Public and Indian Housing, PIH, HUD.

ACTION: Notice.

SUMMARY: HUD is seeking approval from the Office of Management and Budget (OMB) for the information collection described below. In accordance with the Paperwork Reduction Act, HUD is requesting comment from all interested parties on the proposed collection of information. The purpose of this notice is to allow for 60 days of public comment.

DATES: *Comments Due Date: April 30, 2021.*

ADDRESSES: Interested persons are invited to submit comments regarding this proposal. Comments should refer to the proposal by name and/or OMB Control Number and should be sent to: Colette Pollard, Reports Management Officer, QDAM, Department of Housing and Urban Development, 451 7th Street SW, Room 4176, Washington, DC 20410–5000; telephone 202–402–5564 (this is not a toll-free number) or email at *Colette.Pollard@hud.gov* for a copy of the proposed forms or other available information. Persons with hearing or speech impairments may access this number through TTY by calling the toll-free Federal Relay Service at (800) 877–8339.

FOR FURTHER INFORMATION CONTACT: Dacia Rogers, Office of Policy, Programs and Legislative Initiatives, PIH, Department of Housing and Urban Development, 451 7th Street SW, (L'Enfant Plaza, Room 2206), Washington, DC 20410; telephone 202–402–4109, (this is not a toll-free number). Persons with hearing or speech impairments may access this number via TTY by calling the Federal Relay Service at (800) 877–8339. Copies of available documents submitted to OMB may be obtained from Ms. Rogers.

SUPPLEMENTARY INFORMATION: This notice informs the public that HUD is seeking approval from OMB for the information collection described in Section A.

A. Overview of Information Collection

Title of Information Collection: Public Housing Financial Management Template.

OMB Approval Number: 2535–0107.

Type of Request: Reinstatement of a previously approved collection.

Form Number: N/A.

Description of the need for the information and proposed use: To meet the requirements of the Uniform Financial Standards Rule (24 CFR part 5, subpart H) and the asset management requirements in 24 CFR part 990, the Department developed financial management templates that public housing agencies (PHAs) use to annually submit electronically financial information to HUD. HUD uses the financial information it collects from each PHA to assist in the evaluation and assessment of the PHAs' overall condition. Requiring PHAs to report electronically has enabled HUD to provide a comprehensive financial assessment of the PHAs receiving federal funds from HUD.

Respondents: Public Housing Agencies (PHAs).

Estimated Annual Reporting and Recordkeeping Burden: The average burden hour estimate assumes that there are 3,916 PHAs (Low Rent Only, Low Rent and Section 8, and Section 8 only PHAs) that submit one unaudited financial management template annually. The average burden hours associated with an unaudited financial management template is 6.4 hours (25,015.5 total hours divided by 3,916 PHAs). There are 3,538 PHAs that are required to or voluntarily submit an audited financial management template annually. The average burden hours associated with an audited financial management template is 4.2 hours (14,705 total hours divided by 3,538 PHAs). When added together, the average burden hours for a PHA that submits both an unaudited and audited financial management template is 5.3 hours, for a total reporting burden of 39,721 hours.

B. Solicitation of Public Comment

This notice is soliciting comments from members of the public and affected parties concerning the collection of information described in Section A on the following:

(1) Whether the proposed collection of information is necessary for the proper performance of the functions of the agency, including whether the information will have practical utility;

(2) The accuracy of the agency's estimate of the burden of the proposed collection of information;

(3) Ways to enhance the quality, utility, and clarity of the information to be collected; and

(4) Ways to minimize the burden of the collection of information on those who are to respond; including through the use of appropriate automated collection techniques or other forms of information technology, *e.g.*, permitting electronic submission of responses.

HUD encourages interested parties to submit comment in response to these questions.

C. Authority

Section 3507 of the Paperwork Reduction Act of 1995, 44 U.S.C. Chapter 35 as amended.

Dated: February 19, 2021.

Merrie Nichols-Dixon,

Director, Office of Policy, Programs and Legislative Initiatives.

[FR Doc. 2021–04136 Filed 2–26–21; 8:45 am]

BILLING CODE 4210–67–P

DEPARTMENT OF THE INTERIOR

Fish and Wildlife Service

[Docket No. FWS–R1–ES–2020–0131; FXES111401000000, 212, FF01E00000]

Marine Mammals; Incidental Take During Specified Activities; Proposed Incidental Harassment Authorization for Northern Sea Otters in the Northeast Pacific Ocean

AGENCY: Fish and Wildlife Service, Interior.

ACTION: Notice of receipt of application and proposed incidental harassment authorization; availability of draft environmental assessment; and request for public comments.

SUMMARY: The U.S. Fish and Wildlife Service (Service) received a request from the National Science Foundation (NSF) for authorization to take a small number of northern sea otters by harassment incidental to a marine geophysical survey in the northeast Pacific Ocean. Pursuant to the Marine Mammal Protection Act of 1972, as amended (MMPA), the Service is requesting comments on its proposal to issue an incidental harassment authorization (IHA) to NSF for certain activities during the period between May 1 and June 30, 2021. This proposed IHA, if finalized, will be for take by Level A and Level B harassment. We

anticipate no take by death and include none in this proposed authorization. The Service has prepared a draft environmental assessment (EA) addressing the proposed IHA and is soliciting public comments on both documents.

DATES: Comments on the proposed IHA request and the draft EA will be accepted on or before March 31, 2021.

ADDRESSES:

Document availability: The proposed IHA request, the draft EA, and the list of references cited herein are available for viewing at *http://www.regulations.gov* in Docket No. FWS–R1–ES–2020–0131 and at *http://www.fws.gov/wafwo*. NSF's associated environmental assessments can be found at *https://www.nsf.gov/geo/oce/envcomp/*.

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–R1–ES–2020–0131, U.S. Fish and Wildlife Service, 5275 Leesburg Pike, MS: PRB/3W, Falls Church, VA 22041–3803; or
- *Federal eRulemaking Portal: http://www.regulations.gov*. Follow the instructions for submitting comments to Docket No. FWS–R1–ES–2020–0131.

We will post all comments on *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: Brad Thompson, State Supervisor, U.S. Fish and Wildlife Service, Washington Fish and Wildlife Office, 510 Desmond Drive SE, Suite 102, Lacey, WA 98503–1273 (telephone 360–753–9440).

SUPPLEMENTARY INFORMATION:

Background

Section 101(a)(5)(D) of the Marine Mammal Protection Act of 1972, as amended (MMPA; 16 U.S.C. 1361, *et seq.*), authorizes the Secretary of the Interior to allow, upon request, the incidental, but not intentional, taking of small numbers of marine mammals 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 1 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) The take is of a small number of marine mammals; (ii) the 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. As part of the authorization process, we prescribe permissible methods of taking and other means of affecting the least practicable impact on the species or stock and its habitat and prescribe requirements pertaining to the monitoring and reporting of such takings.

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 which (i) has the potential to injure a marine mammal or marine mammal stock in the wild (the MMPA refers to this impact 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 refers to these impacts as Level B harassment) (See 16 U.S.C. 1362(18)).

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. The subsistence provision does not apply to northern sea otters in Washington and Oregon.

If the requisite findings are made, we will issue an 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 (iii) requirements for monitoring and reporting take.

Summary of Request

On December 19, 2019, the Service received an application from the National Science Foundation (hereafter "NSF" or "the applicant") for authorization to take the northern sea otter (*Enhydra lutris kenyoni*, hereafter "sea otters" or "otters" unless another subspecies is specified) by unintentional harassment incidental to a marine geophysical survey of the Cascadia Subduction Zone off the coasts of Washington, Oregon, and British Columbia, Canada. The NSF subsequently postponed the project until 2021.

Description of the Activities and Specified Geographic Region

The specified activity (the "project") consists of Lamont-Doherty Earth Observatory's (L–DEO) 2020 Marine Geophysical Surveys by the Research Vessel *Marcus G. Langseth* (R/V *Langseth*) in the Northeast Pacific Ocean between May 1 and June 31, 2021. The high-energy, two-dimensional (2–D) seismic surveys are expected to last for a total of 40 (nonconsecutive) days, including approximately 37 days of seismic operations, 2 days of equipment deployment/retrieval, and 1 day of transit. A maximum of 6,890 km (4,281 mi) of transect lines would be surveyed in marine waters adjacent to Oregon, Washington, and British Columbia from 41° N to 50° N latitude and − 124 N and − 130 W longitude, of which approximately 6,600 km (4,101 mi) would be in the U.S. Exclusive Economic Zone and 295 km (183 mi) in Canadian territorial waters. The Service cannot authorize the incidental take of marine mammals in waters not under the jurisdiction of the United States, and the Washington stock of the northern sea otter is not found within Canadian territorial waters. 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 survey would include several strike lines, parallel (including one continuous line along the continental shelf) and perpendicular to the coast. 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 6,600 cubic inches (in^3) or 0.11 cubic meter (m^3) at a shot interval of 37.5 m (123 ft). The 36-airgun array could operate 24 hours a day, except during mitigation shutdowns, for the entirety of the 37 days of survey. The energy produced by the seismic array is broadband and 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 receiving system would consist of one 15-km (9.3-mi) long hydrophone streamer, Ocean Bottom Seismometers (OBSs), and Ocean Bottom Nodes (OBNs) deployed within the survey area. In addition to the operations of the airgun array, a multibeam echosounder, a single-beam dual-frequency echosounder (4 and 12 kHz), a sub-bottom profiler (SBP), and an Acoustic Doppler Current Profiler (ADCP) would be operated. Further information and technical specifications can be found in NSF's IHA application and the Service's draft EA available at: *http://www.regulations.gov*, Docket No. FWS–R1–ES–2020–2012;0131.

Description of Northern Sea Otters in the Specified Activity Area

The proposed area of specified activity occurs within the range of the Washington stock of the northern sea otter, a portion of the species' range that is not listed under the Endangered Species Act of 1973, as amended (ESA). This stock primarily occurs along the Washington coast between Cape Flattery and Grays Harbor, but small groups have been reported in the Straits of Juan de Fuca and individual sea otters have been reported in Puget Sound and along the Oregon coast as far south as Cape Blanco (Jeffries *et al.* 2019, USFWS 2018, unpublished observations J. Rice OSU). Among the largest members of the family Mustelidae but one of the smallest of marine mammals, northern sea otters exhibit limited sexual dimorphism (males are larger than females) and can attain weights and lengths up to 40 kg (110 lb) and 1.4 m (4.6 ft), respectively. They have a typical life span of 11–15 years (Riedman and Estes 1990). Unlike most other marine mammals, sea otters have little subcutaneous fat. They depend on their clean, dense, water-resistant fur for insulation against the cold and maintain a high level of internal heat production to compensate for their lack of blubber. Consequently, their energetic requirements are high, and they consume an amount of food equivalent to approximately 23 to 33 percent of their body weight per day (Riedman and Estes 1990).

Northern sea otters forage in both rocky and soft-sediment communities in water depths of 40 m (131 ft) or less (Laidre *et al.* 2009), although otters have been documented along the Washington coast as far as 58 km (36 mi) offshore in waters deeper than 200 m (656 ft) (Pearson 2019; supplemental data provided to USFWS). They tend to be found closer to shore during storms, but they venture farther out during good weather and calm seas (Kenyon 1975). Sea otters occasionally make dives of up to 100 m (328 ft) (Newby 1975), but the vast majority of feeding dives (more than 95 percent) occur in waters less than 40 m (131 ft) in depth (Tinker *et al.* 2006). Therefore, sea otter habitat is typically defined by the 40-m (131-ft) depth contour (Laidre *et al.* 2011).

The number of sea otters in this stock, for the purposes of this analysis, was estimated to be approximately 3,000, based on survey count data and projections for areas not surveyed. The estimated minimum abundance of the stock, based on survey count data, was 2,785 sea otters within the area between Cape Flattery and Grays Harbor, Washington, between shore and the 40-m (131-ft) depth contour (Jeffries *et al.* 2019). While systematic surveys farther offshore have not been conducted in Washington or Oregon, otters have been documented farther offshore (Pearson 2019). Surveys conducted in Southeast Alaska found 95 percent of northern sea otters were found in areas shallower than 40-m (131 ft) and 5 percent farther offshore (Tinker *et al.* 2019). Therefore, assuming a similar proportion of sea otters in Washington occur offshore, we added 5 percent (139 sea otters) to the minimum abundance to account for otters farther offshore than 40-m (131-ft) depth contour, to get a total population estimate of 2,924 for the area between Cape Flattery and Grays Harbor. Based on best professional judgment and limited anecdotal observations, we estimate two sea otters would be somewhere along the coast between Grays Harbor and the Washington/Oregon border and two sea otters would be somewhere along the Oregon coast.

Otter densities were calculated for the area between Cape Flattery and Grays Harbor, broken down to north and south of the Quillayute River. Surveys indicate the otter population is not evenly distributed throughout the area surveyed (Jeffries *et al.* 2019), and the distribution of the population during the proposed project is likely to be similar to that detected during surveys, as work will occur during the same time of year as the surveys were conducted. (See Table 2 for density estimations). A density was not estimated for the area between Grays Harbor and the southern end of the project; rather, we assumed that the four sea otters estimated to occur there would be exposed.

Further biological information on this stock can be found in the Washington Department of Fish and Wildlife's Periodic Status Review (Sato 2018) and Recovery Plan (Lance *et al.* 2004). The sea otters in this stock have no regulatory status under the ESA. The potential biological removal (PBR) for this stock is 18 sea otters (USFWS 2018). PBR is defined by the MMPA as the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population. While no mortality is anticipated or authorized here, PBR is included as a gross indicator of the status of the species.

Sea Otter Hearing

Controlled sound exposure trials on a single older male southern sea otter (*E. l. nereis*) indicate that otters can hear frequencies between 125 Hz and 38 kHz with best sensitivity between 1.2 and 27 kHz in air and 2 to 26 kHz underwater; however, these thresholds may underrepresent best hearing capabilities in younger otters (Ghoul and Reichmuth 2014). Aerial and underwater audiograms for a captive adult (14-year-old) 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 1 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).

Potential Impacts of the Proposed Seismic Survey on Northern Sea Otters in Washington and Oregon

This section includes a summary of the ways that components of the specified activity may impact sea otters and their habitat. A more in-depth analysis can be found in the Service's draft EA (USFWS 2020). The *Estimated Take by Incidental Harassment of Sea Otters* section later in this document includes a quantitative analysis of the number of sea otters that are expected to be taken by this activity. The *Negligible Impact* section considers the content of the *Estimated Take by Incidental Harassment of Sea Otters* section, and the *Mitigation and Monitoring* section, to draw conclusions regarding the likely impacts of these activities on the reproductive success or survivorship of individuals and how those impacts on individuals are likely to impact sea otters.

Otters may be impacted while at the surface by the presence of the vessels traveling to/from the ports to the transects and operating along the transects. Otters underwater may be impacted by the OBS/OBNs as they are deployed and the acoustic effects from the airguns, OBS/SBP/ADCP/echosounders, and ship noise.

Anthropogenic sounds cover a broad range of frequencies and sound levels and can have a range of highly variable impacts on marine life, from none or minor to potentially severe responses, depending on signal characteristics, received levels, duration of exposure, behavioral context, and whether the sea otter is above or below the water surface. Underwater sounds are not likely to affect sea otters at the surface, due to the pressure release effect. Thus, the susceptibility of sea otters from underwater sounds would be restricted to behaviors during which the head or body is submerged, such as during foraging dives and underwater swimming and, intermittently, during grooming bouts. The proposed activities include underwater sound sources that are impulsive (airguns) and non-impulsive (OBS/SBP/ADCP/echosounders and ship noise). Potential effects from impulsive sound sources can range in severity from effects such as behavioral disturbance or tactile perception to physical discomfort, slight to severe injury of the internal organs and the auditory system, or mortality (Yelverton *et al.* 1973; Yelverton and Richmond 1981; Turnpenny and Nedwell 1994; Turnpenny *et al.* 1994).

Marine mammals exposed to high-intensity sound, or to lower-intensity sound for prolonged periods, can experience a hearing threshold shift (TS), which is the loss of hearing sensitivity at certain frequency ranges (Finneran 2015). TS can be permanent (PTS), in which case there is physical damage to the sound receptors in the ear (*i.e.*, tissue damage) and the loss of hearing sensitivity is not fully recoverable, or temporary (TTS), in which case there is primarily tissue fatigue and the animal's hearing threshold would recover over time (Southall *et al.* 2007). Repeated sound exposure that leads to TTS could cause PTS. Temporary or permanent loss of hearing will occur almost exclusively for noise within an animal's hearing range. Given the longer exposure duration necessary to cause PTS as compared with TTS, it is considerably less likely that PTS would occur as a result of project activities because a sea otter could remove itself from exposure by coming to the surface. However, a sea otter underwater in close proximity to the higher level of sound could experience PTS. In addition, otters startled by the sound while foraging in deeper waters will be underwater longer and potentially be exposed to more acoustic sound.

Behavioral disturbance may include a variety of effects, including subtle changes in behavior (*e.g.*, minor or brief avoidance of an area, changes in vocalizations, or changes in antipredator response), more conspicuous changes in similar behavioral activities, and more sustained and/or potentially severe reactions, such as displacement from or abandonment of high-quality habitat. Reactions by sea otters to anthropogenic noise can be manifested as visible startle responses, flight responses (flushing into water from haulouts or ''splash-down'' alarm behavior in surface-resting rafts), changes in moving direction and/or speed, changes in or cessation of certain behaviors (such as grooming, socializing, or feeding), or avoidance of areas where noise sources are located. The biological significance of these behavioral disturbances is difficult to predict, especially if the detected disturbances appear minor. However, the consequences of behavioral modification would be expected to be biologically significant if the change affected growth, survival, or reproduction.

Potentially significant behavioral modifications include disturbance of resting sea otters, marked disruption of foraging behaviors, separation of mothers from pups, or disruption of spatial and social patterns (sexual segregation and male territoriality). Foraging is energetically costly to sea otters, more so than other marine mammals, because of their buoyancy and swimming style (Yeates *et al.* 2007), thus displacement from or reduction of foraging in high-quality habitat could result in increased energy expenditures. The energy expense and associated physiological effects could ultimately lead to reduced survival and reproduction (Gill and Sutherland 2000; Frid and Dill 2002).

Disturbances can also have indirect effects; for example, 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 sharks and eagles, and have a well-developed antipredator response to perceived threats, which includes actively looking above and beneath the water. 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 2006; 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 type and extent of response may be influenced by intensity of the 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).

Exposure Thresholds—Although no specific thresholds have been developed for sea otters, several alternative behavioral response thresholds have been developed for otariid pinnipeds. Otariid pinnipeds (*e.g.*, California sea lions [*Zalophus californianus*]) have a frequency range of hearing most similar to that measured in a southern sea otter (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 communication rather than feeding). NMFS criteria for 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 thresholds for Level A harassment of sea otters.

For otariid pinnipeds, PTS is predicted to occur at 232 dB peak or 203 dB SELcum (cumulative sound exposure level) for impulsive sound, or 219 dB SELcum for non-impulsive (continuous) sound (NMFS 2018). Exposure to unmitigated in-water noise levels between 125 Hz and 38 kHz that are greater than 232 dB peak or 203 dB SELcum for impulsive sound or 219 dB SELcum for non-impulsive (continuous) sound will be considered by the Service as Level A harassment. NMFS predicts that marine mammals are likely to be behaviorally harassed in a manner considered Level B harassment when exposed to underwater anthropogenic noise above received levels of 120 dB re 1 µPa (rms) for continuous (*e.g.*, vibratory pile-driving, drilling) and above 160 dB re 1 µPa (rms) for non-explosive impulsive (*e.g.*, seismic airguns) or intermittent (*e.g.*, scientific sonar) sources (NMFS 2018).

Thresholds based on TTS can be used as a proxy for Level B harassment. Based on studies summarized by Finneran (2015), NMFS (2018) has set the TTS threshold for otariid pinnipeds at 188 dB SELcum for impulsive sounds and 199 dB SELcum for non-impulsive sounds. Thus, using information available for other marine mammals, specifically otariid pinnipeds, as a surrogate, and taking into consideration the best available information about sea otters, the Service has set the received sound level underwater of 160 dB re 1 µPa (rms) as a threshold for Level B harassment for sea otters based on the work of Ghoul and Reichmuth (2012), McShane *et al.* (1995), Riedman (1983), Richardson *et al.* (1995), and others. Exposure to unmitigated impulsive in-water noise levels between 125 Hz and 38 kHz that are greater than 160 dB re 1 µPa (rms) will be considered by the Service as Level B harassment.

Exposure to Project Activities—Based on the studies on sea otters in Washington, California, and Alaska, we believe sea otters spend between 40 and 60 percent of a 24-hour period with at least a portion of their body underwater (foraging, other diving, or grooming behaviors that result in the head being underwater) and forage both diurnally and nocturnally (Esslinger *et al.* 2014, Laidre *et al.* 2009, Yeates *et al.* 2007, Tinker *et al.* 2008). Seismic survey activities can operate 24 hours/day and otters may be exposed at any time. Any single point along the transects could be above thresholds for a maximum of 6.5 hours, during which time sea otters in that area would engage in underwater behaviors and would be exposed to underwater sound. Some areas along the transects will be ensonified more than once.

Because sea otters spend a considerable portion of their time at the surface of the water, they are typically visually aware of approaching boats and are able to move away if the vessel is not traveling too quickly. The noise of approaching boats provides an additional warning, thus otters should be able to detect the vessels and paddle away, rather than be startled and go subsurface. Because the R/V *Langseth* would be traveling relatively slowly (4.5 knots) during the surveys, it is unlikely that sea otters would suffer injury or death from a vessel collision. Otters that may be foraging may be startled by the remotely operated vehicle deployed to retrieve OBNs in waters >60 m (197 ft) along three transects perpendicular to the Oregon coast.

The potential for exposure to all activities is likely to be limited to where the vessel is operating in waters <1,000 m (3,280 ft) deep, as we do not anticipate otters to be farther offshore. Off the Washington coast, females primarily forage and rest in waters <40 m (131 ft), but males spend less time foraging close to shore and rest farther offshore than females (Laidre *et al.* 2009), venturing as far offshore as 58 km (36 mi) (Pearson 2019). Within the waters adjacent to Washington and northern Oregon (to Tillamook Head), the ensonified zone would not penetrate the waters between shore and the 40-m (131-ft) depth contour, thus sea otters that may be exposed are more likely to be the males that occur farther offshore. The otters along the Oregon coast are presumed to be males, based on stranding data (FWS unpublished data).

NSF and L–DEO have proposed measures to minimize the chances of sea otter exposure to the seismic surveys. Along the Washington coast in waters <200 m (656 ft) deep, the airgun array would operate only during daylight hours. The airgun startup would be ramped in order to alert otters that are underwater, in the hope they would move away. Prior to airgun startup and during airgun operations, visual observers would be employed during daylight hours, in order to establish a 500-m (1,640 ft) exclusion zone. Any sea otter observed in this zone would lead to a shutdown of the airgun array. However, there will be gaps in the visual coverage, in particular during nighttime operations in Oregon and beyond 200 m (656 ft) in Washington. In addition, under poor weather conditions and some good weather conditions, observers cannot be 100 percent effective and may not detect a sea otter in, or about to enter, the exclusion zone. Further, visual observations cannot cover the entirety of the area with sound levels that may cause behavioral changes. The lack of ability to fully monitor the ensonified area means an otter(s) may go unobserved and be exposed to underwater noise that results in Level A and/or Level B harassment.

Potential Effects of the Proposed Activity on Northern Sea Otter Habitat

Physical and biological features of habitat essential to the conservation of sea otters include the benthic invertebrates (crabs, urchins, mussels, clams, etc.) eaten by otters and the shallow rocky areas and kelp beds that provide cover from predators. Important sea otter habitat areas of significance in the NSF and L–DEO project area include coastal areas within the 40-m (131-ft) depth contour where high densities of otters have been detected, although deeper waters may be important for male sea otters. A number of recent reviews and empirical studies have addressed the effects of noise on invertebrates (Carroll *et al.* 2017), sea otter prey, with some studies showing little or no effects and others indicating deleterious effects from exposure to increased sound levels. Given the short-term duration of sounds produced by each component of the proposed project, it is unlikely that noises generated by survey activities will have any lasting effect on sea otter prey (see the Service's draft EA (USFWS 2020) for further information). The MMPA allows the Service to identify avoidance and minimization measures for affecting the least practicable impact of the specified activity on important habitats. Although sea otters within this important habitat may be impacted by geophysical surveys conducted by NSF and L–DEO, the project, as currently proposed, is not likely to cause lasting effects to habitat.

Potential Impacts of the Proposed Activity on Subsistence Needs

The subsistence provision of the MMPA does not apply to northern sea otters in Washington and Oregon.

Mitigation and Monitoring

In order to issue an IHA under Section 101(a)(5)(D) of the MMPA, the Service must set forth the permissible methods of taking pursuant to the activity, and other means of affecting the least practicable impact on the species or stock and its habitat, paying particular attention to habitat areas of significance and the availability of sea otters for subsistence uses by coastal-dwelling Alaska Natives, although this factor is not applicable for this action.

In evaluating how mitigation may or may not be appropriate to ensure the least practicable impact on species or stocks and their habitat, as well as subsistence uses where applicable, we carefully consider two primary factors:

(1) The manner in which, and the degree to which, the successful implementation of the measure(s) is expected to reduce impacts to marine mammals, marine mammal species or stocks, and their habitat. This considers the nature of the potential adverse impact being mitigated (*i.e.*, likelihood, scope, range). It further considers the likelihood that the measure will be effective if implemented (probability of accomplishing the mitigating result if implemented as planned), the likelihood of effective implementation (probability implemented as planned); and

(2) The practicability of the measures for applicant implementation, which may consider such things as cost, impact on operations, and, in the case of a military readiness activity, personnel safety, practicality of implementation, and impact on the effectiveness of the military readiness activity.

To reduce the potential for disturbance to marine mammals caused by acoustic stimuli associated with IHA activities, NSF has proposed to implement mitigation measures for the northern sea otter including, but not limited to, the following:

- Development of marine mammal monitoring and mitigation plans;
- Reduced survey transect lines and daylight-only operations in area of highest sea otter densities;
- Establishment of shutdown and monitoring zones;
- Vessel-based visual mitigation monitoring by Protected Species Observers;
- Site clearing before start-up;
- Soft-start and shutdown procedures.

The specific methods to be implemented are further specified in the Service's draft EA (USFWS 2020) available at: *http://www.regulations.gov*, Docket No. FWS–R1–ES–2020–0131.

Estimated Take by Incidental Harassment of Northern Sea Otters

In a previous section, we discussed the components of the project activities that have the potential to affect sea otters and the physiological and behavioral effects that can be expected. Here, we discuss how the Service characterizes these effects under the MMPA.

An individual sea otter's reaction to human activity will depend on the otter's prior exposure to the activity, its need to be in the particular area, 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 harassment:

- Swimming away at a fast pace on belly (*i.e.*, porpoising);
- Repeatedly raising the head vertically above the water to get a better view (spy hopping) while apparently agitated or while swimming away;
- In the case of a pup, repeatedly spy hopping 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 along the shoreline;
- Ceasing mating behaviors;
- Shifting/jostling/agitation in a raft so that the raft disperses;
- Sudden diving of an entire raft; or
- Flushing animals off of a haulout.

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

Reactions capable of causing injury are characterized as Level A harassment events. 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 Estimate of Takes

In the sections below, we estimate take by harassment of the numbers of sea otters from the Washington stock (in Oregon and Washington) that are likely to be affected during the proposed activities. We assumed all animals exposed to underwater sound levels that meet the acoustic exposure criteria would experience Level A (>232 dB_{RMS}) or Level B (160–232 dB_{RMS}) harassment. To determine the number of otters that may be exposed to these sound levels, we created spatially explicit zones of ensonification using the proposed reduced survey transect lines and determined the number of otters present in the ensonification zones using density information generated from minimum population estimates in Jeffries *et al.* (2019), which subdivides the surveyed area into Cape Flattery to La Push and La Push to north entrance of Grays Harbor. An in-depth explanation of the process used can be found in the Service's draft EA (USFWS 2020) available at: *http://www.regulations.gov*, Docket No. FWS–R1–ES–2020–0131.

The Level A and Level B underwater sound thresholds were used to create spatially explicit ensonification zones surrounding the proposed project transects. We created a buffer with a 46-m (151-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, we placed a 12,650-m (7.9-mi) buffer around transects in water <100 m (328 ft) deep, and a 9,468-m (5.9-mi) buffer around transects in water 100–1,000 m (328–3,280 ft) deep.

The minimum population estimate from Jeffries *et al.* (2019) can be specifically applied to the surveyed area, which included the Washington coastline between Cape Flattery and Grays Harbor in the nearshore areas less than 25-m (82-ft) depth contour. Sea otters are overwhelmingly observed (95 percent) within the 40-m (131-ft) depth contour (Laidre *et al.* 2009; Tinker *et al.* 2019), thus for the purposes of this analysis, the population estimated by Jeffries *et al.* (2019) is assumed to apply to the 40-m (131-ft) depth contour for the waters between Grays Harbor and Cape Flattery. The minimum abundance estimates from Jeffries *et al.* (2019) were divided north and south of the Quillayute River, thus for this analysis habitat was divided into subregions, Cape Flattery south to Quillayute River (subregion north) and Quillayute River to Grays Harbor (subregion mid). Density estimates for the north and mid subregions were calculated by dividing the population estimate for that subregion (Jeffries *et al.* 2019) by the area from shore to the 40-m (131-ft) depth contour. See Table 1 for projected sea otter abundance and density estimates.

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Sea otter abundances outside of the area covered by surveys were inferred/ estimated as follows.

- *North and Mid subregions 40–100-m (131–328-ft) depth contour:* While 95 percent of sea otters are observed within the 40-m (131-ft) depth contour, otters do occur farther off shore (see Pearson 2019 for specific instances off Washington coast), thus lower density otter habitat was delineated between the 40- and 100-m (131- and 328-ft) depth contours. To calculate the density of otters in lower density (40–10-m or 131–328-ft) habitat, we multiplied the density of the adjacent high-density habitat by 0.05.
- *North and Mid subregions >100-m (328-ft) depth contour:* Pearson (2019) observed two sea otters (1 in 2017 and 1 in 2018) in waters >100-m (328-ft) depth contour in the Mid subregion. We do not have a reasonable method for determining the density of otters in the waters this deep and far offshore, thus for the purposes of calculating the number of otters that may be exposed, we assumed 2 otters could be in the waters >100-m (328-ft) depth contour in the Mid subregion.
- *South subregion:* Includes the area from Grays Harbor south to Oregon/ California border. This subregion was further divided into three areas because of the differences in transects and sea otter observations: Grays Harbor to Washington/Oregon border, Northern Oregon, Southern Oregon. There are no systematic surveys conducted south of Grays Harbor, but there are consistent reports of individuals as far south as Cape Blanco, Oregon (unpublished FWS data; Jim Rice, Oregon State University, pers. comm). We do not have data to inform a density estimate for these areas; however, in our best professional judgment we estimated that a minimum of four sea otters may be in the south subregion at the time of the project. Pearson (2019) observed one sea otter in waters >100-m (328-ft) depth contour in the South subregion. We do not have a reasonable method for determining the density of otters in the waters this deep and far offshore, thus for the purposes of calculating the number of otters that may be exposed in the Grays Harbor to WA/OR border, we assumed two sea otters could be at any depth. In Oregon, we assumed one otter in each of the two areas, which could be at any depth.

TABLE 1—ESTIMATED SEA OTTER ABUNDANCE AND DENSITIES FOR THE ANALYSIS AREA

Subregion	High density (<40 m)			Lower density (40–100 m)		
	Abundance estimate	Area (km²)	Density	Abundance estimate	Area (km²)	Density
North	549	456	1.2	27	556	0.05
Mid	2,236	1,434	1.56	112	2,060	0.05
South						4

The area impacted in each subregion and depth contour was multiplied by the estimated otter density to determine the number of otters that would experience Level A and Level B sound levels (Tables 2 and 3). The total number of takes was predicted by estimating the projected days of activity in each subregion and depth contour using the reduced transects supplied by NSF. In several areas, the length and direction of the proposed survey transect lines make it highly unlikely that impacts will occur on only 1 day. In these instances, we estimated the days of disturbance based on the number of passes of the survey transect lines.

The following assumptions were pertinent to our estimate of harassment take (see above for specific rationale):

- No otters will occur >100-m (328-ft) depth contour in North subregion.
- Visual observers will not be able to see sea otters in poor weather conditions and will not be observing at night. When visual observers are not able to effectively observe sea otters, there would be no mitigation (shutdown) applied.
- When visual observers are not able to observe sea otters they could be exposed to harassment that has the potential to injure (Level A) or disturb by causing disruption of behavioral patterns (Level B). For the purposes of this analysis, we applied our best professional judgment and erred on the side of the species, attributing the harassment to Level A. In the areas where a density estimate cannot be used to differentiate the number of otters exposed to Level A or Level B, we attributed the harassment to Level A.
- During the project, only two sea otters will be in the waters offshore of Southwest Washington between Grays Harbor and Washington/Oregon border. These two sea otters may be in waters >100 m (328 ft), thus harassment was assigned at Level A conditions.
- During the project, only two sea otters will be in the waters offshore of Oregon. These two sea otters may be in waters at any depth contour, thus harassment was assigned at Level A conditions.

TABLE 2—ESTIMATED NUMBER OF NORTHERN SEA OTTERS ENSONIFIED BY SOUND LEVELS GREATER THAN 232 dB_{RMS} (LEVEL A) DUE TO THE PROPOSED ACTIVITIES

Take was calculated by multiplying the area ensonified in each subregion by that subregion's sea otter density or specific estimate, then multiplied by the projected days of ensonification]

Subregion	Habitat type	Density (otters/km²)	Area impacted (km²)	Estimated take/day	Projected days of take	Estimated survey total takes
North	High (<40m)	1.2	0	0		0
	Low (40–100 m)	.05	0	0		0
	Offshore (>100 m)	0				0
Mid	High (<40 m)	1.56	0	0		0
	Low (40–100 m)	0.05	0	0		0
	Offshore (>100 m)	2 otters		2	2	4

TABLE 2—ESTIMATED NUMBER OF NORTHERN SEA OTTERS ENSONIFIED BY SOUND LEVELS GREATER THAN 232 dB_{RMS} (LEVEL A) DUE TO THE PROPOSED ACTIVITIES—Continued

Take was calculated by multiplying the area ensonified in each subregion by that subregion's sea otter density or specific estimate, then multiplied by the projected days of ensonification]

Subregion	Habitat type	Density (otters/km²)	Area impacted (km²)	Estimated take/day	Projected days of take	Estimated survey total takes
Grays Harbor-WA/OR border.		2 otter		2	2	4
N Oregon		1 otter		1	2	2
S Oregon		1 otter		1	3	3
Total				5		13
Estimated Stock Total						2,928
Percentage of Stock						0.44

TABLE 3—ESTIMATED NUMBER OF NORTHERN SEA OTTERS ENSONIFIED BY SOUND LEVELS GREATER THAN 160 dB_{RMS} (LEVEL B) DUE TO THE PROPOSED ACTIVITIES

[Take was calculated by multiplying the area ensonified in each subregion by that subregion's sea otter density or specific estimate, then multiplied by the projected days of ensonification]

Subregion	Habitat type	Density (otters/km²)	Area impacted (km²)	Estimated take/day	Projected days of take	Estimated survey total takes
North	High (<40 m)	1.2	0	0	0	0
	Low (40–100 m)	.05	0	0	1	0
	Low (40–100 m)	.05	0	0	2	0
	Offshore (>00 m)	0				
Mid	High (<40 m)	1.56	0	0		0
	Low (40–100 m)	0.05	0	0	2	0
	Offshore (>100 m)	2 otters	Accounted for in Level A.			
Grays Harbor–WA/OR border		2 otters	Accounted for in Level A.			
N Oregon		1 otter	Accounted for in Level A.			
S Oregon		1 otter	Accounted for in Level A.			
Total				0		0
Estimated Stock Total						2,928
Percentage of Stock						0.00

We expect that up to 13 sea otters may experience Level A and/or Level B take due to harassment by noise (Tables 2 and 3). While sea otters in these areas are most likely to be exposed to Level B harassment, during times when sea otters cannot be observed, we are erring on the side of the species and attributing the potential harassment to Level A, thus the total number of otters harassed is accounted for under Level A. The revised transects provided by NSF resulted in the area of ensonification being beyond the 100-m (328-ft) depth contour for the entire coast of Washington; therefore, no otters in waters less than 100 m (328 ft) deep are anticipated to be harassed by the activities. The total number of incidental takes of sea otters is expected to be less than 13. Take from sources other than noise is not expected.

Findings

The Service proposes the following findings regarding this action:

Small Numbers Determination

The statute and legislative history do not expressly require a specific type of numerical analysis for the small take evaluation, leaving the determination of "small" to the agency's discretion. In this case, we propose a finding that the NSF and L–DEO project may result in incidental take of up to 13 otters from the Washington sea otter stock. This represents less than 1 percent of the 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 the same geographic area and corrected for the methodology proposed by NSF and L–DEO for this project. Based on these numbers, we propose a finding that the NSF and L–DEO project will take only a small number of marine mammals.

Negligible Impact

We propose a finding that any incidental take by harassment resulting from the proposed activity 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 species or stocks. In making this finding, we considered the best available scientific information, including: (1) The biological and behavioral characteristics of the species; (2) the most recent information on species distribution and abundance within the area of the specified activity; (3) the current and expected future status of the stock (including existing and foreseeable human and natural stressors); (4) the potential sources of disturbance caused by the project; and (5) the potential responses of marine mammals to this disturbance. In addition, we reviewed applicant-provided material, information in our files and datasets, published reference materials, and input from experts on the sea otter.

The Service does not anticipate that mortality of affected otters would occur as a result of NSF and L–DEO's planned survey. Thus, mortality is not authorized. We are proposing to authorize Level A and Level B harassment of 13 sea otters. The effects to these individuals are unknown, and lasting effects to survival and reproduction for these otters are possible. However, we believe that any PTS incurred as a result of the planned activity would be in the form of only a small degree of PTS, not total deafness, and would be unlikely to affect the fitness of any individuals for the following reasons: (1) The constant movement of the *R/V Langseth* means the vessel is not expected to remain in any one area in which individual otters may spend an extended period of time (*i.e.*, since the duration of exposure to loud sounds will be relatively short); and (2) we expect that sea otters would be likely to move away from a sound source that represents an aversive stimulus, especially at levels that would be expected to result in PTS, given sufficient notice of the *R/V Langseth's* approach due to the vessel's relatively low speed when conducting seismic surveys.

We expect that the majority of takes would be in the form of short-term behavioral harassment in the form of temporary avoidance of the area or ceasing/decreased foraging (if such activity were occurring). Reactions to this type of harassment could have significant biological impacts for affected individuals but are not likely to result in measurable changes in their survival or reproduction. The otters subject to short-term behavioral harassment would be the same otters that may be subject to Level A harassment.

The total number of animals affected and severity of impact is not sufficient to change the current population dynamics of the sea otter at the subregion or stock scales. Although the specified activities may result in the take of up to 13 sea otters from the Washington stock, we do not expect this level of harassment to affect annual rates of recruitment or survival or result in adverse effects on the species or stock as all of the projected takes occur outside of the areas used by females and are most likely to be males.

With implementation of the proposed project, sea otter habitat may be impacted by elevated sound levels, but these impacts would be temporary and are not anticipated to result in detrimental impacts to sea otter prey species. Because of the temporary nature of the disturbance, the impacts to sea otters and the food sources they utilize are not expected to cause significant or long-term consequences for individual sea otters or their population.

The proposed mitigation measures are expected to reduce the number and/or severity of take events by allowing for detection of sea otters in the vicinity of the vessel by visual observers, and by minimizing the severity of any potential exposures via shutdowns of the airgun array. 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 and L–DEO project will have a negligible impact on sea otters.

Impact on Subsistence

The subsistence provision of the MMPA does not apply to northern sea otters in Washington and Oregon.

Required Determinations

Endangered Species Act

The Service's proposed take authorization has no effect on any species listed as threatened or endangered under the ESA. The proposed NSF Seismic Survey is a Federal action currently undergoing separate interagency consultation with the Service pursuant to the ESA. As ESA-listed species or critical habitat will not be impacted by the Service's proposed take authorization, intra-agency consultation for the permit action is not required.

National Environmental Policy Act

We have prepared a draft EA (USFWS 2020) addressing the proposed MMPA take authorization in accordance with the requirements of NEPA (42 U.S.C. 4321 *et seq.*). Based on the findings presented in the EA, we have preliminarily concluded that approval and issuance of the authorization for the nonlethal, incidental, unintentional take by Level A and Level B harassment of small numbers of the Washington stock of the northern sea otter caused by activities conducted by the applicant would not significantly affect the quality of the human environment, and that the preparation of an environmental impact statement for this action is not required by section 102(2) of NEPA or its implementing regulations. We are accepting comments on the draft EA as described above in **ADDRESSES**.

Government-to-Government Relations With Native American Tribal Governments

In accordance with: The President's memorandum of April 29, 1994, "Government-to-Government Relations with Native American Tribal Governments" (59 FR 22951); the Native American Policy of the Service (January 20, 2016); Executive Order 13175 (November 6, 2000); and the Department of the Interior's manual at 512 DM 2, we readily acknowledge our responsibility to communicate meaningfully with Federally recognized Tribes on a Government-to-Government basis. We have evaluated possible effects of the proposed MMPA take authorization on federally recognized Indian Tribes and have determined that there are no effects.

Proposed Authorization

We propose to issue an IHA to NSF for incidental takes by Level A and Level B harassment of up to 13 sea otters from the Washington stock of the northern sea otter. The final authorization would incorporate the mitigation, monitoring, and reporting measures as described below and fully detailed in the draft EA. The taking of sea otters whenever the required conditions, mitigation, monitoring, and reporting measures are not fully implemented as required by the IHA will be prohibited. Failure to follow these measures may result in the modification, suspension, or revocation of the IHA. Authorized take will be limited to PTS and disruption of behavioral patterns that may be caused by geophysical surveys and support activities conducted by NSF and L–DEO in Washington and Oregon from May 1 to June 30, 2021. We anticipate no take in the form of death of northern sea otters resulting from these surveys.

If take exceeds the level or type identified in the proposed authorization (*e.g.*, greater than 13 incidents of take of sea otters), the IHA will be invalidated and the Service will reevaluate its findings. If project activities cause unauthorized take, the applicant 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 Washington Fish and Wildlife Office 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 the applicant that they may resume project activities.

All operations managers and vessel operators must possess 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.

The IHA will apply to activities associated with the proposed project as described in this document, the draft EA, and in the applicant's amended application and environmental assessments. Changes to the proposed project without prior Service authorization may invalidate the IHA.

Operators shall allow Service personnel or the Service's designated representative to visit project work sites to monitor impacts to sea otters at any time throughout project activities so long as it is safe to do so. "Operators" are all personnel operating under the applicant's authority, including all contractors and subcontractors.

A final report will be submitted by NSF to the Service within 90 days after completion of work or expiration of the IHA. The report will describe the operations that were conducted and document sightings of sea otters near the operations. The report will provide full documentation of methods, results, and interpretation pertaining to all monitoring, including factors influencing visibility and detectability of sea otters. The final report will summarize the dates and locations of seismic operations, and all northern sea otter sightings (dates, times, locations, activities, associated seismic survey activities). The report will also include estimates of the number and nature of exposures, if any, that occurred above the harassment threshold based on Protected Species Observer (PSO) observations and including an estimate of those that were not detected.

The report shall also include geo-referenced time-stamped vessel transect lines for all time periods during which airguns were operating. Transect lines 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 a full array to a single gun or vice versa). GIS files shall be provided in ESRI shapefile format and include the UTC date and time, latitude in decimal degrees, and longitude in decimal degrees. All coordinates shall be referenced to the GCS_North_American_1983 geographic coordinate system. In addition to the report, all raw observational data shall be made available to the Service. The report will be accompanied by a certification from the lead PSO as to the accuracy of the report, and the lead PSO may submit directly to the Service a statement concerning implementation and effectiveness of the required mitigation and monitoring.

References

A list of the references cited in this notice is available at *www.regulations.gov* in Docket No. FWS–R1–ES–2020–0131.

Request for Public Comments

If you wish to comment on this proposed authorization or the associated draft EA, or both, you may submit your comments by any of the methods described in ADDRESSES. Please identify if you are commenting on the proposed IHA, draft EA, or both. Please make your comments as specific as possible, confine them to issues pertinent to the proposed authorization, 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 above).

Before including your address, phone number, email address, or other personal identifying information in your comment, you should be aware that your entire comment—including your personal identifying information—may be made publicly available at any time. While you can ask us in your comment to withhold your personal identifying information from public review, we cannot guarantee that we will be able to do so.

Dated: February 23, 2021.

Hugh Morrison,

Deputy Regional Director, Interior Regions 9 and 12.

[FR Doc. 2021–04081 Filed 2–26–21; 8:45 am]

BILLING CODE 4333–15–P

INTERNATIONAL TRADE COMMISSION

[Investigation No. 337–TA–1236]

Certain Polycrystalline Diamond Compacts and Articles Containing Same; Notice of Commission Determination Not To Review an Initial Determination Amending the Complaint and Notice of Investigation

AGENCY: U.S. International Trade Commission.

ACTION: Notice.

SUMMARY: Notice is hereby given that the U.S. International Trade Commission ("Commission") has determined not to review an initial determination ("ID") (Order No. 8) of the presiding administrative law judge ("ALJ") granting an unopposed motion of complainant US Synthetic Corporation for leave to amend the complaint and notice of investigation to substitute Guangdong Juxin New Materials Technology Co., Ltd.as a respondent in place of Zhuhai Juxin Technology.

FOR FURTHER INFORMATION CONTACT: Ronald A. Traud, Esq., Office of the General Counsel, U.S. International Trade Commission, 500 E Street SW, Washington, DC 20436, telephone (202) 205–3427. Copies of non-confidential documents filed in connection with this investigation may be viewed on the Commission's electronic docket (EDIS) at *https://edis.usitc.gov*. For help accessing EDIS, please email *EDIS3Help@usitc.gov*. General information concerning the Commission may also be obtained by accessing its internet server at *https://www.usitc.gov*. Hearing-impaired persons are advised that information on this matter can be obtained by contacting the Commission's TDD terminal on (202) 205–1810.

SUPPLEMENTARY INFORMATION: The Commission instituted this investigation on December 29, 2020, based on a complaint filed by US Synthetic Corporation of Orem, Utah ("US Synthetic"). 85 FR 85661 (Dec. 29, 2020). The complaint alleges violations of section 337 of the Tariff Act of 1930, as amended, 19 U.S.C. 1337 ("section 337"), based upon the importation into the United States, the sale for importation, and the sale within the United States after importation of certain polycrystalline diamond compacts and articles containing same by reason of infringement of certain claims of U.S. Patent Nos. 9,932,274; 10,508,502; 9,315,881; 10,507,565; and 8,616,306. *Id.* The complaint further

APPENDIX E: NSF NEPA DRAFT EA COMMENTS AND RESPONSES

APPENDIX E: NSF NEPA DRAFT EA COMMENTS AND RESPONSES

Commenter	**Comment**	**Response**
Marlene P		

	First and foremost is the potential impact on the endangered Southern Resident Killer Whale population along the Vancouver Island BC and Washington State coasts. Your Figure 1 map of the proposed survey sites has this critical habitat area marked, but there are survey transects and receiver locations in that area anyway. This population is down to 72 whales. The three main impacts on them are food sources, pollution, and vessel noise, and yet you are proposing activities that meet, or possibly exceed, Level B harassment takings. This is unacceptable. You cannot put this severely endangered population in harm's way, even for "short-term, localized changes in behavior." You state you will monitor for marine mammals and will "power down" or even shut down in their presence. This is a Resident population. Whether you see them, hear them, or not, they are always there. No surveying should be done within their critical habitat area.	Thank you for your comment. We worked closely with NMFS to ensure that operations would minimize any potential impacts to Southern Resident Killer Whale (SRKW) and their critical habitat (CH). During consultation with NMFS per the ESA and MMPA, additional monitoring and mitigation measures to operate safely and minimize impacts to SRKW were considered and proposed survey tracklines were revised. These changes and additional measures include:
		- elimination of survey tracklines in US & Canadian designated SRKW CH;
		- elimination of survey tracklines in water depths <100 m off WA and Canada;
		- north of Tillamook Head, OR, including within the Canadian EEZ, in water depths between 100-200 m:
		    - daylight only operations;
		    - additional PSOs monitoring from a support vessel operating 5 km in front of R/V *Langseth*
		- shutdowns for SRKW at any distance visually observed or detected acoustically.

	In general, regarding marine mammals, you state you will visually monitor for their presence in daytime and acoustically monitor them during nighttime testing, requiring 30 minutes of absence before doing a start-up. Nighttime operations are too likely to miss the presence of marine mammals and turtles. At the time of year you are proposing for this study, you will have 15-16 hours of daylight each day. Please consider shutting down at night.	NSF took into consideration this suggestion. Shutting down during all nighttime operations would significantly prolong the survey effort within the survey area. PSOs would be on watch during daytime to ensure the exclusion zone around the source is free of animals when the source is ramped up. Once airguns are operational, it is not anticipated that animals would move towards the source if they were experiencing harassment effects. Given specific concerns about SRKW, however, operations would be conducted during daylight only in areas north of Tillamook Head, OR, including within the Canadian EEZ, in water depths between 100-200 m. In addition, operations proposed for occurring in anticipated highest density areas for SRKW were eliminated from the survey design, including in almost all waters <100 m deep.
	Is anyone monitoring the coastlines to be sure there are not any marine mammals, sea turtles, marine birds, or fish washing ashore? If this occurs, you should immediately shut down your operations in that area.	Although strandings are not anticipated from the proposed activities, there is an active stranding network in the survey area. In the event of any stranding resulting from the Proposed Action, operations would be immediately halted. Additionally, in the event of any live stranding (or near-shore atypical milling) event within 50 km of the survey operations not a result of LDEO activities, LDEO would be advised of the need to implement shutdown procedures for all active acoustic sources operating within 50 km of the stranding.
	You state your operations will comply with all international, federal, and state laws and regulations. On your list of laws and agencies, I do not see the Ocean Resources Management Act (ORMA) of Washington state: RCW. 43.143. You need to be sure your operations comply with this law.	Thank you for highlighting this requirement. NSF addressed compliance with ORMA as part of its compliance with the Coastal Zone Management Act.

Oregon Dept of Fish and Wildlife (ODFW)		
	Recommendation: The EA should directly address the enhanced risk to gray whales presented by the survey's cruise plan relative to Oregon's coastline.	ODFW noted particular concern about "...gray whales during their "Phase B" migration between April 1 and June 15, when mothers and calves are moving north through very shallow waters (generally within 800 m of shore) (Herzing and Mate 1984, Adams et al 2014)." There may be some overlap with survey operations and the end of the gray whale migration period off Oregon; however, all seismic lines would be >9.5 km from shore. To reduce potential impacts to migrating gray whale mother-calf pairs, the acoustic source would be shut down at any distance. In addition, survey operations in shallow waters, <100 m, were mostly eliminated off the coast of Oregon.
	Recommendation: We request that NSF provide ODFW with data after the cruise documenting the cruise track, ensonification levels, and Marine Mammal Observer data regarding all marine mammal encounters, to allow us to account for potential effects of the survey on our ongoing study.	Once completed, the protected species observer (PSO) report prepared for the seismic survey, which would include the information requested, would be made publicly available on the NSF website. NSF can provide ODFW a copy of the report as well.
	Recommendation: NSF should pursue the implementation of the analytical approach offered by Crone et al, in applying a streamer-based assessment of the ensonified area. These data should be provided to ODFW after the survey to allow assessment of the potentially affected areas and the development of future mitigation approaches.	Thank you for this suggestion. NSF has taken this recommendation under consideration. Unfortunately, it is not feasible in current circumstances to undertake an acoustic radiation study using a moored hydrophone array to better resolve the three-dimensional acoustic field generated by a seismic source in shallow water. NSF would, however, discuss with Crone et al the possibility of analyzing streamer data. At the present time, NSF does not have any research proposals to survey in the area in the foreseeable future. Survey data would be made available to the public, including ODFW, consistent with NSF's Data Policy.

	Recommendation: Furthermore, NSF should direct some level of project funding associated with conducting marine acoustic surveys toward improving the assessment of shallow-water ensonification levels, as these surveys are repeated events and the need to accurately assess and mitigate shallow-water impacts is likely to grow.	Thank you for the suggestion. NSF has taken this recommendation under advisement.
	Recommendation: The EA should rigorously address the potential for impacts to seafloor associated fish and invertebrates, including commercially important crustaceans and mollusks. One way it could do this would be by providing a table of total seafloor area expected to be ensonified at various intensities by depth stratum and substrate type. This would be analogous to the way total mitigation zone coverage is provided for marine mammals, but calculated for the acoustic energy arriving at the seafloor.	The potential impacts on fish and invertebrates are discussed in Section 4.1.2; however, as noted there, many data gaps remain regarding the potential effects of seismic on fish and invertebrates. Total area expected to be ensonified by water depth is provided in Appendix B. NSF and Bureau of Ocean Energy Management (BOEM) have co-funded a research proposal focused on (1) measuring particle motion and pressure from the seismic survey and (2) behavioral responses of important marine species: rockfishes (*Sebastes* spp.), Dungeness crab, and longnose skate. The study, to be carried out by researchers from Oregon State University, would occur concurrently with the seismic survey.
	Recommendation: Furthermore, NSF should direct some level of project funding associated with conducting marine acoustic surveys toward improving the understanding of impacts on fish and invertebrates in coastal waters. This research should include not only direct effects of high SPL, but also particle motion, which multiple researchers have identified as a likely important mechanism of effect on fish and invertebrates (Hawkins and Popper 2017), especially in shallow water.	NSF has funded research activities and scientific conferences related to improving the understanding the impacts of sound on marine species, including fish. In addition, NSF staff participate in interagency committees focused on making advances on this topic. NSF and Bureau of Ocean Energy Management (BOEM) have co-funded a research proposal focused on (1) measuring particle motion and pressure from the seismic survey and (2) behavioral responses of important marine species: rockfishes (*Sebastes* spp.), Dungeness crab, and longnose skate. The study, to be carried out by researchers from Oregon State University, would occur concurrently with the seismic survey.

	Recommendation: NSF should resolve potential space use conflicts through communication lines already established (e.g. Oregon Sea Grant), modify its OBN deployment plan as necessary to avoid equipment loss, and act early and comprehensively to communicate the location of all OBSs and OBNs, as well as the anticipated dates/times of transit for each transect line. This communication responsibility extends to other ocean users, such as recreational or commercial SCUBA divers (e.g. red urchin harvesters).	NSF has supported research activities in this region previously and has successfully managed space-use conflicts. While NSF anticipates limited space-use conflict with the fishing industry, the action proponents planned outreach efforts and coordinated with members of the fishing industry in advance of the proposed activities to help further reduce any potential space-use conflicts. For example, the PIs coordinated with and engaged with the commercial fishing community through participating in and presenting information at meetings such as the Oregon Fishermen's Cable Committee (OFCC) and the Scientists and Fishermen Exchange (SAFE) Program through Oregon Sea Grant. The researchers prepared and plan to distribute digital maps of the proposed tracklines and OBS/OBN deployments to the fishing community to avoid conflicts. During operations, the vessels would communicate with other ocean users via Notice to Mariners and direct radio communications from the vessel. In addition, the vessel operators would notify identified Coastal Treaty Tribe points of contact 3 days in advance of entering Usual and Accustomed fishery areas.
	Recommendation: NSF should include in its EA an assessment of the predicted SEL (accumulated sound exposure level) for each of the Marine Reserves. We request that NSF provide ODFW with data after the cruise documenting the cruise track, ensonification levels, and SEL (modeled based on actual cruise data) for each of the Marine Reserves, to allow ODFW to interpret any potential seismic survey impacts observed by ODFW in the Reserves.	Survey data would be made available to the public, including ODFW, consistent with NSF's Data Policy. Once completed, NSF can provide to ODFW the PSO report prepared for the seismic survey, which would include the actual survey tracklines.
	Recommendation: The EA should explicitly assess the risk of mortality for any fish or invertebrates in the Marine Reserves. If mortality risks are identified, the cruise plan should be modified to provide a sufficient spatial buffer to insure compliance with the no-take provisions.	Mortality of fish and invertebrates in the Marine Reserves are not anticipated. Section 4.1.2 and 4.1.4 of the Draft EA focused on direct and indirect impacts on fish. The Draft EA noted that any injurious impacts on fish would only occur within a few meters of the airguns. All Marine Reserves are located at least 2 km from the seismic source.

Center for Biological Diversity		
	As a preliminary matter, we ask for an extension of the public comment period for this draft EA. We just received notice of its existence and it has wide-ranging implications for many marine species, including several listed as threatened and endangered under the Endangered Species Act.	The Draft EA was posted on the NSF website for a 30-day public comment period (Feb 7 thru Mar 7, 2020). CBD has commented on NSF activities in the past and is aware that NSF posts Draft EAs on its website for public comment. No other requests for an extension of the public comment period were received. For these reasons, an extension of the public comment period was determined to be unwarranted and NSF did not extend the public comment period.
	This EA does not use best available science for several species, including for Southern Resident killer whales (SRKW). There is an abundance of new data on the status and seasonal distribution of SRKW, threats to SRKW, and specifically the impacts of noise and cumulative impacts on SRKW that are omitted from discussion.	NSF disagrees that the best available science was not used for the species analyzed in the Draft EA. NSF used data sources for abundance and distribution recommended in consultation with NMFS under the MMPA and ESA. In addition, NSF's contractors broadly reviewed published literature to prepare the Draft EA, and no recent literature on the effects of seismic sound on killer whales has been published. NSF has taken into consideration the recent publications noted by CBD; however, these do not change the outcome of the effects assessment. Other new papers on the effects of vessel noise on SRKW published after the Draft EA was issued have been taken into consideration in this Final EA.
	The 2011 PEIS and the EA for similar surveys conducted in June–July 2012 upon which this draft EA relies are woefully outdated.	The 2011 PEIS provides a significant amount of information that is germane to the conduct of marine seismic research, including how they are typically conducted, descriptions of equipment and vessels, potential impacts, etc. In addition to the PEIS, NSF prepared a site-specific Draft EA for the Proposed Action, which tiers to the PEIS and an EA prepared in 2012 for a similar seismic survey conducted in the proposed survey area. The Draft EA includes information from publications issued since the issuance of PEIS in 2011 and the 2012 EA. Therefore, NSF disagrees with CBD's conclusion that the documentation is outdated.
	This EA must separately and thoroughly examine the impacts of this project on the endangered SRKW. It is unacceptable to lump them in with all other stocks of killer whales and imply that as a whole they are abundant across the globe, while	Although Southern Resident Killer Whales (SRKW) were discussed along with other killer whales in the Draft EA, Section 3.3.2.15, estimated takes for killer whales were considered proportionally for SRKW (Table 8, footnote #9). NMFS also parsed takes for SRKW in their analysis conducted under the MMPA and ESA (Appendix C).

	disregarding the fact that this highly imperiled distinct population segment is down to just 72 animals.	The SRKW population size was noted in Table 5. Southern Resident Killer Whale Critical Habitat was discussed in the Draft EA, Section 3.2.1.
	This EA insufficiently considers the impacts of this project on SRKW and its designated and proposed expanded critical habitat (see attached Center for Biological Diversity comments on the proposed expansion rule). The EA does not describe the overlap of the transect lines to the proposed expanded critical habitat or the received noise levels within designated and proposed critical habitat. It also ignores new data on coastal distribution and abundance.	Southern Resident Killer Whale Critical Habitat (SRKW CH), and the proposed expansion currently proposed by NMFS, was discussed in the Draft EA, Section 3.2.1. Although the proposed SRKW CH is not yet in effect, NSF was aware of the sensitivities associated with SRKW and took that into consideration during the survey design. Further NSF consulted with NMFS on the Proposed Action per the MMPA and ESA, and NMFS took the proposed SRKW CH into consideration when evaluating the project. The Draft EA assessed the potential impacts of the Proposed Action in the entire survey area and therefore covered the area under consideration by NMFS' proposed expansion of the SRKW critical habitat. No survey transects are planned in existing critical habitat in the U.S. or Canada, and critical habitat would not be ensonified to levels >160 dB. However, some survey transects are expected to enter proposed critical habitat. NSF has taken into consideration the recent publications noted by CBD; however, this does not change the outcome of the effects assessment.
	We urge you to include more information about the impacts of this project on SRKW and SRKW critical habitat in Canada. The EA only notes that two of the survey transects go right through critical habitat for SRKWs (Swiftsure Bank and La Perouse Bank). This is a potentially significant impact given that SRKWs are spending less time inshore and more time in those areas. This project and this species (and threats to its continued existence) are transboundary and must be assessed as such in a coordinated fashion. To conclude “most sightings within the critical habitat off southwestern Vancouver Island have occurred closer to shore than the proposed seismic transects” is not sufficient.	Thank you for noting these concerns. The proposed survey lines (and any potential Level B ensonified area) within SRKW CH designated by Canada were eliminated from the Proposed Action. NSF used SRKW data sources recommended in consultation with NMFS under the MMPA and ESA. In addition, NSF's contractors broadly reviewed published literature to prepare the Draft EA. LDEO submitted a Request for Review pursuant to the Canadian Fisheries Act to the Department of Fisheries and Oceans Canada for species under their jurisdiction and will comply with the requirements issued when operating within the Canadian EEZ.

	The EA must describe expected received noise levels for SRKW and other species and their critical habitat with specificity.	Potential effects of the Proposed Action are described in Chapter IV of the Draft EA, which included analysis of impacts from received noise levels based on predicted sound propagation also described in Chapter II. In addition, during consultation with NMFS per the MMPA and ESA, NSF analyzed empirical data from a similar survey conducted in 2012 in or near the proposed survey area. Based on this analysis source propagation distances were updated and revised in the Final EA (See Section 2.1.3.1, Table 1 and 2; and, Appendix A).
	The EA does not describe or defend its Level A and Level B estimates sufficiently in Table B-2 and its appendices. For example how did it arrive at the footnote for killer whales committing to only taking 8 SRKW by Level B harassment? How does it assume only 4 leatherback sea turtles taken by Level B harassment?	The methods for determining Level A and Level B are detailed in Section 4.1.1.5 of the EA and followed the guidelines set forth by NMFS. The number of takes were calculated based on the expected density of a species and the area expected to be ensonified. The methods used by NSF to determine the number of takes for various stocks of killer whales, including SRKW, are described in Appendix B. The methods used by NMFS are described in Appendix C.
	The EA must analyze alternate times for conducting this survey and other mitigation measures and alternatives to avoid and minimize impacts to SRKW and other species. It must take into account their seasonal distribution and essential behaviors.	During seismic surveys, factors such as Beaufort sea state can impact the quality of data collected. The proposed survey timeframe is optimized as operations would occur during a timeframe when sea state conditions are generally best for seismic survey data collection. Collecting low quality data would not meet the Purpose and Need of the Proposed Action and would result in the need for re-surveying the area. Therefore, conducting the survey at alternative times is not a viable Action Alternative for the Proposed Action. NSF did consult with NMFS and FWS per the ESA and MMPA to consider ways to reduce any potential impacts to SRKW and other species, including taking into consideration seasonal distribution and behaviors. Additional monitoring and mitigation measures were taken into consideration. Final monitoring and mitigation measures that would be followed (including measures adjusted or added beyond those originally proposed) are noted in Section 2.1.3.

	The EA must actually describe the direct, indirect, and cumulative impacts of this project on the impacted marine species. It describes the project, it describes the species, but it fails to connect the two with any meaningful analysis. For example, the EA notes the survey will take 4 leatherback sea turtles and be conducted within its designated critical habitat where they "could be encountered" and would likely be "adversely affected." That is the extent of the EA's inquiry for this highly endangered species. This cursory analysis is not the "hard look" required by the National Environmental Policy Act.	The Draft EA also tiers to the PEIS which describes potential impacts from marine geophysical research on sea turtles in section 3.4.1. General distribution of sea turtles off B.C. and just south of the survey area off California are discussed in Sections 3.4.3.2 and 3.4.2.3 of the PEIS, respectively. The Draft EA also tiers to the 2012 EA. We believe direct, indirect, and cumulative impacts from the Proposed Action are thoroughly considered when taking the Draft EA, the 2012 EA, and the PEIS into consideration.

APPENDIX F: USFWS ESA LOC & BIOLOGICAL OPINION

United States Department of the Interior

FISH AND WILDLIFE SERVICE
911 NE 11th Avenue
Portland, Oregon 97232-4181

In Reply Refer to:
FWS/R109/R112/AES/
01E00000-2020-I-0001

JAN 1 1 2020

Ms. Holly E. Smith
National Science Foundation
2415 Eisenhower Avenue
Alexandria, Virginia 22314

Dear Ms. Smith:

This responds to your November 22, 2019, letter and Biological Evaluation (BE) requesting informal consultation with the U.S. Fish and Wildlife Service (Service) under section 7 of the Endangered Species Act (ESA), as amended. At issue are the effects of the National Science Foundation's (NSF) funding of proposed high-energy (seismic) marine geophysical surveys on the endangered short-tailed albatross (*Phoebastria albatrus*), endangered Hawaiian petrel (*Pterodroma sandwichensis*), and the threatened marbled murrelet (*Brachyramphus marmoratus*). The proposed surveys, consisting of 6890 km of transect lines covered across 37 days of seismic operation, will occur in the late spring and summer of 2020. The purpose of the surveys is to acquire a regional grid of modern marine seismic reflection data spanning the entire Cascadia Subduction Zone of Northeast Pacific Ocean. The proposed seismic surveys will be conducted from the research vessel (R/V) *Marcus G. Langseth* (*Langseth*), which is owned by NSF and operated by Columbia University's Lamont-Doherty Earth Observatory (L-DEO). Monitoring and mitigation measures described in the BE as part of the proposed action are intended to avoid or minimize impacts from vessel interactions and sound.

Your letter requested Service concurrence with your determination that the proposed action may affect, but is not likely to adversely affect, the above listed species which could be present as seasonal visitors to the project area (albatross and petrel) or forage and loaf on waters in the action area adjacent to suitable inland nesting habitat (murrelet). Critical habitat for the marbled murrelet occurs adjacent to the study area, but this habitat is strictly terrestrial and would not be affected by the proposed activities.

Based on the proposed action, species information, and analysis presented in the BE, which is herein incorporated by reference, and other information in our files, we concur with the NSF's determination that implementation of the proposed seismic surveys may effect, but is not likely to adversely affect the short-tailed albatross and the Hawaiian petrel; we do not concur with your determination that the proposed action may effect, but is not likely to adversely affect, the marbled murrelet. For the reasons discussed below, we recommend that the NSF supplement the effects analysis in the BE so that we can further understand your proposed action and how it affects marbled murrelet.

The BE indicates 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. We are unable to determine whether the exposure of marbled murrelets to the stressors caused by the proposed action are significant or discountable. Murrelets may be difficult to detect on the open ocean at any time, but particularly in low light conditions and at night. This would limit the effectiveness of proposed monitoring and mitigation measures. Whether exposure leads to adverse effects is difficult to determine without some additional analysis. We are requesting the NSF to prepare a supplemental analysis to improve the understanding of how the action may affect the marbled murrelet.

This analysis should include an evaluation of diving murrelet exposure and response to each of the various sound-producing devices and sonar types that are part of the proposed action. The analysis should address potentially injurious exposures by evaluating the exposures in SEL and dBpeak, and potential behavioral disruption by assessing exposure in dBrms, which provides a measure of the total sound pressure level produced by an impulsive source. SEL is a measure of sound exposure level, and dBpeak values are used to define the peak pressure level at which injury may occur (i.e., physical damage to body tissues caused by a sharp pressure gradient between a gas or fluid-filled space inside the body and the surrounding gas or liquid).

The Service has used both dBpeak (for injury) and dBrms (for behavioral effects) threshold values to evaluate adverse injury and disturbance effects on diving seabirds. The supplemental analysis should also address the duration, severity, location, timing and the cumulative effects of exposures on the murrelet. Lack of existing audiograms or thresholds established for seabirds is not a sufficient basis for determining whether adverse effects are likely to result from exposure. Barring any specific data on seabirds, we recommend a surrogate approach using existing data for other wildlife species subject to similar exposures.

This letter concludes informal consultation on the effects of the proposed action on the short-tailed albatross and the Hawaii petrel. As provided in 50 CFR §402.16, reinitiation of consultation is required if: (1) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not previously considered; (2) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not previously considered; or (3) a new species is listed or critical habitat designated that may be affected by the identified action. Please note that the Service is currently conducting a status review in response to a substantial listing petition for the tufted puffin (*Fratercula cirrhata*), which was also mentioned in your request. The puffin is listed as endangered by the State of Washington and could be present in the survey area during the survey period along with a number of migratory birds not listed under the ESA. We recommend applying the proposed conservation and mitigation measures described in the BE to the tufted puffin.

We appreciate your concern and efforts to address the conservation of fish and wildlife. If you have any questions regarding this response, please contact Daniel Brown, Fish and Wildlife Biologist, of this office at 503-231-6281 (tel) or at daniel_brown@fws.gov (email).

Sincerely,

Assistant Regional Director

Endangered Species Act - Section 7 Consultation

Biological Opinion

addressing the

2021 West Coast Seismic Survey

conducted by the

National Science Foundation

U.S. Fish and Wildlife Service Reference Number:
01E00000-2020-F-0001

Action Agency: National Science Foundation

Prepared by: U.S. Fish and Wildlife Service
Interior Regions 9 and 12 - Columbia-Pacific Northwest

Digitally signed by MARJORIE NELSON
Date: 2021.04.12 16:32:25 -06'00'

April 12, 2021

Marjorie Nelson, Acting Assistant Regional Director
Ecological Services
Interior Regions 9 and 12

April 2021

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LIST OF ACRONYMS

2-D	two-dimensional
ADCP	Acoustic Doppler Current Profiler
dB	decibel
EZ	Exclusion Zone
FM	Frequency Modulated
GoM	Gulf of Mexico
Hz	Hertz
kHz	kilohertz
kts	knots
L-DEO	Lamont-Doherty Earth Observatory
MBES	Multibeam Echosounder
MCS	Multi-Channel Seismic
nmi	nautical mile
NSF	National Science Foundation
OBN	Ocean Bottom Node
PTS	Permanent Threshold Shift
PSO	Protected Species Observer
rms	root-mean-square
ROV	remotely operated vehicle
R/V	research vessel
SBP	Sub-bottom Profiler
SEL	Sound Exposure Level (acoustic energy)
SPL	Sound Pressure Level
TS	Threshold Shift
TTS	Temporary Threshold Shift
µPa	microPascal

INTRODUCTION

This document transmits the U.S. Fish and Wildlife Service's (USFWS or Service) biological opinion (BiOp or opinion) addressing the consequences of National Science Foundation (NSF) funding of proposed high-energy (seismic) marine geophysical surveys on the threatened marbled murrelet (*Brachyramphus marmoratus*). Critical habitat for the marbled murrelet occurs adjacent to the study area, but this habitat is strictly terrestrial and is not likely to be affected by the proposed activities. In addition, due to changes in the proposed action that occurred subsequent to initiation of formal consultation, we have determined that the proposed action may affect, but is not likely to adversely affect, the threatened bull trout (*Salvelinus confluentus*) and its designated critical habitat; see Appendix A for the analysis supporting these determinations. This opinion was prepared in accordance with the requirements of section 7 of the Endangered Species Act of 1973, as amended (ESA; 16 U.S.C. 1531 et seq.). Your request for consultation was received on November 22, 2019.

Consultation History

On November 22, 2019, we received a request for consultation from NSF on their proposed funding of a marine geophysical survey by the R/V *Marcus G. Langseth* (R/V *Langseth* or *Langseth*) of the Cascadia Subduction Zone in the Northeast Pacific Ocean during late spring/summer of 2020.

On December 4, 2019, per our request, we received an observation report from NSF on a prior marine geophysical survey conducted by the R/V *Langseth* of the Axial Seamount.

On January 9, 2020, NSF provided clarification on proposed vessel operations, lighting, and an associated observer program to assist in documenting potential seabird interactions with the vessels associated with the project.

On February 19, 2020, an interagency teleconference was convened to discuss and clarify aspects of the proposed action and to identify information needs for completing the consultation.

On March 13, 2020, the Service received additional analyses regarding the potential exposure of marbled murrelets to underwater sound caused by the proposed project.

On April 6, 2020, the Service requested a revised proposed action description to account for the various measures incorporated to address the sea otter (*Enhydra lutris kenyoni*) and NMFS jurisdictional species.

On June 5, 2020, the Service received information from NSF indicating the proposed action was being delayed until the spring/summer of 2021. At that time, the NSF requested the Service to continue working to complete the consultation as soon as possible.

On June 12, 2020, the Service received additional information from NSF regarding project-caused underwater sound levels and a revised track line map.

On February 26, 2021, the Service met with NSF to discuss a completion date for the biological opinion. At that time, the Service committed to NSF that we would endeavor to complete this opinion by April 20, 2021.

On March 10 and 11, 2021, the Service received responses to our request for NSF review of the draft proposed action description prepared for this biological opinion. The NSF responses contained a number of suggested edits and clarifications.

On March 16, 2021, the Service received NSF revisions to their March 13, 2020, effects analysis for the marbled murrelet due to NSF changes in the proposed action.

BIOLOGICAL OPINION

Description of the Proposed Action

The proposed activities will be conducted in the spring and summer of 2021. Surveys are expected to include approximately 37 days of seismic operations, 2 days of equipment deployment/retrieval, and 1 day of transit. Surveys are proposed to occur within the EEZ of the U.S. and Canada, ranging in water depths from 60 to 4,400 m located at ~42-51° N, ~124-130° W. The surveys include several strike lines, parallel (including one continuous line along the continental shelf) and perpendicular to the coast. The margin perpendicular lines would extend approximately 50 km seaward of the deformation front and landward of the deformation front to as close to the shoreline as authorized. Most of the survey (69 percent) would occur in deep water (>1000 m), 28 percent would occur in intermediate water (100–1000 m deep), and 3 percent would take place in shallow water <100 m deep. Representative survey tracklines are shown in Figure 1 and Figure 2.

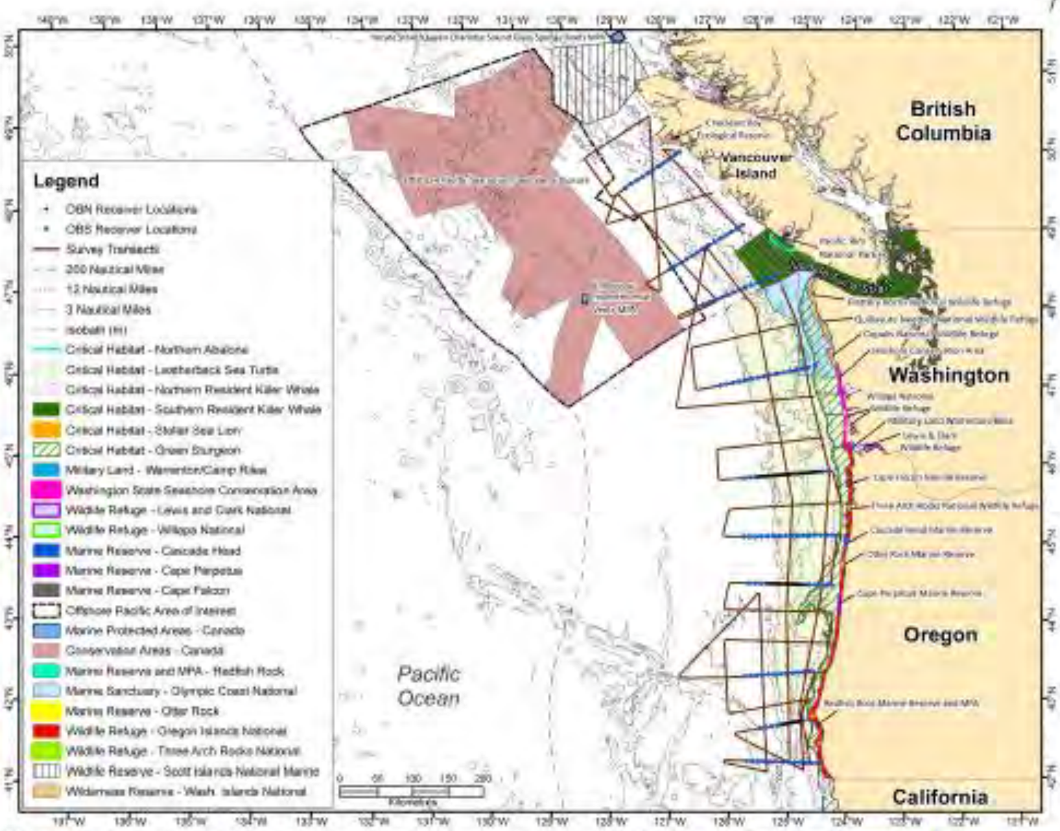

Figure 1. Location of the proposed seismic surveys in the Northeast Pacific Ocean and conservation areas near the proposed survey location (NSF 2019, pg. 3, as updated 5.14.20).

8

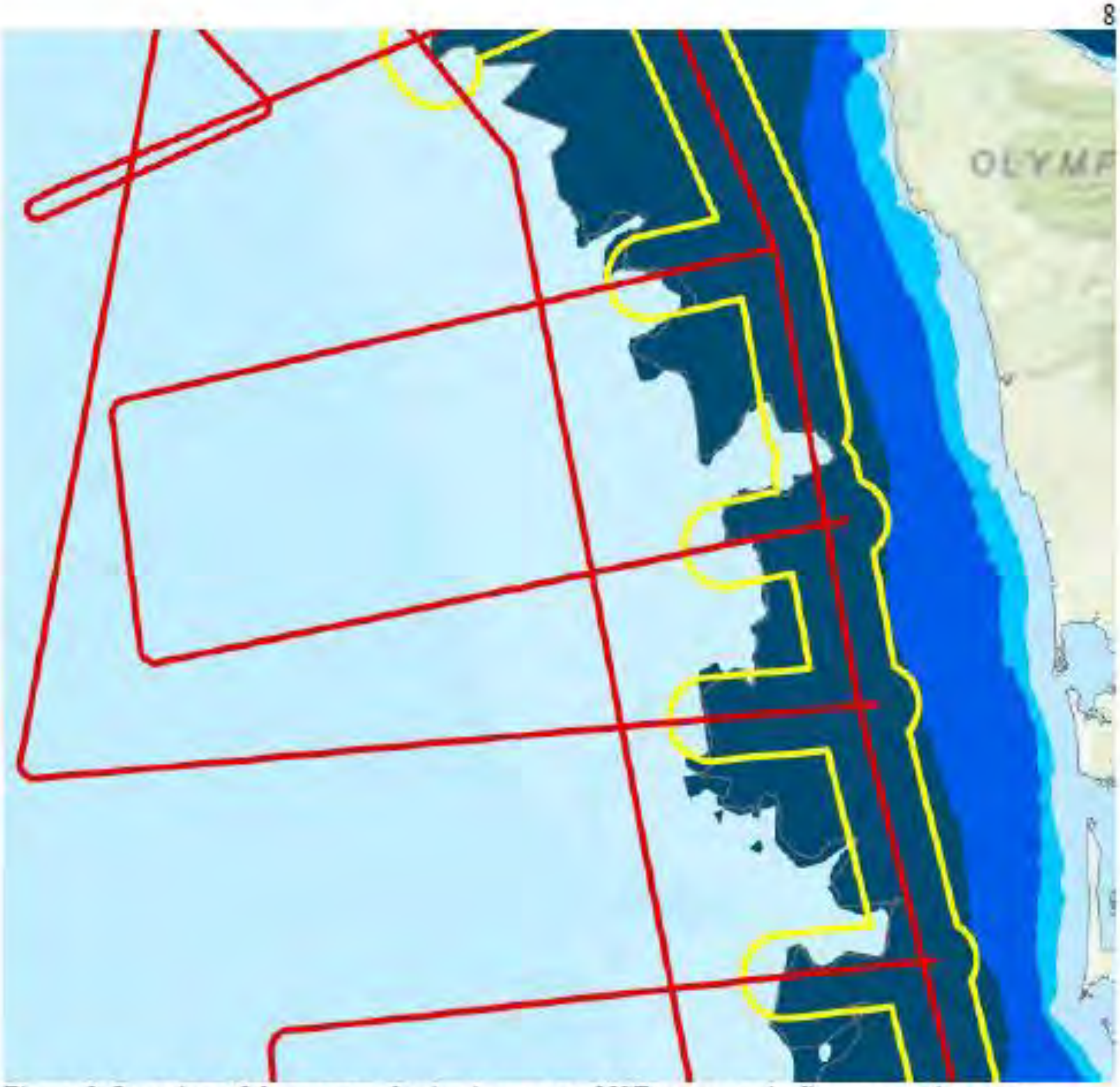

Figure 2. Location of the proposed seismic survey. NSF transects (red) conservation areas (yellow buffers at 9.5 km and 12.5 km) around portions of the transects that are in waters less than 1000 m deep. The blue depth contours are 25, 40, 100, and 1000 m near the proposed survey location (NSF 2019, pg. 3, as updated 5.14.20).

Some deviation in actual track lines, including the order of survey operations, may be necessary for reasons such as poor data quality, inclement weather, or mechanical issues with the research vessel and/or equipment. For these reasons, the track lines could occur anywhere within the coordinates noted above. A maximum of 6,540 km of transect lines would be surveyed. Approximately 3.6 percent of the transect lines (234 km) would be located in Canadian territorial waters.

The surveys involve one source vessel, R/V *Langseth*, which is owned by the NSF and operated on its behalf by the Lamont-Doherty Earth Observatory (L-DEO), that would leave and return to port in Astoria, Oregon. The R/V *Langseth* would deploy an array of 36 airguns as an energy source with a total volume of approximately 6,600 in^3 at a depth of 12 meters and a shot interval of 37.5

m. The 36-airgun array could operate 24 hours a day, except during mitigation shutdowns, for the entirety of the 37 days of survey. The vessel speed during seismic operations would be approximately 4.2 knots (~7.8 km/hour) during the survey. The receiving system would consist of one 15-kilometer (km) long hydrophone streamer, OBSs, and OBNs. The R/V *Oceanus*, which is owned by NSF and operated by Oregon State University, would be used to deploy the OBSs and OBNs. The R/V *Oceanus* would leave and return to port in Newport, Oregon. As the airguns are towed along the survey lines, the hydrophone streamer would transfer the data to an on-board processing system, and the OBSs and OBNs would receive and store the returning acoustic signals internally for later analysis.

Approximately 17 days prior to the seismic survey, the R/V *Oceanus* would deploy short-period multi-component OBSs and a large-N array of OBNs to record shots along approximately 10 margin-perpendicular profiles. OBSs would be deployed within the proposed survey area between 5 nm and 100 nm from the coast, and at a 10-km spacing along approximately 10 profiles from Vancouver Island to Oregon in water depths ranging from 60 to 3,100 m. Two OBS deployments would occur with a total of 115 instrumented locations. One deployment consisting of approximately 60 OBSs would be implemented to instrument six profiles off the Oregon coast, and a second deployment consisting of about 55 OBSs would be implemented to instrument three profiles off the coasts of Washington and Vancouver Island. The first deployment off the Oregon coast would occur prior to the start of the proposed survey, after which the R/V *Langseth* would acquire data in the southern portion of the study area. Then 55 of those OBSs would be recovered by the R/V *Oceanus* and re-deployed off the Washington coast and Vancouver Island, so that the R/V *Langseth* can acquire data in the northern portion of the survey area. The OBSs have a height and diameter of approximately 1 m and an approximately 80-kilogram (kg) anchor. To retrieve the 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.

Under the proposed action, a total of 350 independent OBNs spaced 500-m apart would be deployed at 179 nodes along one transect off northern Oregon (22 to 71 nm from the coast at depths of 128 to 2210 m), at 107 nodes along a second transect off central Oregon (30 to 60 nm from the coast at depths of 293 to 2925 m), and at 64 nodes along a third transect off southern Oregon (9 to 26 nm from the coast at depths of 495 to 2731 m). The OBNs are not connected to each other, and there are no cables attached to them. Each OBN has internal batteries, and all data are recorded and stored internally. Each OBN weighs 21 kg in air (9.5 kg in water). As the OBNs are small [330 millimeters (mm) x 289 mm x 115 mm] compact, not buoyant, and lack an anchor-release mechanism, they cannot be deployed/recovered by free-fall as with the OBSs. The nodes would be deployed and retrieved using a remotely operated vehicle (ROV); the ROV would be deployed from the R/V *Oceanus*. The ROV would be fitted with a skid with capacity for 32 units, lowered to the seafloor, and towed at a speed of 0.6 knots at 5 to 10 m above the seafloor between deployment sites. After the 32 units are deployed, the ROV would be retrieved, the skid would be reloaded with another 32 units, and sent back to the seafloor for deployment, and so on. The ROV would recover the nodes 3 days after the completion of the R/V *Langseth* cruise. The nodes would be recovered one by one by a suction mechanism.

Long 15-km-offset MCS data would be acquired along numerous 2-D profiles oriented perpendicular to the margin and located to provide coverage in areas inferred to be rupture patches during past earthquakes and their boundary zones. The survey would also include several strike lines including one continuous line along the continental shelf centered roughly over gravity-inferred fore-arc basins to investigate possible segmentation near the down-dip limit of the seismogenic zone. The margin normal lines would extend ~50 km seaward of the deformation front to image the region of subduction bend faulting in the incoming oceanic plate, and landward of the deformation front to as close to the shoreline as authorized. It is proposed that the southern transects off Oregon be acquired first, followed by the profiles off Washington and Vancouver Island, British Columbia.

In addition to the operations of the airgun array, a multibeam echosounder (MBES), a sub-bottom profiler (SBP), and an 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. The R/V *Oceanus* would operate a single-beam dual-frequency echosounder (4 and 12 kHz) and an ADCP.

The ocean floor would be mapped with the Kongsberg EM122 MBES. The Kongsberg EM122 MBES operates at 10.5–13 kHz and is hull-mounted on the R/V *Langseth*. The maximum source level is 242 dB re 1 µPa·rms. Each ping consists of eight (in water >3,281 ft [1,000 m] deep) or four (<3,281 ft [1,000 m]) successive fan-shaped transmissions, each ensonifying a sector that extends 1° fore–aft. Continuous-wave signals increase from 2 to 15 ms long in water depths up to 8,530 ft (2,600 m), and FM chirp signals up to 100 ms long are used in water >8,530 ft (2,600 m) in depth. The successive transmissions span an overall cross-track angular extent of about 150°, with 2-ms gaps between the pings for successive sectors.

The ocean floor would also be mapped with the Knudsen 3260SBP which transmits a beam as a 27° cone directed downward by a 3.5-kHz transducer in the hull of the R/V *Langseth*. The nominal power output is 10 kilowatts (kW), but the actual maximum radiated power is 3 kW or 222 dB re 1 µPa-m. The ping duration is up to 64 ms, and the ping interval is 1 s. A common mode of operation is to broadcast five pulses at 1-s intervals followed by a 5-s pause.

An ADCP would be used to calculate speed of the water current, direction of the current, and the depth in the water column of the current. The ADCP would transmit frequencies at 35-1,200 kHz.

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.

Conservation Measures

Several important measures intended to avoid or minimize the likelihood or extent of adverse impacts to listed species and critical habitat have been incorporated into the design of the project. NSF has stated that the following mitigation measures will be implemented to avoid or minimize adverse effects on marbled murrelets or other listed seabirds encountered during the proposed activities:

- Monitoring by Protected Species Observers (PSOs) for ESA-listed seabirds diving near the vessel.
- Passive acoustic monitoring (PAM).

- PSO data and documentation.
- 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).
- 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. In areas where a support vessel would be used, PSOs on board would also monitor for ESA-listed seabirds.

A minimum of one independently contracted PSO would monitor during daylight operational hours for marine species, including ESA-listed seabirds; and two observers 30 min before and during ramp ups during the day and night. In the event an ESA-listed seabird was observed diving or foraging within the designated Exclusion Zone (EZ), the seismic airguns ramp-up would be delayed and, if already operational, would be powered down to a single airgun (so that the seabird remained outside of the EZ of the full array) or shutdown, as appropriate. PSOs would train bridge crew to identify ESA-listed seabirds; during nighttime hours, bridge crew would monitor for any ESA-listed seabirds around the survey vessel, and mitigation measures (e.g., power downs/shutdowns) would be implemented as necessary. In addition, in areas where a support vessel would be used, PSOs on board would also monitor for ESA-listed seabirds and alert R/V *Langseth* PSOs if any are observed.

Deck lighting on the R/V *Langseth* and the R/V *Oceanus* and its ROV, when deployed, is also downward pointing. Curtains/shades are used on cabin windows at night. The fact that the airguns, as a result of their design, direct the majority of the energy downward, and less energy laterally, is also an inherent mitigation measure. Note: the Proposed Action would not involve the intentional hazing of federally listed species which would require a separate permit and formal consultation.

Other Relevant Measures

To reduce the potential for disturbance from acoustic stimuli associated with the activities, L-DEO has proposed to implement mitigation measures for marine species which would also benefit ESA-listed seabirds. As noted above, measures that would be adopted during the planned surveys include (1) reduced survey tracklines in areas of highest sea otter densities and Southern Resident Killer Whale critical habitat; (2) operational restrictions; and (3) additional vessel-based visual mitigation monitoring from a support vessel.

<u>Reduced Survey Transects and Operational Restrictions</u>

Since the initial consultation package was submitted to the FWS, the distance of proposed activities between the coastline and the proposed tracklines and associated ensonified areas have significantly increased. These changes are summarized as follows:

- Proposed tracklines were eliminated off the coast of Washington in water depths <100 m.
- Between Tillamook, OR and Barkley Sound, Canada, in water depths between 100 and 200 m water depths, survey activities would be as follows:
    - Restricted to daylight operations (i.e., from 30 minutes prior to sunrise through 30 minutes following sunset) to ensure that PSOs are able to visually observe the entire

500-m EZ and beyond to implement shutdown procedures.
  - The ensonified areas (the Level B 160dB zone) of proposed tracklines would remain outside of 100m water depths.
  - A support vessel would sail 5 km in advance of the R/V *Langseth* carrying 2 additional PSOs; the additional PSOs would observe, track and communicate relevant marine species presence, including any ESA-listed species, to PSOs on the R/V *Langseth*, alerting them of the potential need to implement shutdown mitigation measures.
- Most tracklines were eliminated off the coast of Oregon in water depths <100 m. A few proposed tracklines remain in water depths <100 m along one section of the coast of Oregon due to a larger protrusion of shallow water topography in this area.
- Proposed tracklines were removed from Southern Resident Killer Whale Critical Habitat established by Canada.
- Within the waters offshore of Washington between Tatoosh Island and the Quillayute River mouth, survey transects must remain 21 km from shore or seaward of the 100 m isobath, whichever is greater. Survey transects must remain seaward of the 100 m isobath between the mouths of the Quillayute River and Grays Harbor.
- If possible, while the R/V *Langseth* is surveying in waters 1,000 m deep or less off the coast of Washington, survey operations will occur in daylight hours only (i.e., from 30 minutes prior to sunrise through 30 minutes following sunset) to ensure that PSOs are able to visually observe the entire 500-m EZ and beyond to implement power/shutdown procedures.

Establishment of Exclusion Zones

If a marbled murrelet is observed within or enters the 500-m EZ, the acoustic source would be powered down or shut down, if necessary. A power down would occur if the marbled murrelet were to dive and/or forage within the 500-m EZ, and a shutdown would occur if the marbled murrelet were to dive/forage within 100-m of the single airgun used during power downs.

The 500-m EZ is intended to be precautionary in the sense that it is designed to minimize impacts to marine species. Although significantly greater distances may be observed from an elevated platform under good conditions, we believe that 500 m is likely regularly attainable for visual monitors using the naked eye during typical conditions.

Vessel-Based Visual Mitigation Monitoring

Visual monitoring requires the use of trained observers (herein referred to as "visual PSOs") to scan the ocean surface visually for the presence of listed species, including diving/foraging ESA-listed seabirds. The effective area to be scanned for seabirds visually includes primarily the EZ. Visual monitoring of the EZ and adjacent waters is intended to establish and maintain zones around the sound source that are clear of listed species that can be visually observed in this manner, thereby reducing or eliminating the potential for injury and minimizing the potential for more severe consequences for animals occurring close to the vessel.

The L-DEO must use dedicated, trained, Service-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 listed species and mitigation requirements. PSO resumes shall be provided to the Service for approval.

At least one of the visual PSOs aboard the vessel must have a minimum of 90 days at-sea experience working in the above-described roles, respectively, 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 protected species observation team. The lead PSO shall serve as primary point of contact for the vessel operator and ensure all PSO requirements per the conservation measures are met. To the maximum extent practicable, the experienced PSOs should be scheduled to be on duty with those PSOs with appropriate training but who have not yet gained relevant experience.

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 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). Visual monitoring of the EZ 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. Visual PSOs shall coordinate to ensure 360° 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 shall establish and monitor the EZ for marbled murrelet and any other ESA-listed seabirds that may be present (e.g., the short-tailed albatross or the Hawaiian petrel). The EZ shall be based upon the radial distance from the edges of the acoustic source (rather than being based on the center of the array or around the vessel itself).

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 listed species by crew members shall be relayed to the PSO team. During good conditions, visual PSOs shall 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.

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.

Pre-clearance and Ramp-up

Ramp-up (sometimes referred to as a "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 array's airguns are active. Each stage should be approximately the same duration, and the total duration should not be less than approximately 20 minutes. The intent of pre-clearance observation (30 minutes) is to ensure that no ESA-listed seabirds are observed diving/foraging within the EZ prior to the beginning of ramp-up. The ramp-up is expected to have the effect of warning listed species of pending seismic operations and to allow sufficient time for those animals to leave the immediate vicinity. A ramp-up procedure, involving a stepwise increase in the number of airguns firing and total 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 acoustic source. All operators must adhere to the following pre-clearance and ramp-up requirements as follows:

- The operator must notify a designated PSO of the planned start of ramp-up as agreed upon with the lead PSO; the notification time should not be less than 60 minutes prior to the planned ramp-up in order to allow the PSOs time to monitor the exclusion and buffer zones for 30 minutes prior to the initiation of ramp-up procedures during the pre-clearance period.
- Ramp-up procedures shall be scheduled so as to minimize the time spent with the source 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 procedures will not be initiated if any ESA-listed seabird is observed diving/foraging within the applicable EZ. If a listed species is observed diving/foraging within the applicable EZ during the 30-minute pre-clearance period, ramp-up procedures may not begin until the animal(s) has been observed exiting the zones or until an additional 15-minute time period has elapsed with no further sightings of listed species.
- Ramp-up procedures shall begin by activating a single airgun with the lowest volume in the array and shall continue in stages by doubling the number of active airguns at the commencement of each stage, with each stage of approximately the same duration. The duration of each stage shall not be less than 20 minutes. The operator must provide information to the PSO documenting that appropriate ramp-up procedures were followed.
- Visual PSOs must monitor the EZ during ramp-up procedures. Ramp-up procedures must cease, and the source must be shut down if an ESA-listed seabird is observed within the applicable EZ.
- Ramp-up procedures may occur at times of poor visibility if appropriate visual monitoring has occurred with no detections of listed species in the 30 minutes prior to initiating ramp-up procedures. Acoustic source activation may only occur at times of poor visibility where operational planning cannot reasonably avoid such circumstances.
- 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 listed species have occurred within the applicable EZ. For any longer shutdown, pre-clearance observations and ramp-up procedures are required. For any shutdown at night or in periods of poor visibility (e.g., BSS 4 or greater), initiation of ramp-up procedures is required, but if the shutdown period was brief and constant visual observation was maintained and no ESA-listed species were detected, a pre-clearance period of 30 minutes is not required.
- Testing of the acoustic source involving all associated components requires initiation of ramp-up procedures. Testing limited to individual source components or strings does not require initiation of ramp-up procedures but does require a pre-clearance observation period of 30 minutes.

<u>Shutdown</u>

The shutdown of an airgun array requires the immediate de-activation of all individual airgun components of the array. The PSO on duty will have the authority to delay the start of survey operations or to call for shutdown of the acoustic source if an ESA-listed seabird is detected diving/foraging within the EZ. The operator must also establish and maintain clear lines of communication directly between on-duty PSOs and crew controlling the acoustic source to ensure that shutdown commands are conveyed swiftly while allowing PSOs to maintain watch. When the airgun array is active (i.e., anytime one or more airguns are active, including during ramp-up procedures) and an ESA-listed seabird is observed diving/foraging within the EZ, the acoustic source will be powered down and shut down, if necessary. When power downs and shutdowns are called for by a PSO, the acoustic source will be immediately reduced or deactivated, and any dispute resolved only after implementation of the mitigation measure.

Following a shutdown, airgun activity will not resume until the ESA-listed seabird has been visually observed exiting the area within the 500-m radius EZ or it has not been seen within the 500-m radius EZ for 15 minutes.

Proposed Monitoring and Reporting

Vessel-Based Visual Monitoring

As described above, PSO observations will occur during daytime airgun operations. During seismic operations, at least five visual PSOs would be based aboard the R/V *Langseth*. Monitoring shall be conducted in accordance with the following requirements:

- The operator shall provide PSOs with bigeye binoculars (e.g., 25 x 150; 2.7 view angle; individual ocular focus; height control) of appropriate quality (e.g., Fujinon or equivalent) solely for PSO use. The binoculars shall be pedestal-mounted on the deck at the most appropriate vantage point that provides for optimal listed species observation, PSO safety, and safe operation of the vessel.
- The operator will work with the selected third-party observer provider to ensure that PSOs have all equipment (including backup equipment) needed to adequately perform necessary tasks, including accurate determination of distance and bearing to observed animals.

PSOs must meet the following requirements and qualifications:

- PSOs shall be independent, dedicated, trained visual PSOs and must be employed by a third-party observer provider.
- PSOs shall have no tasks other than to collect observational data and communicate with and instruct relevant vessel crew members with regard to the presence of protected species and mitigation requirements (including brief alerts regarding maritime hazards).
- PSOs shall have successfully completed an approved PSO training course appropriate for their designated task (visual observations).
- The Service must review and approve PSO resumes accompanied by a relevant training course information packet that includes the name and qualifications (i.e., experience, training completed, or educational background) of the instructor(s), the course outline or syllabus, and course reference material as well as a document verifying successful completion of the course.
- The Service shall have one week to approve PSOs from the time the above information is submitted, after which PSOs meeting minimum requirements shall be considered approved.
- 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.

- 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 biological sciences, and at least one undergraduate course in math or statistics.
- The educational requirements may be waived if the PSO has acquired the relevant skills through alternate experience. Requests for such a waiver shall be submitted to the Service and must include written justification. Requests shall be granted or denied (with justification) by the Service 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.

For data collection purposes, PSOs shall use standardized data collection forms, whether hard copy or electronic. PSOs shall record detailed information about any implementation of mitigation requirements, including the distance of listed species 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, and the length of time before any subsequent ramp-up of the acoustic source. If required mitigation was not implemented, PSOs shall record a description of the circumstances. At a minimum, the following information must be recorded:

- Vessel name(s) (source vessel and other vessels associated with the seismic survey) and call signs.
- PSO names and affiliations.
- Dates of departures and returns to port with the port name.
- Date and participants of PSO briefings.
- Dates and times (Greenwich Mean Time) of survey effort and times corresponding with PSO effort.
- Vessel location (latitude/longitude) when survey effort began and ended and vessel location at beginning and end of visual PSO duty shifts.
- Vessel heading and speed at beginning and end of visual PSO duty shifts and upon any line change.
- Environmental conditions during the visual survey period (i.e., at the start and finish of the PSO shift and whenever environmental conditions have changed significantly), including BSS and any other relevant weather conditions including cloud cover, fog, sun glare, and overall visibility to the horizon.
- 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).
- 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 operational significance (e.g., timing of pre-clearance activities, ramp-up procedures, shutdown, testing, shooting, ramp-up completion, end of operations, use of streamers, etc.).

The following information shall be recorded upon visual observation of any listed species:

- Watch status (sighting made by a PSO on or off duty, opportunistically, by a crew member, or

via an alternate vessel/platform).
- Name of PSO who sighted the animal.
- Time of sighting.
- Vessel location at time of sighting.
- Water depth at time of sighting.
- Direction of vessel's travel (compass direction) at the time of sighting.
- Estimated number of animals (high/low/best) sighted.
- Detailed behavior observations of the listed species (e.g., grooming; actively moving away from vessel; diving; note any observed changes in behavior).
- Animal's closest point of approach (CPA) and/or closest distance from any component of the acoustic source.
- Platform activity at time of sighting (e.g., deploying, recovering, testing, shooting, data acquisition, other).
- Description of any actions implemented in response to the sighting (e.g., delays, shutdown, ramp-up) and the time and location of the action.

A draft report summarizing the above information shall be submitted to the Service within 90 days after the end of the cruise. The report shall describe the operations that were conducted and sightings of animals near the operations. The report shall provide full documentation of methods, results, and interpretation pertaining to all monitoring activities. The 90-day report shall summarize the dates and locations of seismic operations, and all ESA-listed seabird sightings (dates, times, locations, activities, associated seismic survey activities). The report shall also include estimates of the number and nature of listed species exposures that occurred above the harassment threshold based on PSO observations.

The draft report shall also include 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). GIS files shall be provided in ESRI shapefile format and include the UTC date and time, latitude in decimal degrees, and longitude in decimal degrees. All coordinates shall be referenced to the GCS_North_American_1983 geographic coordinate system. In addition to the draft report, all raw observational data shall be made available to the Service. The draft report must be accompanied by a certification from the lead PSO as to the accuracy of the report, and the lead PSO may submit directly to the Service a statement concerning implementation and effectiveness of the required mitigation and monitoring. A final report must be submitted within 30 days following resolution of any Service comments on the draft report.

<u>Reporting Vessel Strikes or Injured or Dead Animals</u>

See the Incidental Take Statement Terms and Conditions section below for specific procedures required to report, handle, or dispose of any sick or injured individuals of an ESA-listed species.

Term of the Action

The proposed action is scheduled to be implemented from May 20 through July of 2021. However, if there are unanticipated delays, while the total number of survey days will not change, the project time frame could be extended further into the summer period.

Action Area

The action area includes the Cascadia Subduction Zone survey area and transit routes to and from ports. The proposed survey location is approximately 42–51°N, ~124–130°W. Representative survey tracklines are shown in Figure 1 (above). As described further in the EA, some deviation in actual track lines, including the order of survey operations, could be necessary for reasons such as 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, as well as in U.S. state waters and Canadian Territorial Waters, ranging in depth from 60 m to 4,400 m.

Analytical Framework for the Jeopardy Determination

In accordance with policy and regulation, the jeopardy determination in this Biological Opinion relies on the following components:

The *Status of the Species*, which evaluates the species' range-wide condition relative to its reproduction, numbers, and distribution, the factors responsible for that condition, and its survival and recovery needs.

The *Environmental Baseline*, which evaluates the condition of the species in the action area relative to its reproduction, numbers, and distribution without the consequences caused by the proposed action, the factors responsible for that condition, and the relationship of the action area to the survival and recovery of the species.

The *Effects of the Action*, which evaluates all future consequences to the species that are reasonably certain to be caused by the proposed action, including the consequences of other activities that are caused by the proposed action, and how those impacts are likely to influence the conservation role of the action area for the species; and

Cumulative Effects, which evaluates the consequences of future, non-Federal activities reasonably certain to occur in the action area on the species, and how those impacts are likely to influence the conservation role of the action area for the species.

In accordance with policy and regulation, the jeopardy determination is made by evaluating the consequences of the proposed Federal action in the context of the species' current range-wide status, taking into account any cumulative effects, to determine if implementation of the proposed action is likely to cause an appreciable reduction in the likelihood of both the survival and recovery of the species in the wild. The key to making this finding is clearly establishing the role of the action area in the conservation of the species as a whole, and how the effects of the proposed action, taken together with cumulative effects, are likely to alter that role.
NOTE: If recovery units were defined for the species in the final listing rule for use in completing jeopardy analyses, pursuant to Service policy, when an action impairs or precludes the capacity of a recovery unit from providing both the survival and recovery function assigned to it, that action may represent jeopardy to the species. When using this type of analysis, the Biological Opinion describes how the consequences of the proposed Federal action on the listed species, taken

together with cumulative effects, affect the capability of the recovery unit to support both the survival and recovery of the species as a whole.

Status of the Species

The marbled murrelet (*Brachyramphus marmoratus*) (marbled murrelet) was listed by the U.S. Fish and Wildlife Service (Service) as a threatened species in Washington, Oregon, and California in 1992. The primary reasons for listing included extensive loss and fragmentation of the older-age forests that serve as nesting habitat for marbled murrelets, and human-induced mortality in the marine environment from gillnets and oil spills (57 FR 45328 [Oct. 1, 1992]). Although some threats such as gillnet mortality and loss of nesting habitat on Federal lands have been reduced since the 1992 listing, the primary threats to species persistence continue (75 FR 3424 [Jan. 21, 2010]).

Life History

The marbled murrelet is a small, fast-flying seabird in the Alcidae family that occurs along the Pacific coast of North America. Marbled murrelets forage for small schooling fish or invertebrates in shallow, nearshore, marine waters and primarily nest in coastal older-aged coniferous forests. The marbled murrelet lifespan is unknown, but is expected to be in the range of 10 to 20 years based on information from similar alcid species (De Santo and Nelson 1995, pp. 36-37). Marbled murrelet nesting is asynchronous and spread over a prolonged season. In Washington, the marbled murrelet breeding season extends from April 1 to September 23. Egg laying and incubation occur from April to early August and chick rearing occurs between late May and September, with all chicks fledging by late September (Hamer et al. 2003; USFWS 2012a).

Marbled murrelets lay a single-egg which may be replaced if egg failure occurs early in the nesting cycle, but this is rare (Nelson 1997, p. 17). During incubation, one adult sits on the nest while the other forages at sea. Adults typically incubate for a 24-hour period, then exchange duties with their mate at dawn. Chicks hatch between May and August after 30 days of incubation. Hatchlings appear to be brooded by an adult for several days (Nelson 1997, p. 18). Once the chick attains thermoregulatory independence, both adults leave the chick alone at the nest for the remainder of the rearing period, except during feedings. Both parents feed the chick, which receives one to eight meals per day (Nelson 1997, p. 18). Most meals are delivered early in the morning while about a third of the food deliveries occur at dusk and intermittently throughout the day (Nelson and Hamer 1995, p. 62).

Marbled murrelets and other fish-eating alcids exhibit wide variations in nestling growth rates. The nestling stage of marbled murrelet development can vary from 27 to 40 days before fledging (De Santo and Nelson 1995, p. 45). The variations in alcid chick development are attributed to constraints on feeding ecology, such as unpredictable and patchy food distributions, and great distances between feeding and nesting sites (Øyan and Anker-Nilssen 1996, p. 830). Food limitation during nesting often results in poor growth, delayed fledging, increased mortality of chicks, and nest abandonment by adults (Øyan and Anker-Nilssen 1996, p. 836).

Marbled murrelets are believed to be sexually mature at 2 to 4 years of age (Nelson 1997, p. 19). Adult birds may not nest every year, especially when food resources are limited. For example, in central California, the proportion of marbled murrelets attempting to breed was more than four times higher (50 percent versus 11 percent) in a year when prey availability was apparently good than in a year when more foraging effort was required (Peery et al. 2004, p. 1095). In Oregon, there was similarly a four-fold increase in vacancy rates of previously occupied nesting habitat following the poorest ocean conditions, as compared with the years following the best ocean conditions (Betts et al. 2020, p. 6). In 2017, none of the 61 marbled murrelets radio-tagged in Oregon attempted nesting, likely because anomalous ocean conditions reduced prey availability (Horton et al. 2018, p. 77). At other times and places, radio-telemetry and demographic modeling indicate that the proportion of adults breeding in a given year may vary from 5 to 95 percent (Lorenz et al. 2017, p. 312; McShane et al. 2004, p. 3-5). In other words, in some years, very few marbled murrelets attempt nesting, but in other years, almost all breeding-age adults may initiate nesting.

Marbled Murrelets in the Marine Environment

Marbled murrelets spend most (>90 percent) of their time at sea. They generally forage in pairs on the water, but they also forage solitarily or in small groups. In addition to foraging, their activities in the marine environment include preening, social behaviors, and loafing. Following the breeding season, marbled murrelets undergo the pre-basic molt, in which they exchange their breeding plumage for their winter plumage. They replace their flight feathers during this molt, and for a few weeks they are flightless. Therefore, they spend this entire period at sea. Their preferred marine habitat includes sheltered, nearshore waters, although they occur farther offshore in some locations and during the nonbreeding season (Huff et al. 2006, p. 19).

Breeding Season Distribution

The marbled murrelet is widely distributed in nearshore waters along the west coast of North America. It occurs primarily within 5 km of shore (in Alaska, within 50 km), and primarily in protected waters, although its distribution varies with coastline topography, river plumes, riptides, and other physical features (Nelson 1997, p. 3). For example, along the Pacific coast of Washington, the most heavily-used area during the breeding season extends to at least 8 km from the coast, with use in some years concentrated in the outer portions of this area (Bentivoglio et al. 2002, p. 29; McIver et al., in press, pp. 34, 85; Menza et al. 2015, pp. 16, 20-21). The distribution of marbled murrelets in marine waters during the summer breeding season is highly variable along the Pacific coast, with areas of high density occurring along the Strait of Juan de Fuca in Washington, the central Oregon coast, and northern California (Raphael et al. 2015, p. 20). Low-density areas or gaps in marbled murrelet distribution occur in central California, and along the southern Washington coast (Raphael et al. 2015, p. 21). Marbled murrelet marine habitat use is strongly associated with the amount and configuration of nearby terrestrial nesting habitat (Raphael et al. 2015, p. 17). In other words, they tend to be present in marine waters adjacent to areas of suitable breeding habitat. Local aggregations or "hot spots" of marbled murrelets in nearshore marine waters are strongly associated with landscapes that support large, contiguous areas of mature and old-growth forest. In Puget Sound and along the Strait of Juan de Fuca, these "hot spots" are also strongly associated with a low human footprint in the marine environment, for example, areas natural shorelines and relatively little vessel traffic (Raphael et al. 2016a, p. 106).

Non-breeding adults and subadults are thought to occur in similar areas as breeding adults. This species does occur farther offshore during the breeding season, but in much reduced numbers (Drew and Piatt 2020; Strachan et al. 1995, p. 247). Their offshore occurrence is probably related to current upwelling and plumes during certain times of the year that tend to concentrate their prey species. Even within the breeding season, individual marbled murrelets may make large movements, and large average marine home ranges (505 km^2 and 708 km^2, respectively) have been reported for northern California and Washington (Hébert and Golightly 2008, p. 99; Lorenz et al. 2017, p. 318).

Non-breeding Season Distribution

Marbled murrelet marine habitat use during the non-breeding season is poorly documented, but they are present near breeding sites year-round in most areas (Nelson 1997, p. 3). Marbled murrelets exhibit seasonal redistributions following the pre-basic molt (Peery et al. 2008a, p. 119), and can move up to 750 km from their breeding season locations (Hébert and Golightly 2008, p. 101; Adrean et al. 2018). The southern end of the range extends as far south as the Southern California Bight; but some individuals also move northward at the end of the breeding season (Hall et al. 2009, p. 5081; Peery et al. 2008a, p. 121). Generally they are more dispersed and may be found farther offshore than during the breeding season, up to approximately 50 miles from shore (Adams et al. 2014; Ballance 2015, in litt.; Drew and Piatt 2020; Pearson 2019, p. 5; Speich and Wahl 1995, p. 322).

The highest concentrations likely still occur close to shore and in protected waters, but given the limited data available regarding non-breeding season marbled murrelet distribution or densities, a great deal of uncertainty remains (Nelson 1997, p. 3; Pearson 2019, p. 5). More information is available regarding non-breeding season marbled murrelet density and distribution in some areas of Puget Sound. Marbled murrelets move from the outer exposed coasts of Vancouver Island and the Straits of Juan de Fuca into the sheltered and productive waters of northern and eastern Puget Sound (Beauchamp et al. 1999, entire; Burger 1995, p. 297; Speich and Wahl 1995, p. 325). However, in central and southern Puget Sound, marbled murrelet densities are lower during the non-breeding season than they are during the breeding season (McIver et al. 2021, pp. 11-17; Pearson and Lance 2020, p. 12). Known areas of winter concentration include and southern and eastern end of Strait of Juan de Fuca (primarily Sequim, Discovery, and Chuckanut Bays), San Juan Islands and Puget Sound, Washington (Speich and Wahl 1995, p. 314).

Foraging and Diet

Marbled murrelets dive and swim through the water by using their wings in pursuit of their prey; their foraging and diving behavior is restricted by physiology. They usually feed in shallow, nearshore water less than 30 m (98 ft) deep, which seems to provide them with optimal foraging conditions for their generalized diet of small schooling fish and large, pelagic invertebrates: Pacific sand lance (*Ammodytes personatus*), northern anchovy (*Engraulis mordax*), Pacific herring (*Clupea harengus*), surf smelt (*Hypomesus* sp.), euphausiids, mysids, amphipods, and other species (Nelson 1997, p. 7). However, they are assumed to be capable of diving to a depth of 47 m (157 ft) based on their body size and diving depths observed for other alcid species (Mathews and Burger 1998, p. 71).

Contemporary studies of marbled murrelet diets in the Puget Sound–Georgia Basin region indicate that Pacific sand lance now make up the majority of the marbled murrelet diet

(Gutowsky et al. 2009, p. 251). Historically, energy-rich fishes such as herring and northern anchovy comprised the majority of the marbled murrelet diet (Becker and Beissinger 2006, p. 470; Gutowsky et al. 2009, p. 247). This is significant because sand lance have the lowest energetic value of the fishes that marbled murrelets commonly consume. For example, a single northern anchovy has nearly six times the energetic value of a sand lance of the same size (Gutowsky et al. 2009, p. 251), so a marbled murrelet would have to eat six sand lance to get the equivalent energy of a single anchovy. Reductions in the abundance of energy-rich forage fish species is likely a contributing factor in the poor reproduction in marbled murrelets (Becker and Beissinger 2006, p. 470).

The duration of dives appears to depend upon age (adults vs. juveniles), water depth, visibility, and depth and availability of prey. Dive duration has been observed ranging from 8 seconds to 115 seconds, although most dives are between 25 to 45 seconds (Day and Nigro 2000; Jodice and Collopy 1999; Thoresen 1989; Watanuki and Burger 1999). Diving bouts last over a period of 27 to 33 minutes (Nelson 1997, p. 9). They forage in deeper waters when upwelling, tidal rips, and daily activity of prey concentrate prey near the surface (Strachan et al. 1995). Marbled murrelets are highly mobile, and some make substantial changes in their foraging sites within the breeding season. For example, Becker and Beissinger (2003, p. 243) found that marbled murrelets in California responded rapidly (within days or weeks) to small-scale variability in upwelling intensity and prey availability by shifting their foraging behavior and habitat selection within a 100-km (62-mile) area. In Washington, changes in water temperature, likely also related to prey availability, influence foraging habitat use, but the influence of upwelling is less clear (Lorenz et al. 2017, pp. 315, 318).

For more information on marbled murrelet use of marine habitats, see literature reviews in McShane et al. 2004, USFWS 2009, and USFWS 2019.

Marbled Murrelets in the Terrestrial Environment

Marbled murrelets are dependent upon older-age forests, or forests with an older tree component, for nesting habitat (Hamer and Nelson 1995, p. 69). Specifically, marbled murrelets prefer high and broad platforms for landing and take-off, and surfaces which will support a nest cup (Hamer and Nelson 1995, pp. 78-79). In Washington, marbled murrelet nests have been found in live conifers, specifically, western hemlock (*Tsuga heterophylla*), Sitka spruce (*Picea sitchensis*), Douglas-fir (*Pseudotsuga menziesii*), and western red cedar (*Thuja plicata*) (Hamer and Nelson 1995; Hamer and Meekins 1999). Most marbled murrelets appear to nest within 37 miles of the coast, although occupied behaviors have been recorded up to 52 miles inland, and marbled murrelet presence has been detected up to 70 miles inland in Washington (Huff et al. 2006, p. 10). Nests occur primarily in large, older-aged trees. Overall, nests have been found in trees greater than 19 inches in diameter-at-breast and greater than 98 ft tall. Nesting platforms include limbs or other branch deformities that are greater than 4 inches in diameter and are at greater than 33 ft above the ground. Substrate such as moss or needles on the nest platform is important for protecting the egg and preventing it from falling off (Huff et al. 2006, p. 13).

Marbled murrelets do not form the dense colonies that are typical of most other seabird species. Limited evidence suggests they may form loose colonies in some cases (Ralph et al. 1995). The reliance of marbled murrelets on cryptic coloration to avoid detection suggests they utilize a wide spacing of nests in order to prevent predators from forming a search image (Ralph et al.

1995). Individual marbled murrelets are suspected to have fidelity to nest sites or nesting areas, although this is has only been confirmed with marked birds in a few cases (Huff et al. 2006, p. 11). There are at least 15 records of marbled murrelets using nest sites in the same or adjacent trees in successive years, but it is not clear if they were used by the same birds (McShane et al. 2004, p. 2-14). At the landscape scale, marbled murrelets are probably faithful to specific watersheds for nesting (McShane et al. 2004, p. 2-14). Marbled murrelets have been observed visiting nesting habitat during non-breeding periods in Washington, Oregon, and California which may indicate adults are maintaining fidelity and familiarity with nesting sites and/or stands (Naslund 1993; O'Donnell et al. 1995, p. 125).

Loss of nesting habitat reduces nest site availability and displaces any marbled murrelets that may have had nesting fidelity to the logged area (Raphael et al. 2002, p. 232). Marbled murrelets have demonstrated fidelity to nesting stands and in some areas, fidelity to individual nest trees (Burger et al. 2009, p. 217). Marbled murrelets returning to recently logged areas may not breed for several years or until they have found suitable nesting habitat elsewhere (Raphael et al. 2002, p. 232). The potential effects of displacement due to habitat loss include nest site abandonment, delayed breeding, failure to initiate breeding in subsequent years, and failed breeding due to increased predation risk at a marginal nesting location (Divoky and Horton 1995, p. 83; Raphael et al. 2002, p. 232). Each of these outcomes has the potential to reduce the nesting success for individual breeding pairs, and could ultimately result in the reduced recruitment of juvenile birds into the local population (Raphael et al. 2002, pp. 231-233).

Detailed information regarding the life history and conservation needs of the marbled murrelet are presented in the *Ecology and Conservation of the Marbled murrelet* (Ralph et al. 1995), the Service's 1997 *Recovery Plan for the Marbled murrelet* (USFWS 1997), and in subsequent 5-year status reviews (McShane et al. 2004; USFWS 2009; USFWS 2019).

Terrestrial Distribution

Marbled murrelets are distributed along the Pacific coast of North America, with birds breeding from central California through Oregon, Washington, British Columbia, southern Alaska, westward through the Aleutian Island chain, with presumed breeding as far north as Bristol Bay (Nelson 1997, p. 2), and non-breeding distribution extending as far south as the Southern California Bight (Hall et al. 2009, p. 5081). The federally listed marbled murrelet population in Washington, Oregon, and California is classified by the Service as a distinct population segment (75 FR 3424). The coterminous United States population of marbled murrelets is considered significant as the loss of this distinct population segment would result in a significant gap in the range of the taxon and the loss of unique genetic characteristics that are significant to the taxon (75 FR 3430).

The inland nesting distribution of marbled murrelets is strongly associated with the presence of mature and old-growth conifer forests. Marbled murrelets have been detected farther than100 km inland in Washington (70 miles).The inland distribution in the southern portion of the species range is associated with the extent of the hemlock/tanoak vegetation zone which occurs up to 16-51 km inland (10-32 miles) (Evans Mack et al. 2003, p. 4). Although marbled murrelets are distributed throughout their historical range, the area of occupancy within their historic range appears to be reduced from historic levels. The distribution of the species also exhibits five areas of discontinuity: a segment of the border region between British Columbia, Canada and

Washington; southern Puget Sound, WA; Destruction Island, WA to Tillamook Head, OR; Humboldt County, CA to Half Moon Bay, CA; and the entire southern end of the breeding range in the vicinity of Santa Cruz and Monterey Counties, CA (McShane et al. 2004, p. 3-70).

Marbled murrelets use inland habitats primarily for nesting, including egg laying, incubation, and feeding of nestlings. In addition, marbled murrelets have been observed in nesting habitat demonstrating social behaviors, such as circling and vocalizing, in groups of up to ten birds (Nelson and Peck 1995, p. 51). Nest sites tend to be clustered spatially, indicating that although marbled murrelets are not colonial seabirds, they also are not strictly solitary in their nesting behavior; in other words, at least in some circumstances, they nest semi-colonially (Conroy et al. 2002, p. 131; Naslund et al. 1995, p. 12). In California and southern Oregon, marbled murrelets occupy habitat more frequently when there is other occupied habitat within 5 km (Meyer et al. 2002, p. 103), and we assume that the same is true in Washington. Usually, multiple nests can be found in a contiguous forested area, even in places where they are not strongly clustered (Evans Mack et al. 2003, p. 6). In Oregon, marbled murrelets were ten times more likely to nest in previously unoccupied nesting habitat where recordings of marbled murrelet calls had been broadcast the previous year than in control sites where no recordings were played, indicating that marbled murrelets select nesting habitat in part based on the apparent presence of conspecifics (Valente et al. 2021, p. 50).

Distribution of Nesting Habitat

The loss of nesting habitat was a major cause of the marbled murrelet's decline over the past century and may still be contributing as nesting habitat continues to be lost to fires, logging, insects, tree diseases, and wind storms (Miller et al. 2012, p. 778; Raphael et al. 2016b, pp. 80-81). Due mostly to historical timber harvest, only a small percentage (~11 percent) of the habitat-capable lands within the listed range of the marbled murrelet currently contain potential nesting habitat (Raphael et al. 2016b, p. 69).

Monitoring of marbled murrelet nesting habitat within the Northwest Forest Plan (NWFP, equivalent to Conservation Zones 1 through 5) area indicates nesting habitat declined from an estimated 2.53 million acres in 1993 to an estimated 2.23 million acres in 2012, a decline of about 12.1 percent (Raphael et al. 2016b, p. 72). Fire has been the major cause of nesting habitat loss on Federal lands, while timber harvest is the primary cause of loss on non-Federal lands (Raphael et al. 2016b, p. 79). While most (60 percent) of the potential habitat is located on Federal reserved-land allocations, a substantial amount of nesting habitat occurs on non-federal lands (34 percent) (Table 1).

In Zone 6, monitoring of nesting habitat has not been carried out in the same way as within the NWFP area. Most of the existing nesting habitat within Zone 6 is located on state and local public lands, where logging has not occurred (Halbert and Singer 2017, p. 1). During August of 2020, over 60 percent of the nesting habitat in Zone 6 burned in a large wildfire (Singer 2021, in litt.). Preliminary data indicate that this fire has resulted in substantial habitat loss, though some lost habitat features may recover over the next several years. Many trees within the burned areas survived the fire, including the "Father of the Forest" redwood where marbled murrelet nesting has been documented repeatedly (California Department of Parks and Recreation 2020, p. 2; Halbert and Singer 2017, p. 35); however, suitable platforms likely burned even in trees that survived the fire, leading to a loss of suitability for many years as branches regrow (Singer 2020, in litt.). In a sample of 40 previously identified potential nest trees within Big Basin State Park, 22 trees (55 percent) appeared to have survived the fire (Singer 2021, in litt.). If this sample is representative, more than one quarter (i.e. 45 percent x 60 percent) of potential marbled murrelet nest trees in Zone 6 may have been killed by the fire, with platform structures lost from a substantial percentage of the remaining trees. Future monitoring will be necessary to refine these estimates of habitat loss.

Table 1. Estimates of higher-quality marbled murrelet nesting habitat by State and major land ownership within the area of the NWFP – derived from 2012 data.

State	Habitat capable lands (1,000s of acres)	Habitat on Federal reserved lands (1,000s of acres)	Habitat on Federal non-reserved lands (1,000s of acres)	Habitat on non-federal lands (1,000s of acres)	Total potential nesting habitat (all lands) (1,000s of acres)	Percent of habitat capable land that is currently in habitat
WA	10,851.1	822.4	64.7	456	1,343.1	12 %
OR	6,610.4	484.5	69.2	221.1	774.8	12 %
CA	3,250.1	24.5	1.5	82.9	108.9	3 %
Totals	20,711.6	1,331.4	135.4	760	2,226.8	11 %
Percent		60 %	6 %	34 %	100 %	-

Source: (Raphael et al. 2016b, pp. 78-81).

Population Status

The 1997 *Recovery Plan for the Marbled murrelet* (USFWS 1997) identified six Conservation Zones throughout the listed range of the species: Puget Sound (Conservation Zone 1), Western Washington Coast Range (Conservation Zone 2), Oregon Coast Range (Conservation Zone 3), Siskiyou Coast Range (Conservation Zone 4), Mendocino (Conservation Zone 5), and Santa Cruz Mountains (Conservation Zone 6) (Figure 3). Conservation Zones are the functional equivalent of recovery units as defined by Service policy (USFWS 1997, p. 115). The subpopulations in each Zone are not discrete. There is some movement of marbled murrelets between Zones, as indicated by radio-telemetry studies (e.g., Bloxton and Raphael 2006, p. 162), but the degree to which marbled murrelets migrate between Zones is unknown. Genetic studies also indicate that there is movement of marbled murrelets between Zones, although Zone 6 is more isolated genetically than the other Zones (Friesen et al. 2005, pp. 611-612; Hall et al. 2009, p. 5080; Peery et al. 2008b, pp. 2757-2758; Peery et al. 2010, p. 703; Vásquez-Carrillo et al. 2014, pp. 251-252). For the purposes of consultation, the Service treats each of the Conservation Zones as separate sub-populations of the listed marbled murrelet population.

Population Status and Trends

Population estimates for the marbled murrelet are derived from marine surveys conducted during the nesting season as part of the NWFP effectiveness monitoring program. Surveys from 2001 to 2018 indicated that the marbled murrelet population in Conservation Zones 1 through 5 (NWFP area) increased at a rate of 0.5 percent per year (McIver et al. 2021, p. 4). While the trend estimate across this period is slightly positive, the confidence intervals are tight around zero

(95% confidence interval [CI]: -0.5 to 1.5 percent), indicating that at the scale of the NWFP area, the population is changing very little (McIver et al. 2021, p. 4) (Table 2). At the state scale, Washington exhibited a significant declining trend between 2001 and 2018 (3.9% decrease per year, while Oregon and California showed significant positive trends (OR = 2.2% increase per year; CA = 4.6% increase per year (McIver et al. 2021, p. 4) (Table 2). Zone 1 shows the greatest decline of 5.0 percent per year, while the decline in Zone 2 is smaller, 2.2 percent per year, and less statistically certain (Table 2). Zone 4 shows the greatest increase of 3.5 percent per year, while Zone 3 shows a smaller, and less statistically certain, increase of 1.5 percent per year (Table 2). There is great uncertainty regarding the trend in Zone 5 due to the infrequency of surveys in that zone and the influence of a single anomalous year in 2017 (McIver et al., in press, p. 37). No trend estimate is available for Zone 6.

While the direct causes for population declines in Washington are unknown, potential factors include the loss of nesting habitat, including cumulative and time-lag effects of habitat losses over the past 20 years (an individual marbled murrelets potential lifespan), changes in the marine environment reducing the availability or quality of prey, increased densities of nest predators, and emigration (Miller et al. 2012, p. 778). As with nesting habitat loss, marine habitat degradation is most prevalent in the Puget Sound area, where anthropogenic activities (e.g., shipping lanes, boat traffic, shoreline development) are an important factor influencing the marine distribution and abundance of marbled murrelets in Conservation Zone 1 (Falxa and Raphael 2016, p. 110).

The most recent population estimate for the entire Northwest Forest Plan area in 2019 was 21,200 marbled murrelets (95 percent confidence interval [CI]: 16,400 to 26,000 birds) (McIver et. al 2021, p. 10). The largest and most stable marbled murrelet subpopulations now occur off the Oregon and northern California coasts, while subpopulations in Washington have experienced the greatest rates of decline. Marbled murrelet zones are now surveyed on an every other-year basis, so the last year that an extrapolated range-wide estimate for all zones combined is 2018 (Table 2).

The marbled murrelet subpopulation in Conservation Zone 6 (central California- Santa Cruz Mountains) is outside of the NWFP area and is monitored separately by California State Parks and the U.S. Geological Survey using similar at-sea survey methods (Felis et al. 2020, p. 1). Surveys in Zone 6 indicate a small population of marbled murrelets with no clear trends. Population estimates from 2001 to 2018 have fluctuated from a high of 699 marbled murrelets in 2003, to a low of 174 marbled murrelets in 2008 (Felis et al. 2020 p. 7). In 2019, surveys indicated an estimated population of 404 marbled murrelets in Zone 6 (95% CI: 272-601) (Felis et al. 2020, p. 7) (Table 3).

Table 2. Summary of marbled murrelet population estimates and trends (2001-2019/2020) at the scale of Conservation Zones and states.

Zone	Year	Estimated number of marbled murrelets	95% CI Lower	95% CI Upper	Average density (at sea) (marbled murrelets /km²)	Average annual rate of population change (%)	95% CI Lower	95% CI Upper
1	2020	3,143	2,030	4,585	0.899	-5.0	-7.0	-2.9
2	2019	1,657	745	2,752	1.004	-2.2	-5.7	+1.5
3	2020	8,359	5,569	11,323	5.239	+1.5	+0.02	+3.1
4	2019	6,822	5,576	11,063	5.885	+3.5	+1.6	+5.5
5	2017	868	457	1,768	0.983	+7.2	-4.4	+20.3
Zones 1-5	2019	21,230	16,446	26,015	2.417	+0.5	-0.5	+1.5
Zone 6	2019	404	272	601	na	na	na	na
WA	2019	5,151	2,958	7,344	1.00	-3.9	-5.4	-2.4
OR	2019	10,339	7,070	13,607	4.99	+2.2	+0.9	+3.4
CA Zones 4 & 5	2019	5,741	3,894	7,588	3.67	+4.6	+2.7	+6.5

Sources: (McIver et al. 2021, pp. 16-20, Felis et al. 2020, p. 7).

Factors Influencing Population Trends

Population monitoring data show marbled murrelet populations declining in Washington but increasing in Oregon and northern California (McIver et al. 2021, p. 4). Marbled murrelet population size and distribution is strongly and positively correlated with the amount and pattern (large contiguous patches) of suitable nesting habitat, and population trend is most strongly correlated with trend in nesting habitat, although marine factors also contribute to this trend (Raphael et al. 2016a, p. 115). From 1993 to 2012, there was a net loss of about 2 percent of potential nesting habitat from on federal lands, compared to a net loss of about 27 percent on nonfederal lands, for a total cumulative net loss of about 12.1 percent across the NWFP area (Raphael et al. 2016b, p. 72). Cumulative habitat losses since 1993 have been greatest in Washington, with most habitat loss in Washington occurring on non-Federal lands due to timber harvest (Raphael et al. 2016b, pp. 80-81) (Table 3).

Table 3. Distribution of higher-suitability marbled murrelet nesting habitat by Conservation Zone, and summary of net habitat changes from 1993 to 2012 within the NWFP area.

Conservation Zone	1993	2012	Change (acres)	Change (percent)
Zone 1 - Puget Sound/Strait of Juan de Fuca	829,525	739,407	-90,118	-10.9 %
Zone 2 - Washington Coast	719,414	603,777	-115,638	-16.1 %
Zone 3 - Northern to central Oregon	662,767	610,583	-52,184	-7.9 %
Zone 4 - Southern Oregon - northern California	309,072	256,636	-52,436	-17 %
Zone 5 - north-central California	14,060	16,479	+2,419	+17.2 %

Source: (Raphael et al. 2016b, pp. 80-81).

The decline in marbled murrelet populations from 2001 to 2013 is weakly correlated with the decline in nesting habitat, with the greatest declines in Washington, and the smallest declines in California, indicating that when nesting habitat decreases, marbled murrelet abundance in adjacent marine waters may also decrease. At the scale of Conservation Zones, the strongest correlation between habitat loss and marbled murrelet decline is in Zone 2, where marbled murrelet habitat has declined most steeply, and marbled murrelet populations have also continued to decline. However, these relationships are not linear, and there is much unexplained variation (Raphael et al. 2016a, p. 110). While terrestrial habitat amount and configuration (i.e., fragmentation) and the terrestrial human footprint (i.e., cities, roads, development) appear to be strong factors influencing marbled murrelet distribution in Zones 2-5; terrestrial habitat and the marine human footprint (i.e., shipping lanes, boat traffic, shoreline development) appear to be the most important factors that influence the marine distribution and abundance of marbled murrelets in Zone 1 (Raphael et al. 2016a, p. 106).

Like other marine birds, marbled murrelets depend for their survival on their ability to successfully forage in the marine environment. Despite this, it is apparent that the location, amount, and landscape pattern of terrestrial nesting habitat are strongest predictors of the spatial and temporal distributions of marbled murrelets at sea during the nesting season (Raphael et al. 2015, p. 20). Outside of Zone 1, various marine habitat features (e.g., shoreline type, depth, temperature, human footprint, etc.) apparently have only a minor influence on marbled murrelet distribution at sea. Despite this relatively weak spatial relationship, marine factors, and especially any decrease in forage species, likely play an important role in explaining the apparent population declines, but the ability to detect or model these relationships is currently limited (Raphael et al. 2015, p. 20). Over both the long and short term, there is evidence that diet quality is related to marbled murrelet abundance, the likelihood of nesting attempts, reproductive success (Becker et al. 2007, p. 276; Betts et al. 2020, pp. 6-7; Norris et al. 2007, p. 881).

The interplay between marine and terrestrial habitat conditions also influences marbled murrelet population dynamics. A recent analysis indicates that in Oregon, over a 20-year period, nesting activity was most likely to occur following years with cool ocean temperatures (indicating good forage availability), and at sites where large blocks of mature forest were close to the coast (Betts et al. 2020, pp. 5-9). Even when ocean conditions were poor, nesting marbled murrelets colonized new sites that were surrounded by abundant old forest, but during good ocean conditions, even sites with less old forest could be colonized (Betts et al. 2020, p. 6). This relationship has not been investigated in other parts of the range, but is consistent with observations in Washington, where marbled murrelets occupy nesting habitat at lower rates, often fly long distances to reach foraging areas, breed at very low observed rates, and the population continues to decline (Lorenz et al. 2017, pp. 312-313, 318; McIver et al. 2021, p. 20).

Population Models

Prior to the use of survey data to estimate trend, demographic models were more heavily relied upon to generate predictions of trends and extinction probabilities for the marbled murrelet population (Beissinger 1995; Cam et al. 2003; McShane et al. 2004; USFWS 1997). However, marbled murrelet population models remain useful because they provide insights into the demographic parameters and environmental factors that govern population stability and future extinction risk, including stochastic factors that may alter survival, reproductive, and immigration/emigration rates.

In a report developed for the *5-year Status Review of the Marbled murrelet in Washington, Oregon, and California* (McShane et al. 2004, pp. 3-27 to 3-60), models were used to forecast 40-year marbled murrelet population trends. A series of female-only, multi-aged, discrete-time stochastic Leslie Matrix population models were developed for each conservation zone to forecast decadal population trends over a 40-year period with extinction probabilities beyond 40 years (to 2100). The authors incorporated available demographic parameters (Table 4) for each conservation zone to describe population trends and evaluate extinction probabilities (McShane et al. 2004,
p. 3-49).

McShane et al. (2004) used mark-recapture studies conducted in British Columbia by Cam et al. (2003) and Bradley et al. (2004) to estimate annual adult survival and telemetry studies or at-sea survey data to estimate fecundity. Model outputs predicted -3.1 to -4.6 percent mean annual rates of population change (decline) per decade the first 20 years of model simulations in marbled murrelet Conservation Zones 1 through 5 (McShane et al. 2004, p. 3-52). Simulations for all zone populations predicted declines during the 20 to 40-year forecast, with mean annual rates of -2.1 to -6.2 percent, depending on Zone and decade (McShane et al. 2004, p. 3-52). While these modeled rates of decline are similar to those observed in Washington (McIver et al. 2021, p. 20), the simulated projections at the scale of Zones 1-5 do not match the apparently increasing populations observed in Oregon and California during the 2001-2019 monitoring period. Comparable trend information is not available for Zone 6 in central California.

Table 4. Rangewide marbled murrelet demographic parameter values based on four studies all using Leslie Matrix models.

Demographic Parameter	Beissinger 1995	Beissinger and Nur 1997*	Beissinger and Peery (2007)	McShane et al. 2004
Juvenile Ratio (R)	0.10367	0.124 or 0.131	0.089	0.02 - 0.09
Annual Fecundity	0.11848	0.124 or 0.131	0.06-0.12	-
Nest Success	-	-	0.16-0.43	0.38 - 0.54
Maturation	3	3	3	2 - 5

Estimated Adult Survivorship	85 % – 90%	85 % – 88 %	82 % - 90 %	83 % – 92 %

*In U.S. Fish and Wildlife (1997).

Reproduction

Overall fecundity is a product of the proportion of marbled murrelets that attempt nesting and the proportion of nest attempts that succeed. Telemetry studies can be used to estimate both the proportion of marbled murrelets attempting nesting, and the proportion of nest attempts that succeed. When telemetry estimates are not available, at-sea surveys that separately count the number of hatch-year and after-hatch-year birds can be used to estimate productivity. Telemetry estimates are typically preferred over marine counts for estimating breeding success due to fewer biases (McShane et al. 2004, p. 3-2). However, because of the challenges of conducting telemetry studies, estimating marbled murrelet reproductive rates with an index of reproduction, referred to as the juvenile ratio ($\hat{R}$),[1] continues to be important, despite some debate over use of this index (see discussion in Beissinger and Peery 2007, p. 296).

Marbled murrelet fecundity is likely limited in part by low rates of nesting attempts in some parts of the range. Radio-telemetry monitoring Washington between 2004 and 2008 indicated only a small portion of 158 tagged adult birds actually attempted to nest (13 to 20 percent) (Lorenz et al. 2017, p. 316; Raphael and Bloxton 2009, p. 165). Studies from California and Oregon also report low rates. Two studies from central and northern California reported that an average of around 30 percent of radio-tagged marbled murrelets attempted to nest (Hébert and Golightly 2006, p. 130; Peery et al. 2004, p. 1093). In preliminary results from a study in Oregon, only 11 out of 203 marbled murrelets (5 percent) tagged between 2017 and 2019, attempted to nest (Adrean 2021, pers. comm.). This represents the lowest rate yet reported for the species; however, the study is not yet complete and is therefore not fully comparable to the others cited above. These low rates of nesting are not intrinsic to the species; other studies outside of the listed range reported that between 46 and 80 percent of marbled murrelets attempted to breed each year (Barbaree et al. 2014, p. 177; Bradley et al. 2004, p. 323), and most population modeling studies suggest a range of 80 to 95 percent of adults breed each year (McShane et al. 2004, p. 3-5). The process of radio-tagging or the additional weight and drag of the radio tag itself may reduce the probability that a tagged individual will attempt to breed, but studies reporting higher rates of attempted nesting used similar radio tags, so radio-telemetry methods do not account for differences between the studies conducted in the listed range and those conducted elsewhere (Peery et al. 2004, p. 1094).

Although difficult to obtain, nest success rates[2] are available from telemetry studies conducted in California (Hébert and Golightly 2006; Peery et al. 2004, p. 1094), Washington (Lorenz et al. 2017, p. 312; Lorenz et al. 2019, p. 160), and, preliminarily, in Oregon (Adrean et al. 2019, p. 2). In northwestern Washington, Lorenz and others (2017, p. 312; 2019, pp. 159-160) documented a nest success rate of 0.20 (3 chicks fledging from 15 nest starts). In central California, marbled

[1] The juvenile ratio ($\hat{R}$) for marbled murrelets is derived from the relative abundance of hatch-year (HY; 0-1 yr-old) to after-hatch-year (AHY; 1+ yr-old) birds (Beissinger and Peery 2007, p. 297) and is calculated from marine survey data. All ratios presented here are date-corrected using the methods of Peery et al. (2007, p. 234) to account adults incubating and chicks not yet fledged at the time of the survey.

[2] Nest success here is defined by the annual number of known hatchlings departing from the nest (fledging) divided by the number of nest starts.

murrelet nest success is 0.16 (Peery et al. 2004, p. 1098) and in northern California it ranges from 0.069 to 0.243 (Hébert and Golightly 2006, p. 129). In Oregon, preliminary results from a telemetry study indicate that 3 of 7 active nests successfully fledged young, a rate of 0.43, but this success rate may not be comparable to the others reported above; for example, it is not clear whether it includes all nesting attempts (Adrean et al. 2019, p. 2).

At least one telemetry study reported overall fecundity rates, combining both the rates of nesting attempts with the rates of fledging success. In central California, the fecundity rate was estimated to be 0.027, or 2.7 female chicks produced per year for every 100 females of breeding age (Peery et al. 2004, p. 1094). In other studies, the overall fecundity rate is not known, because it is not clear how many of the radio-tagged birds were of breeding age. However, in northern California, of 102 radio-tagged birds, at least two and at most six successfully produced fledglings (Hébert and Golightly 2006, pp. 130-131), and in Washington and southern Vancouver Island, of 157 radio-tagged birds, four produced fledglings (Lorenz et al. 2017, p. 312). If we assume (as in Peery et al. 2004, p. 1094) that 93 percent of captured birds in each sample were of breeding age, and that half of all captured birds and half of all fledged chicks were female, fecundity rates from these samples would be 0.027 in Washington, and between 0.021 and 0.063 in northern California.

Unadjusted and adjusted values for estimates of marbled murrelet juvenile ratios also suggest low reproductive rates. In northern California and Oregon, annual estimates for Ŕ range from 0 to 0.140, depending on the area surveyed (Strong 2014, p. 20; Strong 2015, p. 6; Strong 2016, p. 7; Strong 2017, p. 6; Strong 2018, p. 7; Strong 2019, p. 6; Strong and Falxa 2012, p. 4). In Conservation Zone 4, the annual average between 2000 and 2011 was 0.046 (Strong and Falxa 2012, p. 11). In central California, estimates of Ŕ range from 0 to 0.12, with an annual average of 0.048, over 21 years of survey between 1996 and 2019 (Felis et al. 2020, p. 9). An independent calculation of Ŕ among marbled murrelets captured in central California between 1999 and 2003 resulted in estimates ranging from 0 to 0.111, with an average of 0.037 (Peery et al. 2007, p. 235). Estimates for Ŕ in the San Juan Islands in Washington tend to be higher, ranging from 0.02 to 0.12, with an average of 0.067, over 18 years of survey between 1995 and 2012 (Lorenz and Raphael 2018, pp. 206, 211). Notably, Ŕ in the San Juan Islands did not show any temporal trend over the 18-year period, even while the abundance of adult and subadult marbled murrelets declined (Lorenz and Raphael 2018, pp. 210-211).

Although these estimates of Ŕ are higher than one would expect based on fecundity rates derived from radio-telemetry studies, they are below the level thought to be necessary to maintain or increase the marbled murrelet population. Demographic modeling, historical records, and comparisons with similar species all suggest that marbled murrelet population stability requires juvenile ratios between 0.176 and 0.3 (Beissinger and Peery 2007, p. 302; USFWS 1997, p. B-13). Even the lower end of this range is higher than any current estimate for Ŕ for any of the Conservation Zones. This indicates that the marbled murrelet reproductive rate is likely insufficient to maintain stable population numbers throughout all or portions of the species' listed range. These sustained low reproductive rates appear to be at odds with the potentially stable population size measured for Zones 1 through 5 and are especially confusing in light of apparent population increases in Oregon and California. However, the populations of birds that breed in each zone (which, by all measures of productivity, we would expect to be shrinking throughout the range) is not necessarily the same thing as the numbers of birds at sea. This issue is discussed further in the section below.

Integration and Summary: Marbled murrelet Abundance, Distribution, Trend, and Reproduction

A statistically significant decline was detected in Conservation Zones 1 and 2 for the 2001-2019 period (Table 2). The overall population trend from the combined 2001-2019 population estimates (Conservation Zones 1 - 5) indicates a potentially stable population with a 0.5 percent increase per year (McIver et al. 2021, p. 4). Because the confidence intervals for this estimate are fairly tight around 0, there is not clear evidence of either or a positive or negative trend. At the state-scale, significant declines have occurred in Washington, while subpopulations in Oregon and California show a statistically meaningful increase (McIver et al. 2021, p. 4).

The current ranges of estimates for fecundity and for $\dot{R}$, the juvenile to adult ratio, are below the level assumed to be necessary to maintain or increase the marbled murrelet population. Whether derived from radio-telemetry, marine surveys or from population modeling ($\dot{R}$ = 0.02 to 0.13, Table 4), the available information is in general agreement that the current ratio of hatch-year birds to after-hatch year birds is insufficient to maintain stable numbers of marbled murrelets throughout the listed range. The current estimates for $\dot{R}$ also appear to be well below what may have occurred prior to the marbled murrelet population decline (Beissinger and Peery 2007, p. 298).

The reported stability of the population at the larger scale (Zones 1 through 5) and growth of subpopulations in Oregon and California appear to be at odds with the sustained low reproductive rates reported throughout the listed range. A number of factors could contribute to this discrepancy. For example, population increases could be caused by an influx of marbled murrelets moving from the Canadian population into Oregon and California, or into Washington and displacing Washington birds to Oregon and California. The possibility of a population shift from Washington to Canada has previously been dismissed, based on nest-site fidelity and the fact that both Washington and British Columbia populations are declining simultaneously (Falxa et al. 2016, p. 30), but these arguments do not rule out the possibility that non-breeding marbled murrelets originating in Canada may be spending time foraging in Oregon or California waters.

Another possibility is the proportion of birds present on the water during surveys, rather than inland at nest sites, may be increasing. If so, this would artificially inflate population estimates. Such a shift could be driven by low nesting rates, as were observed in Oregon in 2017 (Adrean et al. 2018, p. 2; Horton et al. 2017, p. 77); or by shifts toward earlier breeding, for which there is anecdotal evidence (for example, Havron 2012, p. 4; Pearson 2018, in litt.; Strong 2019, p. 6); or a combination of both factors. In either case, individuals that would in earlier years have been incubating an egg or flying inland to feed young, and therefore unavailable to be counted, would now be present at sea and would be observed during surveys. For the same number of birds in the population, the population estimate would increase as adults spend more of the survey period at sea.

Finally, the shift that occurred in 2015 to sampling only half of the Conservation Zones in each survey year (McIver et al. 2021, pp. 5-6) is increasing the uncertainty in how to interpret the survey results, especially in light of large-scale movements that can occur during the breeding season, sometimes involving numerous individuals (Horton et al. 2018, p. 77; Peery et al. 2008a, p. 116). Marbled murrelets that move into or out of the zone being sampled during the breeding season could artificially inflate or deflate the population estimates. Even interannual movements among the Zones could temporarily resemble population growth, without an actual increase in the number of birds in the population (McIver et al., in press, pp. 14, 43).

Some of these factors would also affect measures of fecundity and juvenile ratios. For example, if marbled murrelets are breeding earlier on average, then the date adjustments applied to juvenile ratios may be incorrect, possibly resulting in inflated estimates of $\dot{R}$. If current estimates of $\dot{R}$ are biased high, this would mean that the true estimates of $\dot{R}$ are even lower, exacerbating, rather than explaining, the discrepancy between the apparently sustained low reproductive rates and the apparently stable or increasing subpopulations south of Washington. A shift toward later breeding could result in more adults being present at sea during surveys, and would also result in artificially low estimates of $\dot{R}$. We are not aware of evidence for a widespread shift toward later breeding, but this kind of alteration in seasonal behavior may be more difficult to detect than a shift to earlier breeding. Early-fledging juveniles are conspicuous when observed at sea, whereas late-fledging juveniles are not.

Considering the best available data on abundance, distribution, population trend, and the low reproductive success of the species, the Service concludes the marbled murrelet population within the Washington portion of its listed range currently has little or no capability to self-regulate, as indicated by the significant, annual decline in abundance the species is currently undergoing in Conservation Zones 1 and 2. Populations in Oregon and California are apparently more stable, but reproductive rates remain low in those areas, and threats associated with habitat loss and habitat fragmentation continue to occur. The Service expects the species to continue to exhibit further reductions in distribution and abundance , due largely to the expectation that the variety of environmental stressors present in the marine and terrestrial environments (discussed in the *Threats to Marbled murrelet Survival and Recovery* section) will continue into the foreseeable future.

Threats to Marbled murrelet Survival and Recovery

When the marbled murrelet was listed under the Endangered Species Act in 1992, several anthropogenic threats were identified as having caused the dramatic decline in the species:

- Habitat destruction and modification in the terrestrial environment from timber harvest and human development caused a severe reduction in the amount of nesting habitat.
- Unnaturally high levels of predation resulting from forest "edge effects".
- The existing regulatory mechanisms, such as land management plans (in 1992), were considered inadequate to ensure protection of the remaining nesting habitat and reestablishment of future nesting habitat.
- Manmade factors such as mortality from oil spills and entanglement in fishing nets used in gill-net fisheries.

The regulatory mechanisms implemented since 1992 that affect land management in Washington, Oregon, and California (for example, the NWFP) and new gill-netting regulations in northern California and Washington have reduced the threats to marbled murrelets (USFWS 2004, pp. 11-12). However, additional threats were identified, and more information was compiled regarding existing threats, in the Service's 5-year reviews for the marbled murrelet compiled in 2009 and 2019 (USFWS 2009, pp. 27-67; USFWS 2019, pp. 19-65). These stressors are related to environmental factors affecting marbled murrelets in the marine and terrestrial environments. These stressors include:

- Habitat destruction, modification, or curtailment of the marine environmental conditions necessary to support marbled murrelets due to:
  - Elevated levels of toxic contaminants, including polychlorinated biphenyls, polybrominated diphenyl ether, polycyclic aromatic hydrocarbons, and organochlorine pesticides, in marbled murrelet prey species.
  - The presence of microplastics in marbled murrelet prey species.
  - Changes in prey abundance and availability.
  - Changes in prey quality.
  - Harmful algal blooms that produce biotoxins leading to domoic acid and paralytic shellfish poisoning that have caused marbled murrelet mortality.
  - Harmful algal blooms that produce a proteinaceous foam that has fouled the feathers of other alcid species and affected areas of marbled murrelet marine habitat.
  - Hypoxic or anoxic events in marbled murrelet marine habitat.
  - Climate change in the Pacific Northwest.
- Manmade factors that affect the continued existence of the species include:
  - Derelict fishing gear leading to mortality from entanglement.
  - Disturbance in the marine environment (from exposures to lethal and sub-lethal levels of high underwater sound pressures caused by pile-driving, underwater detonations, and potential disturbance from high vessel traffic).
  - Wind energy generation, currently limited to onshore projects, leading to mortality from collisions.

Since the time of listing, some marbled murrelet subpopulations have continued to decline due to lack of successful reproduction and recruitment, and while other subpopulations appear to be stable or increasing, productivity in these populations remains lower than the levels likely to support sustained population stability. The marbled murrelet Recovery Implementation Team identified five major mechanisms that appear to be contributing to poor demographic performance (USFWS 2012b, pp. 10-11):

- Ongoing and historic loss of nesting habitat.
- Predation on marbled murrelet eggs and chicks in their nests.
- Changes in marine conditions, affecting the abundance, distribution, and quality of marbled murrelet prey species.
- Post-fledging mortality (predation, gillnets, oil-spills).
- Cumulative and interactive effects of factors on individuals and populations.

Climate Change

In the Pacific Northwest, climate change affects both the marine and forested environments on which marbled murrelets depend. Changes in the terrestrial environment may have a direct effect on marbled murrelet reproduction, and also affect the structure and availability of nesting habitat. Changes in the marine environment affect marbled murrelet food resources. Changes in either location may affect the likelihood, success, and timing of marbled murrelet breeding in any given year.

Changes in the Physical Environment

Projected changes to the climate within the range of the marbled murrelet include air and sea surface temperature increases, changes in precipitation seasonality, and increases in the frequency and intensity of extreme rainfall events (Mauger et al. 2015, pp. 2-1 – 2-18; Mote and Salathé 2010, p. 29; Salathé et al. 2010, pp. 72-73). Air temperature warming is already underway, and is expected to continue, with the mid-21st century projected to be approximately four to six degrees Fahrenheit (°F) (2.2 to 3.3 degrees Celsius [°C]) warmer than the late 20th century (Mauger et al. 2015, p. 2-5; USGCRP 2017, pp. 196-197). Similarly, sea surface temperatures are already rising and the warming is expected to continue, with increases between 2.2 °F (1.2 °C) and 5.4 °F (3 °C) projected for Puget Sound, the Strait of Georgia, and the Pacific Coast between the late 20th century and mid-or late-21st century (Mote and Salathé 2010, p. 16; Riche et al. 2014, p. 41; USGCRP 2017, p. 368). Summer precipitation is expected to decrease, while winter precipitation is expected to increase (Mauger et al. 2015, p. 2-7; USGCRP 2017, p. 217). In particular, heavy rainfall events are projected to occur between two and three times as frequently and to be between 19 and 40 percent more intense, on average, in the late 21st century than they were during the late 20th century (Warner et al. 2015, pp. 123-124).

The warming trend and trends in rainfall may be masked by naturally-occurring climate cycles, such as the El Niño Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO) (Reeder et al. 2013, p. 76). These oscillations have similar effects in the Pacific Northwest, with relatively warm coastal water and warm, dry winter conditions during a "positive" warm phase, followed by cooler coastal water and cooler, wetter winter conditions during the cool "negative" phase (Moore et al. 2008, p. 1747). They differ in that one phase of the ENSO cycle typically lasts between 6 and 18 months (one to three years for a full cycle), whereas, during the 20th century, each phase of the PDO cycle lasted approximately 20 to 30 years (approximately 40 to 60 years for a full cycle) (Mantua and Hare 2002, p. 36). Some studies break the PDO into two components, one with a full cycle length between 16 and 20 years and the other with a 50 to 70-year period, with the longer component referred to as the Pacific Multidecadal Oscillation (PMO) (Steinman et al. 2015, p. 988). Another recent study has identified a 60-year cycle separate from the longer-term component of the PDO, also referring to this as the PMO (Chen et al. 2016, p. 319). An additional pattern, the North Pacific Gyre Oscillation, is associated with changes in the alongshore winds that drive upwelling and appears to complete approximately one cycle per decade (Di Lorenzo et al. 2008, pp. 2-3).

The overall warming projections described above for the listed range of the marbled murrelet will be superimposed over the natural climate oscillations. The climate models used to project future trends account for naturally occurring cycles (IPCC 2014, p. 56). Therefore, the projected trend combined with the existing cycles mean that temperatures during a cool phase will be less cool than they would be without climate change, and warm phases will be warmer. During the winter of 2014-2015, the climate shifted from a negative cool phase of the PDO to a positive warm phase (Peterson et al. 2016, p. 46). Additionally, one study predicts that the PMO will enter a positive warm phase around the year 2025 (Chen et al. 2016, p. 322). The phases of these long-term climate cycles in addition to the projected warming trend imply that we should expect sea surface temperatures during the period over the next couple of decades to be especially warm. However, climate change may also alter the patterns of these oscillations, for example, by shortening the cycle length of the PDO (Zhang and Delworth 2016, pp. 6007-6008). Many studies of climate effects to marine species and ecosystems use indices of these climate oscillations, rather than individual climate variables such as sea surface temperature, as their measures of the climatic state (e.g. Becker and Beissenger 2006, p. 473). Therefore, if climate factors that covary with a given oscillation become decoupled, the relationships inferred from these studies may no longer be valid in the future.

Changes in the Forest Environment

Forested habitats in the Pacific Northwest are affected by climate change mainly via changes in disturbances, including wildfire, insects, tree diseases, and drought mortality. These types of disturbances can all cause the loss of marbled murrelet nesting habitat, though it is hoped that this loss will be offset by ingrowth as existing mid-successional forest matures. Following stand-replacing disturbances, climate conditions may not allow recruitment of the tree species that are currently present, leading to ecotype change; however, the effect of this kind of ecotype change may not directly affect marbled murrelet habitat availability until many decades in the future.

Historical fire regimes have varied throughout the range of the marbled murrelet. In many of the moist forests of western Washington and Oregon, the fire regime has historically been typified by large, stand-replacing fires occurring at intervals of 200 years or more (Halofsky et al. 2018a, pp. 3-4; Haugo et al. 2019, pp. 2-3; Long et al. 1998, p. 784). Parts of the marbled murrelet range in southern Oregon and California have historically had low- and mixed-severity fires occurring every 35 years or less (Haugo et al. 2019, pp. 2-3; Perry et al. 2011, p. 707). Still other areas throughout the range historically had mixed severity fires occurring between 35 and 200 years apart (Haugo et al. 2019, pp. 2-3; Perry et al. 2011, p. 707). Within each type of historical fire regime, fire has occurred less frequently during the recent decades usually used for statistical analyses of fire behavior or projections of future fire than it did historically (Huago et al. 2019, pp. 8-9; Littell et al. 2010, p. 150).

Between 1993 and 2012, monitoring based on a database of large (1,000 acres or greater) fire perimeters detected losses associated with wildfires of 22,063 acres of Maxent-modeled high-quality marbled murrelet nesting habitat on federal and non-federal lands in the NWFP area (Raphael et al. 2016b, pp. 80-81). Fire was the leading natural cause of habitat loss within the NWFP area, but this ranking was driven by the 20,235-acre loss to fire on federal lands in the Klamath Mountains, and fire was far less important elsewhere in the range. Within subregions overlapping the listed range of the marbled murrelet, the proportion of area currently "highly suitable" for large fires varies from less than 1 percent in the Coast Range of Oregon and Washington to 18 percent in the Klamath Mountains (Davis et al. 2017, p. 179). The fire regime in the listed range of the marbled murrelet has historically been sensitive to climate conditions, though less so during recent decades (Henderson et al. 1989, pp. 13-19; Littell et al. 2010, p. 140; Littell and Gwozdz 2011, pp. 130-131; Weisberg and Swanson 2003, pp. 23-25). South of the NWFP area, extreme heat and unusual lightning activity contributed to the 2020 fires that burned through much of the remaining marbled murrelet habitat in central California, and these conditions were likely caused or exacerbated by climate change (Goss et al. 2020, p. 11; Mulkern 2020, pp. 2, 5-6; Romps et al. 2014, p. 853; Temple 2020, p. 2).

The area burned in the range of the marbled murrelet is expected to increase in the coming decades, but there is great uncertainty about the magnitude of the increase, and it is likely to affect some areas more than others (Davis et al. 2017, pp. 179-182; Rogers et al. 2011, p. 6; Sheehan et al. 2015, p. 25). On forested lands in the Cascades, Coast Ranges, and Klamath Mountains of Washington and Oregon, the percentage of forested area highly suitable for large fires is projected to increase from the current (less than 1 percent to 18 percent, varying by ecoregion) up to between 2 and 51 percent by the late 21st century, with much of this increase projected to occur after 2050 (Davis et al. 2017, pp. 179-181). At the same time, the percentage of forested lands with low suitability for large fire is expected to decrease from the current range of 21 to 97 percent to a lower range of 4 to 85 percent, depending on ecoregion. The increase in large fire suitability is expected to have the greatest effect on the Klamath ecoregion and the smallest effect on the Coast Ranges, with Cascades ecoregions falling in between (Davis et al. 2017, pp. 181). One study has classified most of the marbled murrelet range as having low vulnerability to fire for the 2020-2050 period, relative to all western forests, but parts of the range in southern Oregon and northern California are classified as having medium or high vulnerability (Buotte et al. 2018, pp. 5, 8). A different study found that forests west of the Cascade Crest are likely to be more vulnerable other western forests, because they will be sensitive to hotter, drier summers, but will not benefit from increased winter precipitation since soils are already saturated during winter months (Rogers et al. 2011, p. 6). Throughout the range, the annual number of days with high wildfire potential is expected to nearly double by mid-century (Martinuzzi et al. 2019, pp. 3, 6). Fire severity is also projected to increase over the 21st century (Rogers et al. 2011, p. 6).

Two recent studies have modeled future fires based on projected climate and vegetation characteristics, rather than simply using statistical projections based on past rates of wildfire. One study projected a 1.5- to 5-fold increase in forest fire in western Washington between the historical period and the 21st century (Halofsky et al. 2018b, p. 10). The baseline annual percentage of area burned was based on information about pre-European settlement fire rotation in western Washington, 0.2 to 0.3 percent of the forest land base burned per year, which is a much greater annual area burned than we have observed in the recent past. The late 21st-century annual area burned was projected to reach 0.3 to 1.5 percent of the forest land base per year, with extreme fire years burning 5 to 30 percent of the forest land base (Halofsky et al. 2018b, p. 10). The other study projected a 2- to 4-fold increase in western Washington and Oregon between the late 20th century and mid-century (Sheehan et al. 2019, p. 14). This study started with even larger baseline annual percentage of area burned, starting at 0.47 to 0.56 percent per year in the late 20th century and increasing to 1.14 to 1.99 percent per year by the mid-21st century (Sheehan et al. 2019, p. 14). In both studies, smaller increases in annual area burned were associated with a model assumption that firefighting would continue to be effective.

Insects and disease were the leading natural cause of marbled murrelet habitat loss within most ecoregions within the NWFP area between 1993 and 2012 (Raphael et al. 2016b, p. 81). Across the NWFP area, 8,765 acres of Maxent-modeled high-quality marbled murrelet habitat were lost to insects and disease, with the majority of these on federal lands in Washington. The USFS and WDNR have worked together since 1981 to collect and distribute aerial survey data regarding the presence of insects, disease, and other damage agents in Washington's forests (WDNR and USFS 2018). This dataset indicates the identity of various insect and disease problems that have been recorded in the current marbled murrelet habitat: Douglas-fir beetle (*Dendroctonus pseudotsugae*), "dying hemlock," fir engraver (*Scolytus ventralis*), spruce aphid (*Elatobium abietinum*), Swiss needle cast (*Phaeocryptopus gaeumannii*), and western (*Lambdina fiscellaria lugubrosa*) and phantom (*Nepytia phantasmaria*) hemlock loopers. It is likely that various root diseases have also attacked marbled murrelet habitat, but these are generally classified as bear damage during the aerial surveys (Clark et al. 2018, p. 31). Root diseases that may be present include annosus (*Heterobasidium annosum*), armillaria (*Armillaria ostoyae*), and black stain (*Leptographium wageneri*) root diseases, as well as laminated (*Phellinus weirii*), tomentosus (*Inonotus tomentosus*), and yellow (*Parenniporia subacida*) root rots (Goheen and Willhite 2006, pp. 72-87).

Some of these pests, such as Swiss needle cast, are most typically found in younger stands, and are more likely to affect the development of marbled murrelet habitat over the long term; whereas others, such as Douglas-fir beetle, are more likely to attack older trees (Goheen and Willhite 2006, pp. 30, 224). Swiss needle cast typically does not result in tree mortality (Maguire et al. 2011, pp. 2069-2070), but can affect mixed-species forest stands by allowing increased western hemlock growth in stands where severe Swiss needle cast affects Douglas-fir growth (Zhao et al. 2014, entire). Higher average temperatures, in particular warmer winters, and increased spring precipitation in the Oregon Coast Range have contributed to an increase in the severity and distribution of Swiss needle cast in Douglas-fir (Stone et al. 2008, pp. 171-174; Sturrock et al. 2011, p. 138; Zhao et al. 2011, p. 1,876; Lee et al. 2013, pp. 683-685; Ritóková et al. 2016, p. 2). The distribution of Swiss needle cast increased from about 131,087 ac (53,050 ha) in 1996 to about 589,840 ac (238,705 ha) of affected trees in 2015 within 31 mi (50 km) of the coast in the Oregon Coast Range (Hansen et al. 2000, p. 775; Ritóková et al. 2016, p. 5).

Drought has not historically been a major factor in most of the listed range of the marbled murrelet, because these forests are not typically water limited, especially in Washington and northern Oregon (Littell et al. 2010, p. 139; McKenzie et al. 2001, p. 531; Nemani et al. 2003, p. 1560). Nonetheless, every part of the listed range has been affected by multi-year drought at some point during the 1918-2014 period, varying geographically from areas with occasional mild two- to five-year droughts, to areas with moderate-severity two- or three-year droughts, to a few small areas, all in Washington, that have had at least one extreme three-year drought (Crockett and Westerling 2018, p. 345). Over the last few decades, the number of rainy summer days has decreased, and the rain-free period has lengthened in much of the marbled murrelet's listed range, especially in Oregon and Washington (Holden et al. 2018, p. 4). In the Pacific Northwest generally, drought is associated with Douglas-fir canopy declines that can be observed via satellite imagery (Bell et al. 2018a, pp. 7-10). In Western Washington, Oregon, and Southwestern British Columbia, tree mortality more than doubled (from around 0.5 percent per year to more than 1 percent per year) over the 30-year period between 1975 and 2005, likely due to increasing water stress (van Mantgem et al. 2009, pp. 522-523). Tree mortality may be caused by warm dry conditions in and of themselves (via xylem failure) or when hot, dry conditions compound the effects of insects, disease, and fire.

Some of the insects and pathogens already present in marbled murrelet habitat, such as Douglas-fir beetles, are likely to become more prevalent and cause greater mortality in the future. Douglas-fir trees stressed by heat and drought emit ethanol, which attracts Douglas-fir beetles, and have lowered chemical defenses, which is likely to increase the endemic levels of Douglas-fir infestation and could result in higher probability of epidemic infestation (Agne et al. 2018, p. 326-327; Bentz et al. 2010, p. 605). Similarly, higher temperatures as the 21st century progresses will also increase the potential of spruce beetle (*Dendroctonus rufipennis*) outbreaks, which require mature spruce forests such as those found within the range of the marbled murrelet (Bentz et al. 2010, p. 607). There is more uncertainty with respect to future levels of infection by

Swiss needle cast, a disease that that has increased in severity over the past decade (Agne et al. 2018, p. 326). Warm, wet spring weather is thought to provide ideal conditions for Swiss needle cast infection, whereas warm, dry spring weather may inhibit the pathogen. Future spring weather will be warmer, but it is not clear whether it will be wetter, drier, or both (i.e., more variable), or perhaps current precipitation patterns will continue. Swiss needle cast effects to trees appear to be more severe during drought conditions, however. Therefore, the worst-case scenario for Swiss needle cast would be warm, wet springs followed by hot, dry summers. Swiss needle cast is also expected to spread inland and north to sites where fungal growth is currently limited by cold winter temperatures (Stone et al. 2008, p. 174; Zhao et al. 2011, p. 1,884; Lee et al. 2013, p. 688). Future climate conditions are also hypothesized to promote other diseases, such as Armillaria root disease, that could affect marbled murrelet habitat (Agne et al. 2018, p. 326).

All climate models project increased summer warming for the Pacific Northwest, and most project decreased spring snowpack and summer precipitation, resulting in increasing demand on smaller amounts of soil water in the forest during the growing season. Forests within the marbled murrelet range are expected to experience increasing water deficits over the 21st century (McKenzie and Littell 2017, pp. 33-34). These deficits will not be uniform, with the California and southern Oregon Coast Ranges, Klamath region, eastern Olympic Peninsula, and parts of the Cascades and northern Oregon Coast Range projected to experience much greater hydrological drought, starting sooner than in other places, while there are even projected reductions in water deficit for some other portions of the Washington Cascades and Olympic Mountains (McKenzie and Littell 2017, p. 31). Spring droughts, specifically, are projected to decrease in frequency in Washington and most of Oregon, but to increase in frequency in most of California, with some uncertainty as to the future likelihood of spring drought near the Oregon-California border (Martinuzzi et al. 2019, p. 6). The projected future warm, dry conditions sometimes called "hotter drought" or "climate change-type drought" in the scientific literature, are expected to lead to continued increases in tree mortality. Though projections of future drought-related tree mortality in throughout the listed range of the marbled murrelet are not available, the effects of the recent multi-year drought in the Sierra Nevada may provide some context about what to expect. Drought conditions in California during 2012 through 2015 led to an order of magnitude increase in tree mortality in Sierra Nevada forests (Young et al. 2017, p. 83). More mesic regions, including most areas of marbled murrelet habitat, are unlikely to have near-future impacts as severe as those already seen in the Sierra Nevada. For example, redwood forests in northwestern and central California, which include areas of marbled murrelet nesting habitat, are more resistant to drought effects than other California forests (Brodrick et al. 2019, pp. 2757-2758). However, extreme climate conditions are eventually likely to further increase drought stress and tree mortality, especially since trees in moist forests are unlikely to be well-adapted to drought stress (Allen et al. 2010, p. 669; Allen et al. 2015, pp. 19-21; Anderegg et al. 2013, p. 705; Crockett and Westerling 2018, p. 342; Prestemon and Kruger 2016, p. 262; Vose et al. 2016, p. 10).

Blowdown is another forest disturbance that has historically caused extensive stand-replacing disturbances in the Pacific Northwest. The effect of climate change on blowdown frequency, extent, and severity is unknown, and there are reasons to believe that blowdowns may become either more or less frequent or extensive. Blowdown events are often associated with extra-tropical cyclones, which are often associated with atmospheric rivers. Blowdown is influenced by wind speeds and by soil saturation. Hurricane-force winds hit the Washington coast approximately every 20 years during the 20th century (Henderson et al. 1989, p. 20). Destructive windstorms have occurred in the Pacific Northwest in 1780-1788, 1880, 1895, 1921, 1923, 1955, 1961, 1962, 1979, 1981, 1993, 1995, and 2006 (Henderson et al. 1989, p. 20; Mass and Dotson 2010, pp. 2500-2504). During the 20th century, the events in 1921, 1962, and 2006 were particularly extreme. Although there are some estimates of timber losses from these events, there are no readily available estimates of total marbled murrelet habitat loss from particular events. In addition to habitat loss from these extreme blowdown events, a smaller amount of habitat is lost each year in "endemic" blowdown events. Wind damage may be difficult to detect via methods that rely on remotely sensed data (e.g., Raphael et al. 2016b, pp. 80-81) because much of the wind-damaged timber may be salvaged, and therefore appears to have been disturbed by harvest rather than wind. Nonetheless, between 1993 and 2012, 3,654 acres of Maxent-modeled higher suitability nesting habitat loss was detected via remote sensing and attributed to blowdown or other natural, non-fire, non-insect disturbances (Raphael et al. 2016b, pp. 80-81). Nearly all of the habitat loss in this category affected federal lands in Washington.

Because we did not locate any studies attempting to project marbled murrelet habitat loss to blowdown into the future, we looked to studies regarding the conditions associated with blowdown: wind, rain, and landscape configuration. There are indications that average wind speeds over the Pacific Northwest have declined since 1950, and average wind speeds are projected in most climate models to decline further by the 2080s (Luce et al. 2013, pp. 1361-1362). However, it is not clear how average wind speeds might be related to blowdown since blowdown events usually happen during extreme wind events. Extreme extra-tropical cyclones are expected to become less frequent in the Northern Hemisphere in general, and perhaps along the Pacific Northwest coastline in particular, but these predictions involve many uncertainties. Different models show local increases in storm frequency in different places (Catto et al. 2011, pp. 5344-5345). Also, how "extreme" events are categorized differs between studies, and the results vary depending on what definition of "extreme" is used (Catto et al. 2001, p. 5348; Ulbrich et al. 2009, p. 127). One recent model projects no change in the extreme ground-level winds most likely to damage nesting habitat, and an increase in the frequency of extreme high-altitude winds (Chang 2018, pp. 6531, 6539). Atmospheric rivers are expected to become wetter and probably more frequent. The frequency of atmospheric river days is expected to increase by 50 to around 500 percent over the 21st century, depending on latitude and season (Gao et al. 2015, p. 7182; Warner and Mass 2017, p. 2135), though some models project up to an 18 percent decrease in frequency for either the northern or the southern end of the listed range (Payne and Magnusdottir 2015, p. 11,184). The most extreme precipitation events are expected to be between 19 and 40 percent wetter, with the largest increases along the northern California coast (Warner et al. 2015, p. 123). If increased rain causes greater soil saturation, it is easily conceivable that blowdown would become likely at lower wind speeds than would be needed to cause blowdown in less saturated conditions, but we did not find studies addressing this relationship. Since blowdown is more likely at forest edges, increased fragmentation may lead to more blowdown for the same wind speed and amount of soil saturation. The proportion of Maxent-modeled higher suitability nesting habitat located along forest edges increased between 1993 and 2012, and now makes up the majority of habitat in the NWFP area (Raphael et al. 2016b, p. 77). Some forested areas within the range may become less fragmented over the next 30 years, as conservation plans such as the NWFP continue to allow for forest growth; other areas may become more fragmented due to harvest, development, or the forest disturbances discussed above. Thus, the amount of marbled murrelet habitat likely to be lost to blowdown over the next 30 years is highly uncertain.

Synergistic effects between drought, disease, fire, and/or blowdown are likely to occur to some extent and could become widespread. If large increases in mortality do occur, interactions between these agents are likely to be involved (Halofsky et al. 2018a, pp. 4-5). The large recent increase in tree mortality in the Sierra Nevada has been caused in large part due to these kinds of synergistic interactions. As noted above, range of the marbled murrelet is unlikely to be as severely affected and severe effects are likely to happen later in time here than drier forests (where such effects are already occurring). In fact, one study rates much of the range as having low vulnerability, relative to other western forests, to drought or fire effects by 2049 (Buotte et al. 2018, p. 8). However, that study and many other studies do indicate that there is a risk of one or more of these factors acting to cause the loss of some amount of marbled murrelet habitat over the next 30 years.

In addition to habitat loss resulting from forest disturbances at the scale of a stand or patch, habitat features may be altered as a result of climate change. For example, epiphyte cover on tree branches may change as a result of the warmer, drier summers projected for the future (Aubrey et al. 2013, p. 743). Climate-related changes in epiphyte cover will be additive or synergistic to changes in epiphyte cover resulting from the creation of forest edges through timber harvest (Van Rooyen et al. 2011, pp. 555-556). Epiphyte cover is assumed to have decreased throughout the listed range as the proportion of suitable habitat in edge condition has increased (USFWS 2019, p. 34), and as epiphyte cover decreases further, nest sites will become less available even in otherwise apparently suitable habitat.

In summary, forest disturbances, including wildfire, insect damage, disease, drought mortality, and windthrow, are likely to continue to remove marbled murrelet nesting habitat, and many of these disturbances are likely to remove increasing amounts of habitat in the future. The effects of each type of disturbance are likely to be variable in different parts of the range, with wildfire affecting the Klamath Mountains far more than other parts of the range, and insect and disease damage largely focused in Washington. The magnitude of future increases is highly uncertain, and it is unclear whether windthrow will increase, decrease, or remain constant. Habitat not lost to disturbance may nonetheless be affected by climate change, as particular habitat features may be lost. The effects of habitat loss and the loss of habitat features will reduce the availability of nesting habitat, which will reduce the potential for marbled murrelet reproduction.

<u>Changes in the Marine Environment</u>

Changes in the climate, including temperature changes, precipitation changes, and the release of carbon dioxide into the atmosphere, affect the physical properties of the marine environment, including water circulation, oxygen content, acidity, and nutrient availability. These changes, in turn, affect organisms throughout the marine food web. For top predators like the marbled murrelet, Prey abundance, quality, and availability are all likely to be affected by climate change. Climate change is also likely to change the marbled murrelet's level of exposure to toxic chemicals and potentially to disease agents. All of these changes are likely to alter the reproduction and survival of individual marbled murrelets.

Marine waters within the range of the marbled murrelet have warmed, as noted above. This warming involves not only a gradual increase in average temperatures, but also extreme marine heatwaves, which have dramatic effects on marine ecosystems. Preceding the development of El

Niño conditions in 2015, a rise in sea surface temperatures in the Gulf of Alaska occurred in late 2013, likely due to a shift in wind patterns, lack of winter storms, and an increase in sea-level pressure (Bond et al. 2015, p. 3414; Leising et al. 2015, pp. 36, 38, 61). This warm water anomaly expanded southward in 2014, with further warming along the California Current in 2015, and then merged with another anomaly that developed off Baja California, becoming the highest sea surface temperature anomaly observed since 1982 when measurements began (NMFS 2016, p. 5). These anomalies became known as "the Blob" (Bond et al. 2015, p. 3414) and helped to compress the zone of cold upwelled waters to the nearshore (NMFS 2016, p. 7). During the late summer of 2019, a new marine heatwave began developing, and is currently on a trajectory to be as extreme as the 2014-2015 "Blob" (NMFS 2019).

The marine portion of the listed range of the marbled murrelet is located along the California Current and estuary systems (including the Salish Sea) adjacent to it. The California Current is strongly influenced by upwelling, in which water rises from the deep ocean to the surface. Upwelling along the west coast leads to an influx of cold waters rich in nutrients such as nitrates, phosphates, and silicates, but that are also acidic (due to high dissolved carbon dioxide content) and low in dissolved oxygen (Johannessen et al. 2014, p. 220; Krembs 2012, p. 109; Riche et al. 2014, pp. 45-46, 48; Sutton et al. 2013, p. 7191). Changes in upwelling are likely to occur, and to influence the ecosystem components most important to marbled murrelets. If changes in upwelling occur along the outer coast of Washington, these changes will also affect the interchange of waters through the Strait of Juan de Fuca (Babson et al. 2006, p. 30; Newton et al. 2003, p. 718). It has been hypothesized that as climate change accentuates greater warming of air over land areas than of air over the ocean, alongshore winds will intensify, which will lead to an increase in upwelling (Bakun 1990, entire). Historical records show that these winds have intensified over the past several decades (Bylhower et al. 2013, p. 2572; García-Reyes and Largier 2010, p. 6; Sydeman et al. 2014, p. 78-79; Taboada et al. 2019, p. 95; Wang et al. 2015, pp. 390-391). Projections for future changes in upwelling offer some support for this hypothesis, but are more equivocal (Foreman et al. 2011, p. 10; Moore et al. 2015, p. 5; Mote and Mantua 2002, p. 53-3; Rykaczewski et al. 2015, pp. 6426-6427; Wang et al. 2010, pp. 263, 265). Some studies indicate a trend toward a later, shorter (but in some cases, more intense) upwelling season, though at the southern end of the range the season may be lengthening (Bograd et al. 2009, pp. 2-3; Bylhower et al. 2013, p. 2572; Diffenbaugh et al. 2004, p. 30; Foreman et al. 2011, p. 8; Garcia-Reyes and Largier 2010, p. 6). Trends and projections for the future of upwelling in the California Current may be so variable because upwelling is inherently difficult to model, or because upwelling in this region is heavily influenced by climate cycles such as the NPGO, PDO, and ENSO (Macias et al. 2012, pp. 4-5; Taboada et al. 2019, p. 95; Wang et al. 2015, p. 391).

Regardless of potential changes in the timing or intensity of upwelling, the dissolved oxygen content of the waters in the listed range is expected to decrease. The solubility of oxygen in water decreases with increasing temperature, so as the climate becomes warmer, the dissolved oxygen content of the marine environment is expected to decrease (IPCC 2014, p. 62; Mauger et al. 2015, pp. 7-3, 7-8). The oxygen content in the North Pacific Ocean has declined significantly since measurements began in 1987 (Whitney et al. 2007, p. 184), and this decline is projected to continue (Whitney et al. 2013, p. 2204). Hypoxic and anoxic events, in which the lack of dissolved oxygen creates a dead zone, have occurred in Puget Sound and along the outer coasts of Washington and Oregon (PSEMP Marine Waters Workgroup 2017, p. 22; PSEMP Marine Waters Workgroup 2016, p. 15; Oregon State University 2017, entire). These dead zones have expanded into shallower depths and areas closer to shore, and impacts are expected to increase rapidly (Chan et al. 2016, p. 4; Somero et al. 2016, p. 15). If upwelling does increase in intensity, the effect would likely be to further reduce the oxygen content of nearshore waters, but these changes are not likely to be consistent throughout the region or throughout the year. Changes in oxygen content, or in the timing of low-oxygen periods, may have important biological consequences (see below). Oxygen content also responds to biological activity. In addition to climate change-induced effects, some locations will likely experience reductions in oxygen content stemming from biological responses to eutrophication in areas that receive (and do not quickly flush) nutrient inputs from human activities (Cope and Roberts 2013, pp. 20-23; Mackas and Harrison 1997, p. 14; Roberts et al. 2014, pp. 103-104, 108; Sutton et al. 2013, p. 7191).

Similarly, acidification of waters in the listed range is expected to increase, regardless of any changes in upwelling. Acidification results when carbon dioxide in the air dissolves in surface water, and is the direct consequence of increasing carbon dioxide emissions (IPCC 2014, pp. 41, 49). Marine waters are projected to continue becoming more acidic, and ocean acidification is now expected to be irreversible at human-relevant timescales (IPCC 2014, pp. 8-9, 49; IPCC 2019, pp. 1-4, 1-7, 1-14). Both the surface and upwelled waters of North Pacific Ocean have become more acidic due to carbon dioxide emissions (Feely et al. 2008, pp. 1491-1492, Murray et al. 2015, pp. 962-963), and this trend is expected to continue (Byrne et al. 2010, p. L02601; Feely et al. 2009, pp. 40-46). These waters also contribute to acidification Conservation Zone 1 as they flow in through the Strait of Juan de Fuca (Feely et al. 2010, p. 446, Murray et al. 2015, p. 961). Any increase in upwelling intensity or changes in seasonality would respectively increase acidification or change the timing of pH changes in the marbled murrelet range. It is unknown whether regional carbon dioxide emissions cause additional localized acidification within particular parts of the range (Newton et al. 2012, p. 36), but it is likely that other products of fossil fuel combustion, such as sulfuric acid, do contribute (Doney et al. 2007, pp. 14582-14583). Linked to reductions in dissolved oxygen (Riche et al. 2014, p. 49), acidification has important biological consequences (see below), and also responds to biological activity. For example, local areas of eutrophication are likely to experience additional acidification beyond that caused directly or indirectly by carbon dioxide emissions (Newton et al. 2012, pp. 32-33).

Sea level rise is also expected to affect the listed range of the marbled murrelet. Sea level rise is a consequence of the melting of glaciers and ice sheets combined with the expansion of water as it warms (IPCC 2014, p. 42). At regional and local scales, numerous factors affect sea level rise, including ocean currents, wind patterns, and plate tectonics (Mauger et al. 2015, p. 4-1; Dalrymple 2012, p. 81; Petersen et al. 2015, p. 21). Sea level is rising at most coastal locations in the action area (Mauger et al. 2015, p. 4-2; Dalrymple 2012, pp. 79-81; Shaw et al. 1998, p. 37). These increases in sea level are likely to continue and may accelerate in the near future (Bromirski et al. 2011, pp. 9-10; Dalrymple 2012, pp. 71, 102; Mauger et al. 2015, pp. 4-3 – 4-5; Mote et al. 2008, p. 10; Petersen et al. 2015, pp. 21, 29, and Appendix D). However, in some places, such as Neah Bay, Washington, plate tectonics are causing upward land movement that is currently outpacing sea level rise (Dalrymple 2012, p. 80; Montillet et al. 2018, p. 1204; Mote et al. 2008, pp. 7-8; Petersen et al. 2015, pp 24-26). In other places, sea-level rise is expected to have consequences for near-shore ecosystems (see below).

Physical Changes Specific to Conservation Zone 1

Conservation Zone 1 will be affected by changes in upwelling, dissolved oxygen content, and acidification discussed above, but these effects are expected to vary, both between Conservation Zone 1 and the other Zones, and within Zone 1, based on the exchange of waters through the Strait of Juan de Fuca and water circulation patterns within Zone 1. These water circulation patterns, in and of themselves, are expected to be affected by climate change. The complexity of the physical environment within Zone 1 can make some climate change effects difficult to predict.

Changes in temperature and the seasonality of precipitation over land affect the freshwater inflows to Conservation Zone 1. Spring and summer freshwater inflows are expected to be warmer and reduced in volume, whereas winter freshwater inflows are expected to increase (Lee and Hamlet 2011, p. 110; Mauger et al. 2015, p. 3-8; Moore et al. 2015, p. 6; Mote et al. 2003, p. 56). Many watersheds draining to the Salish Sea have historically been fed by a mix of rain and snowmelt, but are expected to be increasingly dominated by rainfall, which will cause the timing of peak flows to shift from spring to winter (Elsner et al. 2010, pp. 248-249; Hamlet et al. 2001, pp. 9-11; Hamlet et al. 2013, pp. 401-404; Mauger et al. 2015, pp. 3-4 – 3-5). With winter warming and increases in heavy rainfall events, flooding has increased, and this increase is expected to continue (Hamlet and Lettenmaier 2007, pp. 25-16; Lee and Hamlet 2011, p. 113; Mauger et al. 2015, pp. 3-6 – 3-7). Increased winter freshwater inflows, in combination with melting glaciers, are expected to bring increased sediments to the mouths of rivers; however, it is uncertain whether these sediments are more likely to enter the marine waters or to be deposited in estuaries (Czuba et al. 2011, p. 2; Lee and Hamlet 2011, pp. 129-134; Mauger et al. 2015, pp. 5-7 – 5-10).

These changes in seasonal freshwater inflows are expected to alter water circulation and stratification within Conservation Zone 1, and to affect the rate and timing of exchange of waters through the Strait of Juan de Fuca between the Puget Sound and the North Pacific Ocean (Babson et al. 2006, pp. 29-30; MacCready and Banas 2016, p. 13; Mauger et al. 2015, p. 6-2, Riche et al. 2014, pp. 37-39, 44-45, 49-50). This exchange occurs in two layers, with fresh water at the surface flowing toward the ocean, and denser, saltier ocean waters flowing from the ocean at greater depths (Babson et al. 2006, p. 30). With the projected changes in timing of freshwater inflows, the rate of exchange is expected to increase during winter and decrease during summer (Mauger et al. 2015, pp. 6-2 – 6-3). The effect of changes in freshwater inflow on stratification is likely to vary by location within the action area, with greater potential for effect in, for example, southern Puget Sound than in well-mixed channels like Admiralty Inlet and Dana Passage (Newton et al. 2003, p. 721).

When hypoxic (low dissolved oxygen) events occur in the waters of Zone 2, these waters also flow into the inland waters of Conservation Zone 1, driving down the oxygen content there as well, although there is considerable variation over time, space, and depth, due to patterns of circulation and mixing within the Salish Sea (Bassin et al. 2011, Section 3.2; Johannessen et al. 2014, pp. 214-220). For example, Hood Canal is particularly susceptible to hypoxic conditions, partly because circulation of water through Hood Canal is slow (Babson et al. 2006, p. 30), whereas the vigorous tidal currents in Haro Strait allow for the mixing of oxygen-rich surface water throughout the water column (Johannessen et al. 2014, p. 216). Increased stratification, as is expected during winter with the larger freshwater inflows, can lead to hypoxic conditions in deeper waters (Mauger et al. 2015, p. 6-3; Whitney et al. 2007, p. 189). On the other hand, weaker stratification, as expected in the summer, may decrease the probability of low oxygen due to greater mixing, or increase the probability of low oxygen due to slower circulation (Newton et al. 2003, p. 725).

Primary Productivity - Changes in temperature, carbon dioxide, and nutrient levels are likely to affect primary productivity by phytoplankton, macroalgae, kelp, eelgrass, and other marine photosynthesizers (IPCC 2019, p. 5-72; Mauger et al. 2015, p. 11-5). In general, warmer temperatures, higher carbon dioxide concentrations, and higher nutrient levels lead to greater productivity (Gao and Campbell 2014, pp. 451, 454; Nagelkerken and Connell 2015, p. 13273; Newton and Van Voorhis 2002, p. 10; Roberts et al. 2014, pp. 11, 22, 108; Thom 1996, pp. 386-387), but these effects vary by species and other environmental conditions, such as sunlight levels or the ratios of different nutrients (Gao and Campbell 2014, pp. 451, 454; Krembs 2012, p. 109; Kroeker et al. 2013, p. 1889; Low-Decarie et al. 2011, p. 2530). In particular, phytoplankton species that form calcium carbonate shells, such as coccolithophores, show weaker shell formation and alter their physiology in response to acidification, and are expected to decline in abundance with continued acidification (Feely et al. 2004, pp. 365-366; IPCC 2019, p. 5-62; Kendall 2015, pp. 26-46). Due to changes in the seasonality of nutrient flows associated with upwelling and freshwater inputs, there may also be alterations in the timing, location, and species composition of bursts of primary productivity, for example, earlier phytoplankton blooms (Allen and Wolfe 2013, pp. 6, 8-9; MacCready and Banas 2016, p. 17; Mauger et al. 2015, p. 6-3). Changes in primary productivity may not occur in every season; for example, during winter, sunlight is the major limiting factor through most of Conservation Zone 1 (Newton and Van Voorhis 2002, pp. 9, 12), and it is not clear whether winter sunlight is likely to change with climate change. Models project reductions in overall annual marine net primary productivity in the world's oceans during the 21st century, trends will vary across the listed marbled murrelet range, with decreases at the southern end of the range and increases at the northern end (IPCC 2019, pp. 5-31, 5-38). Changes in primary productivity are also likely to vary at smaller scales, even within a Conservation Zone; for example, primary productivity in Possession Sound is more sensitive to nutrient inputs than other areas within Puget Sound (Newton and Van Voorhis 2002, pp. 10-11). In sum, in addition to localized increases and decreases in productivity, we expect changes in the timing, location, and species dominance of primary producers.

Eelgrass (*Zostera marina*) is a particularly important primary producer in some parts of the range. In some areas, such as Padilla Bay in Zone 1, sea level rise is expected to lead to larger areas of suitable depth for eelgrass meadows. In such areas, eelgrass cover, biomass, and net primary production are projected to increase during the next 20 years (Kairis 2008, pp. 92-102), but these effects will depend on the current and future topography of the tidal flats in a given area. In addition, increasing dissolved carbon dioxide concentrations are associated with increased eelgrass photosynthetic rates and resistance to disease (Groner et al. 2018, p. 1807; Short and Neckles 1999, pp. 184-186; Thom 1996, pp. 385-386). However, increasing temperatures are not likely to be beneficial for eelgrass, and in combination with increased nutrients, could favor algal competitors (Short and Neckles 1999, pp. 172, 174; Thom et al. 2014, p. 4). Changes in upwelling are likely to influence eelgrass productivity and competitive interactions in small estuaries along the California Current (Hayduk et al. 2019, pp. 1128-1131). Between 1999 and 2013, eelgrass growth rates in Sequim Bay and Willapa Bay increased, but at a site in central Puget Sound, shoot density over a similar time period was too variable to detect trends (Thom et al. 2014, pp. 5-6). Taken together, these studies indicate that climate change may benefit eelgrass over the coming decades, but these benefits may be limited to specific areas, and negative effects may dominate in other areas (Thom et al. 2014, pp. 7-9).

Kelp forests also make important contributions to primary productivity in some parts of the range. Like eelgrass, bull kelp (*Nereocystis luetkeana*) responds to higher carbon dioxide concentrations with greater productivity (Thom 1996, pp. 385-386). On the other hand, kelp forests are sensitive to high temperatures (IPCC 2019, p. 5-72), and warming waters (among other factors) have reduced the range of giant kelp (*Macrocystis pyrifera* [Agardh]) (Edwards and Estes 2006, pp. 79, 85; Ling 2008, p. 892). In central and northern California, kelp forests have declined, but not along Oregon, Washington, and Vancouver Island (Krumhansl et al. 2016, p. 13787; Wernberg et al. 2019, p. 69). Along Washington's outer coast and the Strait of Juan de Fuca, bull kelp and giant kelp canopy area did not change substantially over the 20th century, though a few kelp beds have been lost (Pfister et al. 2018, pp. 1527-1528). In southern Puget Sound, bull kelp declines were observed between 2013 and 2017-2018, likely resulting from increasing temperature along with decreasing nutrient concentrations, suspended sediment, and the presence of parasites and herbivores (Berry et al. 2019, p. 43). In northern California, a severe decline in bull kelp occurred in conjunction with the marine heatwave of 2014 and 2015, though a number of other ecological factors were involved (Catton et al. 2019, entire). In central California, trends in giant kelp biomass are related to climate cycles such as the NPGO, making the effect of climate change difficult to detect (Bell et al. 2018b, p. 11). It is unclear what the future effects of climate change will be on kelp in the listed range of the marbled murrelet.

In contrast, increases in harmful algal blooms (also known as red tides or toxic algae) have been documented over the past several decades, and these changes are at least partly due to climate change (IPCC 2019, pp. 5-85 – 5-86; Trainer et al. 2003, pp. 216, 222). Future conditions are projected to favor higher growth rates and longer bloom seasons for these species. In the case of one species, *Alexandrium catanella,* increases in the length of bloom season are projected primarily due to increases in sea surface temperature (Moore et al. 2015, pp. 7-9). As with other climate change effects discussed above, increases in the length of the toxic algae bloom season is likely to vary across the listed range. Even within Zone 1, in the eastern end of the Strait of Juan de Fuca and the inlets of southern Puget Sound, the *A. catanella* bloom season is projected to increase by 30 days per year by 2069, in contrast with Whidbey basin, where little or no change in season length is projected (Moore et al. 2015, p. 8). In another genus toxic algae, *Pseudo-nitzschia*, toxin concentrations increase with increasing acidification of the water, especially in conditions in which silicic acid (used to construct the algal cell walls) or phosphate is limiting (Brunson et al. 2018, p. 1; Tatters et al. 2012, pp. 2-3). These and many other harmful alga species also exhibit higher growth rates with higher carbon dioxide concentrations (Brandenburg et al. 2019, p. 4; Tatters et al. 2012, pp. 3-4). During and following the marine heatwave in 2015, an especially large and long-lasting outbreak of *Pseudo-nitzschia* species stretched from southern California to the Aleutian Islands and persisted from May to October, rather than the typical span of a few weeks (Du et al. 2016, pp. 2-3; National Ocean Service 2016; NOAA Climate 2015, p. 1). This harmful algal bloom produced extremely high concentrations of toxic domoic acid, including the highest ever recorded in Monterey Bay, California (NOAA Climate 2015, p. 2; Ryan et al. 2017, p. 5575). With future climate change, toxic algae blooms are likely to be more frequent than in the past, and the larger, more toxic event of 2015 may become more typical (McCabe et al. 2016, p. 10374).

Higher Trophic Levels - There are several pathways by which climate change may affect species at higher trophic levels (i.e, consumers, including marbled murrelets and their prey). Changing physical conditions, such as increasing temperatures, hypoxia, or acidification will have direct effects on some species. Other consumers will be affected via changes in the abundance, distribution, or other characteristics of their competitors or prey species. Changes in the timing of seasonal events may lead to mismatches in the timing of consumers' life history requirements with their habitat conditions (including prey availability as well as physical conditions) (Mackas et al. 2007, p. 249). The combination of these effects is likely to cause changes in community dynamics (e.g. competitive interactions, predator-prey relationships, etc.), but the magnitude of these effects cannot be predicted with confidence (Busch et al. 2013, pp. 827- 831).

A wide variety of marine species are directly affected by ocean acidification. Like their phytoplankton counterparts, foraminiferans and other planktonic consumers that form calcium carbonate shells are less able to form and maintain their shells in acidified waters (Feely et al. 2004, pp. 356-366). Similarly, chemical changes associated with acidification interfere with shell development or maintenance in pteropods (sea snails) and marine bivalves (Busch et al. 2014, pp. 5, 8; Waldbusser et al. 2015, pp. 273-278). These effects on bivalves can be exacerbated by hypoxic conditions (Gobler et al. 2014, p. 5), or ameliorated by very high or low temperatures (Kroeker et al. 2014, pp. 4-5), so it is not clear what the effect is likely to be in a future that includes acidification, hypoxia, and elevated temperatures. Acidification affects crustaceans, for example, slowing growth and development in Pacific krill (*Euphausia pacifica*) and Dungeness crabs (*Cancer magister*) (Cooper et al. 2016, p. 4; Miller et al. 2016, pp. 118-119). Fish, including marbled murrelet prey rockfish species (*Sebastes* spp.) and Pacific herring (*Clupea pallasii*), are also negatively affected by acidification. Depending on species, life stage, and other factors such as warming and hypoxia, these effects include embryo mortality, delayed hatching, reduced growth rates, reduced metabolic rates, altered sensory perception, and changes in behavior, among other effects (Baumann 2019, entire; Hamilton et al. 2014, entire; Nagelkerken and Munday 2016, entire; Ou et al. 2015, pp. 951, 954; Villalobos 2018, p. 18).

Climate effects are expected to alter interactions within the marine food web. When prey items decrease in abundance, their consumers are also expected to decrease, and this can also create opportunities for other species to increase. In California's Farallon Islands, the recently increasing variance of climate drivers is leading to increased variability in abundance of prey species such as euphausiids and juvenile rockfish, associated with corresponding variability in the demography of predators such as seabirds and salmon (Sydeman et al. 2013, pp. 1662, 1667-1672). In future scenarios with strong acidification effects to benthic prey in the California Current, euphausiids and several fish species are expected to decline, while other species are expected to increase (Kaplan et al. 2010, pp. 1973-1976). An investigation of the planktonic food web off of Oregon shows that sea surface temperature has contrasting effects on different types of zooplankton, and competitive interactions are much more prevalent during warm phases of ENSO or PDO than during cool phases (Francis et al. 2012, pp. 2502, 2505-2506). A food web model of Puget Sound shows that moderate or strong acidification effects to calcifying species are expected to result in reductions in fisheries yield for several species, including salmon and Pacific herring, and increased yield for others (Busch et al. 2013, pp. 827-829). Additionally, the same model shows that these ocean acidification effects are expected to cause reductions in forage fish biomass, which are in turn expected to lead to reductions in diving bird biomass (Busch et al. 2013, p. 829). While Busch and coauthors (2013, p. 831) express confidence that this model is accurate in terms of the nature of ocean acidification effects to the Puget Sound food web of the future, they are careful to note that there is a great deal of uncertainty when it comes to the magnitude of the changes. The model also illustrates that some of the effects to the food web will dampen or make up for other effects to the food web, so that changes in abundance of a given prey species will not always correspond directly to changes in the abundance of their consumers (Busch et al. 2013, pp. 827, 830).

Changes in seasonality at lower trophic levels may lead to changes in population dynamics or in interactions between species at higher trophic levels. In central and northern California, reproductive timing and success of common murres (*Uria aalge*) and Cassin's auklets (*Ptychoramphus aleuticus*) are related to not only the strength but also the seasonal timing of upwelling, as are growth rates of *Sebastes* species (Black et al. 2011, p. 2540; Holt and Mantua 2009, pp. 296-297; Schroeder et al. 2009, p. 271). At the northern end of the California Current, Triangle Island in British Columbia, Cassin's auklet breeding success is reduced during years when the peak in copepod prey availability comes earlier than the birds' hatch date, and this mismatch is associated with warm sea surface temperatures (Bertram et al. 2009, pp. 206-207; Hipfner 2008, pp. 298-302). However, piscivorous seabirds (tufted puffins [*Fratercula cirrhata*], rhinoceros auklets [*Cerorhinca monocerata*], and common murres) breeding at the same Triangle Island site have, at least to some extent, been able to adjust their breeding dates according to ocean conditions (Bertram et al. 2001, pp. 292-293; Gjerdrum et al. 2003, p. 9379), as have Cassin's auklets breeding in the Farallon Islands of California (Abraham and Sydeman 2004, p. 240). Because of the changes in tufted puffin, rhinoceros auklet, and common murre hatch dates at Triangle Island, the breeding periods of these species have converged to substantially overlap with one another and with that of Cassin's auklet (Bertram et al. 2001, pp. 293-294), but studies have not addressed whether this overlap has consequences for competitive interactions among the four species. Note that all four of these bird species are in the family Alcidae, which also contains marbled murrelets. All these species also breed and forage within the listed range of the marbled murrelet.

Several studies have suggested that climate change is one of several factors allowing jellyfish to increase their ecological dominance, at the expense of forage fish (Parsons and Lalli 2002, pp. 117-118; Purcell et al. 2007, pp. 154, 163, 167-168; Richardson et al. 2009, pp. 314-216). Many (though not all) species of jellyfish increase in abundance and reproductive rate in response to ocean warming, and jellyfish are also more tolerant of hypoxic conditions than fish are (Purcell 2005, p. 472; Purcell et al. 2007, pp. 160, 163; see Suchman et al. 2012, pp. 119-120 for a Northeastern Pacific counterexample). Jellyfish may also be more tolerant of acidification than fish are (Atrill et al. 2007, p. 483; Lesniowski et al. 2015, p. 1380). In the California Current, jellyfish populations appear to be increasing, but nearshore areas are likely to be susceptible to being dominated by jellyfish, rather than forage fish (Schnedler-Meyer et al. 2016, p. 4). Jellyfish abundance in southern and central Puget Sound has increased since the 1970s (Greene et al. 2015, p. 164). Over the same time period, herring abundance has decreased in south and central Puget Sound, and surf smelt (*Hypomesus pretiosus*) abundance has also decreased in south Puget Sound, although other Puget Sound forage fish populations have been stable or increasing (Greene et al. 2015, pp. 160-162). Forage fish abundance and jellyfish abundance were negatively correlated within Puget Sound and Rosario Strait (Greene et al. 2015, p. 164). In the northern California Current, large jellyfish and forage fish have similar diet composition and likely compete for prey, in addition to the two groups' contrasting responses to climate and other anthropogenic factors (Brodeur et al. 2008, p. 654; Brodeur et al. 2014, pp. 177-179).

Many species of forage fish are expected to fare poorly in the changing climate, regardless of any competitive effects of jellyfish. North of the listed range, in the Gulf of Alaska, Anderson and Piatt (1999, pp. 119-120) documented the crash of capelin (*Mallotus villosus*), Pacific herring, and species of Irish lord (*Hemilepidotus* spp.), prickleback (Stichaeidae family), greenlings and mackerel (*Hexagrammos* and *Pleurogrammus* spp.), as well as several shrimp species, as part of a major community reorganization following a climate regime shift from a cool phase to a warm phase in the 1970s. In the northeastern Pacific Ocean, capelin, sand lance (Ammodytidae family), and rockfish abundance are all negatively correlated with seasonal sea surface temperatures (Thayer et al. 2008, p. 1616). A model of multiple climate change effects (e.g., acidification and deoxygenation) to marine food webs in the Northeast Pacific consistently projects future declines in small pelagic fish abundance (Ainsworth et al. 2011, pp. 1219, 1224). Within Zone 1, abundance of surf smelt and Pacific herring in the Skagit River estuary are positively associated with coastal upwelling during the spring and early summer, likely because nutrient-rich upwelled water increases food availability (Reum et al. 2011, pp. 210-212). If projections of later, shorter upwelling seasons are correct (see above), the delays may lead to declines in these stocks of herring and surf smelt, as happened in 2005 (Reum et al. 2011, p. 212). Similarly, delayed upwelling in 2005 led to reduced growth rates, increased mortality, and recruitment failure of juvenile northern anchovies off of the Oregon and Washington coasts (Takahashi et al. 2012, pp. 397-403). In contrast, anchovy abundance in Zone 1 was unusually high in 2005, as it was in 2015 and 2016 following the marine heatwave, and is positively associated with sea surface temperature (Duguid et al. 2019, p. 38). In the northeastern Pacific, Chavez and coauthors (2003, pp. 217-220) have described a shift between an "anchovy regime" during the cool negative phase of the PDO and a "sardine regime" during the warm positive phase, where the two regimes are associated with contrasting physical and biological states. However, global warming may disrupt the ecological response to the naturally-occurring oscillation, or alter the pattern of the oscillation itself (Chavez et al. 2003, p. 221; Zhang and Delworth 2016, entire).

Marbled murrelets - Marbled murrelets are likely to experience changes in foraging and breeding ecology as the climate continues to change. Although studies are not available that directly project the effects of marine climate change on marbled murrelets, several studies have been conducted within and outside the listed range regarding ocean conditions and marbled murrelet behavior and fitness. Additionally, numerous studies of other alcids from Mexico to British Columbia indicate that alcids as a group are vulnerable to climate change in the northeastern Pacific.

These studies suggest that the effects of climate change will be to reduce marbled murrelet reproductive success, and to some extent, survival, largely mediated through climate change effects to prey. In British Columbia, there is a strong negative correlation between sea surface temperature and the number of marbled murrelets observed at inland sites displaying behaviors associated with nesting (Burger 2000, p. 728). In central California, marbled murrelet diets vary depending on ocean conditions, and there is a trend toward greater reproductive success during cool water years, likely due to the abundant availability of prey items such as euphausiids and juvenile rockfish (Becker et al. 2007, pp. 273-274). Across the northern border of the listed range, in the Georgia Basin, much of the yearly variation in marbled murrelet abundance from 1958 through 2000 can be explained by the proportion of fish (as opposed to euphausiids or amphipods) in the birds' diet (Norris et al. 2007, p. 879). If climate change leads to further declines in forage fish populations (see above), those declines are likely to be reflected in marbled murrelet populations.

The conclusion that climate change is likely to reduce marbled murrelet breeding success via changes in prey availability is further supported by several studies of other alcid species in British Columbia and California. Common murres, Cassin's auklets, rhinoceros auklets, and tufted puffins in British Columbia; common murres in Oregon; pigeon guillemots (*Cepphus columba*), common murres, and Cassin's auklets in California; and even Cassin's auklets in Mexico all show altered reproductive rates, altered chick growth rates, or changes in the timing of the breeding season, depending on sea surface temperature or other climatic variables, prey abundance, prey type, or the timing of peaks in prey availability (Abraham and Sydeman 2004, pp. 239-243; Ainley et al. 1995, pp. 73-77; Albores-Barajas 2007, pp. 85-96; Bertram et al. 2001, pp. 292-301; Borstad et al. 2011, pp. 291-299; Gjerdrum et al. 2003, pp. 9378-9380; Hedd et al. 2006, pp. 266-275; Piatt et al. 2020, pp. 13-15; Sydeman et al. 2006, pp. 2-4). The abundance of Cassin's auklets and rhinoceros auklets off southern California declined by 75 and 94 percent, respectively, over a period of ocean warming between 1987 and 1998 (Hyrenbach and Veit 2003, pp. 2546, 2551). Although the details of the relationships between climate variables, prey, and demography vary between bird species and locations, the consistent demonstration of such relationships indicates that alcids as a group are sensitive to climate-related changes in prey availability, prompting some researchers to consider them indicator species for climate change (Hedd et al. 2006, p. 275; Hyrenbach and Veit 2003, p. 2551).

In addition to effects on foraging ecology and breeding success, climate change may expose adult and juvenile marbled murrelets to health risks. These risks include poisoning, and potentially feather fouling, from harmful algal blooms, as well as from anthropogenic toxins. Climate change can also cause unexpected changes in disease exposure. Reductions in forage fish quality and availability may also lead to starvation in extreme circumstances, though in less extreme circumstances these reductions are more likely to preclude breeding, which could, counterintuitively, increase adult survival.

It is likely that marbled murrelets will experience more frequent domoic acid poisoning, as this toxin originates from harmful algae blooms in the genus *Pseudo-nitzchia*, which are expected to become more prevalent in the listed range (see above). In central California, domoic acid poisoning was determined to be the cause of death for at least two marbled murrelets recovered during a harmful algae bloom in 1998 (Peery et al. 2006, p. 84). During this study, which took place between 1997 and 2003, the mortality rate of radio-tagged marbled murrelets was highest during the algae bloom (Peery et al. 2006, p. 83). Domoic acid poisoning has previously been shown to travel through the food chain to seabirds via forage fish that feed on the toxic algae (Work et al. 1993, p. 59). Other types of harmful algae, including the *Alexandrium* genus, which is also likely to become more prevalent in the listed range (see above), produce saxitoxin, a neurotoxin that causes paralytic shellfish poisoning. Consumption of sand lance contaminated with saxitoxin was implicated in the deaths of seven out of eight (87.5 percent) of Kittlitz's marbled murrelet (*Brachyramphus brevirostrus*) chicks that were tested following nest failure at a study site in Alaska in 2011 and 2012 (Lawonn et al. 2018, pp. 11-12; Shearn-Bochsker et al. 2014). Yet another species of harmful algae produces a foam that led to plumage fouling and subsequent mortality of common murres and other seabird species off of Oregon and Washington during October of 2009, and similar events may become more frequent with climate change (Phillips et al. 2011, pp. 120, 122-124). Due to changes in the Salish Sea food web, climate change is projected to increase mercury and, to a lesser extent, polychlorinated biphenyls (PCB) levels in forage fish and top marine predators (Alava et al. 2018, pp. 4); presumably marbled murrelets will experience a similar increase.

Climate change may also promote conditions in which alcids become exposed to novel pathogens, as occurred in Alaska during 2013, when crested auklets (*Aethia cristatella*) and thick-billed murres (*Uria lomvia*) washed ashore after dying of avian cholera (Bodenstein et al. 2015, p. 935). Marbled murrelets in Oregon may be especially susceptible to novel diseases, because these populations lack diversity in genes related to immunity (Vásquez-Carrillo et al. 2014, p. 252).

In extreme warm-water conditions, adult marbled murrelets may suffer starvation, as occurred with common murres during the marine heatwave of 2014-2016. High levels of adult mortality were observed among common murres from California to Alaska, and this mortality was likely caused by a combination of reductions in forage fish nutritional content and increases in competition with large piscivorous fish, a combination termed the "ectothermic vise" (Piatt et al. 2020, pp. 17-24). Counterintuitively, in the 1997-2003 study of radio tagged marbled murrelets in California, marbled murrelet adult survival was higher during warm-water years and lower during cold-water years, likely because they did not breed and therefore avoided the associated physiological stresses and additional predator risk (Peery et al. 2006, pp. 83-85).

Overall, the effects of climate change in marine ecosystems are likely to be complex, and will vary across the range. Alterations in the physical properties of the marine environment will affect the productivity and composition of food webs, which are likely to affect the abundance, quality, and availability of food resources for marbled murrelets. These changes, in turn, will affect marbled murrelet reproductive performance. In addition, toxic algae and potentially disease organisms are expected to present increasing risks to marbled murrelet health and survival. Different types of effects can be predicted with varying levels of certainty. For example, large increases in the prevalence of harmful algal blooms have already been observed, whereas the likely future magnitude and direction of overall changes in net primary productivity remain highly uncertain. Some changes may be positive (for example, the potential for a northward shift in anchovy abundance), but on the whole climate change is expected to have a detrimental effect to marbled murrelet foraging and health.

Summary of Climate Change Effects

In summary, marbled murrelets are expected to experience effects of climate change in both their nesting habitat and marine foraging habitat. Natural disturbances of nesting habitat are expected to become more frequent, leading to accelerated habitat losses that may outpace ingrowth even in protected landscapes. Marine food chains are likely to be altered, and the result may be a reduction in food resources for marbled murrelets. Even if food resources remain available, the timing and location of their availability may shift, which may alter marbled murrelet nesting seasons or locations. In addition, health risks from harmful algal blooms, anthropogenic toxins, and perhaps pathogens are likely to increase with climate change.

Within the marine environment, effects on the marbled murrelet food supply (amount, distribution, quality) provide the most likely mechanism for climate change impacts to marbled murrelets. Studies in British Columbia (Norris et al. 2007) and California (Becker and

Beissinger 2006) have documented long-term declines in the quality of marbled murrelet prey, and one of these studies (Becker and Beissinger 2006, p. 475) linked variation in coastal water temperatures, marbled murrelet prey quality during pre-breeding, and marbled murrelet reproductive success. These studies indicate that marbled murrelet recovery may be affected as long-term trends in ocean climate conditions affect prey resources and marbled murrelet reproductive rates. While seabirds such as the marbled murrelet have life-history strategies adapted to variable marine environments, ongoing and future climate change could present changes of a rapidity and scope outside the adaptive range of marbled murrelets (USFWS 2009, p. 46).

Conservation Needs of the Species

Reestablishing an abundant supply of high-quality marbled murrelet nesting habitat is a vital conservation need given the extensive removal during the 20th century. Even following the establishment of the NWFP, habitat continued to be lost between 1993 and 2012, and the rate of loss on non-federal lands has been 10 times greater than on federal lands (Raphael et al. 2016b, pp. 80-81). If this rate of loss continues, the conservation of the marbled murrelet may not be possible because almost half of the higher-suitability nesting habitat is on non-federal lands (Raphael et al. 2016b, p. 86). Therefore, recovery of the marbled murrelet will be aided if areas of currently suitable nesting habitat on non-federal lands are retained until ingrowth of habitat on federal lands provides replacement nesting opportunities (USFWS 2019, p. 21).

There are also other conservation imperatives. Foremost among the conservation needs are those in the marine and terrestrial environments to increase marbled murrelet fecundity by increasing the number of breeding adults, improving marbled murrelet nest success (increasing nestling survival and fledging rates), and reducing anthropogenic stressors that reduce individual fitness or lead to mortality. The overall reproductive success (fecundity) of marbled murrelets is directly influenced by nest predation rates (reducing nestling survival rates) in the terrestrial environment and an abundant supply of high quality prey in the marine environment before and during the breeding season (improving breeding rates, potential nestling survival, and fledging rates). Anthropogenic stressors affecting marbled murrelet fitness and survival in the marine environment are associated with commercial and tribal gillnets, derelict fishing gear, oil spills, and high underwater sound pressure (energy) levels generated by pile-driving and underwater detonations (which can be lethal or reduce individual fitness). Anthropogenic activities, such as coastline modification and nutrient inputs in runoff, also affect prey availability and harmful algal blooms, which in turn affect marbled murrelet fitness.

Further research regarding marine threats, general life history, and marbled murrelet population trends in the coastal redwood zone may illuminate additional conservation needs that are currently unknown (USFWS 2019, p. 66).

Recovery Plan

The Marbled murrelet Recovery Plan outlines the conservation strategy with both short- and long-term objectives. The Plan places special emphasis on the terrestrial environment for habitat-based recovery actions due to nesting occurring in inland forests.

In the short-term, specific actions identified as necessary to stabilize the populations include protecting occupied habitat and minimizing the loss of unoccupied but suitable habitat (USFWS 1997, p. 119). Specific actions include maintaining large blocks of suitable habitat, maintaining and enhancing buffer habitat, decreasing risks of nesting habitat loss due to fire and windthrow, reducing predation, and minimizing disturbance. The designation of critical habitat also contributes towards the initial objective of stabilizing the population size through the maintenance and protection of occupied habitat and minimizing the loss of unoccupied but suitable habitat.

Long-term conservation needs identified in the Plan include:

- Increasing productivity (abundance, the ratio of juveniles to adults, and nest success) and population size.
- Increasing the amount (stand size and number of stands), quality, and distribution of suitable nesting habitat.
- Protecting and improving the quality of the marine environment.
- Reducing or eliminating threats to survivorship by reducing predation in the terrestrial environment and anthropogenic sources of mortality at sea.

General criteria for marbled murrelet recovery (delisting) were established at the inception of the Plan and they have not been met (USFWS 2019, p. 65). More specific delisting criteria are expected in the future to address population, demographic, and habitat based recovery criteria (USFWS 1997, p. 114-115). The general criteria include:

- Documenting stable or increasing population trends in population size, density, and productivity in four of the six Conservation Zones for a 10-year period.
- Implementing management and monitoring strategies in the marine and terrestrial environments to ensure protection of marbled murrelets for at least 50 years.

Thus, increasing marbled murrelet reproductive success and reducing the frequency, magnitude, or duration of any anthropogenic stressor that directly or indirectly affects marbled murrelet fitness or survival in the marine and terrestrial environments are the priority conservation needs of the species. The Service estimates recovery of the marbled murrelet will require at least 50 years (USFWS 1997).

Survival and Recovery Role of Each Conservation Zone

The six Conservation Zones, defined in the Recovery Plan as equivalent to Recovery Units, vary not only in their population status, as described above, but also in their intended function with respect to the long-term survival and recovery of the marbled murrelet.

Conservation Zones 1 extends inland 50 miles from the marine waters of Puget Sound and most waters of the Strait of Juan de Fuca south of the U.S.-Canadian border. The terrestrial portion of Zone 1 includes the north Cascade Mountains and the northern and eastern sections of the Olympic Peninsula. Nesting habitat in the Cascades is largely separated from high-quality marine foraging habitat by both urban development on land and highly altered coastal marine environments, leading to long commutes between nesting and foraging habitat (Lorenz et al. 2017, p. 314; Raphael et al. 2016a, p. 106; USFWS 1997, p. 125). In contrast, large blocks of nesting habitat remain near the coast along the Strait of Juan de Fuca, where there is a lower human footprint (Raphael et al. 2016b, p. 72; van Dorp and Merrick 2017, p. 5). This combination of large blocks of habitat close to foraging habitat is likely more conducive to successful production of young than conditions other portions of Zone 1. Zone 1 is unique among the six Zones in that the marine environment is not a part of the California Current ecosystem, but is part of a complex system of estuaries, fjords, and straits. This means that the Zone 1 population is subject to a different set of environmental influences than the populations in the other five zones. For example, in 2005, delayed upwelling led to widespread nesting failure of seabirds, including marbled murrelets, along the northern California Current, while above-average productivity was observed in Zone 1 (Lorenz and Raphael 2018, pp. 208-209; Peterson et al. 2006, pp. 64, 71; Ronconi and Burger 2008, p. 252; Sydeman et al. 2006, p. 3). This example illustrates the importance of Zone 1 in bolstering the rangewide resilience of marbled murrelets. Zone 1 is one of the four Zones where increased productivity and stable or increasing population size are needed to provide redundancy and resilience that will enable recovery and long-term survival.

Conservation Zone 2 also extends inland 50 miles from marine waters. Conservation Zone 2 includes marine waters within 1.2 miles (2 km) off the Pacific Ocean shoreline, with the northern terminus immediately south of the U.S.-Canadian border near Cape Flattery along the midpoint of the Olympic Peninsula, and extending to the southern border of Washington (the Columbia River) (USFWS 1997, pg. 126). Although Zone 2 was defined to include only the nearshore waters, marbled murrelets in this area are regularly found up to 8 km from shore, sometimes at higher densities than in the nearshore environment, even during the breeding season (Bentivoglio et al. 2002, p. 29; McIver et al. in press, pp. 34, 85). Zone 2 includes the rich waters of the Olympic Coast National Marine Sanctuary, which are adjacent to areas of the Olympic Peninsula that retain large blocks of nesting habitat (Raphael et al. 2016b, p. 72). Like the northern Olympic Peninsula in Zone 1, parts of the western Olympic Peninsula appear to provide one of the few remaining strongholds for marbled murrelets in Washington. The southern portion of Zone 2 previously hosted a small but consistent subpopulation of nesting marbled murrelets, and is now only sparsely used for nesting inland or foraging at sea. This reduction in marbled murrelet population density in the southern portion of Zone 2 represents a widening of a gap in distribution that was described in the Recovery Plan (USFWS 1997, p. 126). This gap is likely a partial barrier to gene flow (USFWS 1997, p. 145). The eventual long-term survival and recovery of listed marbled murrelets depends on the maintenance of a viable marbled murrelet populations that are well distributed throughout Zone 2, along with the other three Zones where increased productivity and stable or increasing population size are needed for survival and recovery.

Conservation Zone 3 extends 35 miles inland, and includes marine waters within 1.2 miles of the Pacific Ocean shoreline between the northern border of Oregon (the Columbia River) and North Bend, Oregon (USFWS 1997, pp. 126-127). The terrestrial portion of Zone 3 historically experienced large-scale wildfires and timber harvest, which together likely led to a loss of nesting habitat that caused a dramatic decline in the marbled murrelet population in this Zone (USFWS 1997, p. 117). In the northern portion of Zone 3, this lack of nesting habitat persists, and the at-sea population density of marbled murrelets is relatively low, extending the gap in the southern portion Zone 2 (USFWS 1997, p. 145; McIver et al. 2021, pp. 11-17). Additionally, marbled murrelet populations in Oregon are expected to be more susceptible to novel pathogens, due to low genetic diversity coding for important immune system peptides (Vásquez-Carrillo et al. 2014, p. 252). However, in Zone 3 as a whole, at-sea population density is high, and is trending upward, though the reason for the population increase is not well understood. The marbled murrelet population of Zone 3 is one of the two largest among the Conservation Zones. The eventual long-term survival and recovery of listed marbled murrelets depends on the maintenance of a viable marbled murrelet populations that is well distributed throughout Zone 3, along with the other three Zones where increased productivity and stable or increasing population size are needed for survival and recovery.

Conservation Zone 4 extends 35 miles inland, and includes marine waters within 1.2 miles of the Pacific Ocean shoreline between North Bend, Oregon and the southern end of Humboldt County, California (USFWS 1997, p. 127). Since 1993, this Zone has experienced the majority of all nesting habitat losses on federal lands within the listed range, nearly all due to large wildfires (Raphael et al. 2016b, p. 75). Much of the nesting habitat within this Zone is located within National and California State Parks, and recreation likely reduces marbled murrelet productivity in these areas, particularly via accidental food subsidies to corvid nest predators at picnic sites and camping areas (USFWS 1997, p. 128). Over the last decade, Redwood National and State Parks have made efforts to reduce this supplemental feeding of corvids, with some success in reducing corvid density at recreation sites, but it would be difficult to detect any population-scale benefit of these efforts (Brunk et al. 2021, pp. 7-8; McIver et al., in press, p. 43). The marbled murrelet population of Zone 4 is one of the two largest among the Conservation Zones, and is increasing, though the reason for the population increase is not well understood. The eventual long-term survival and recovery of listed marbled murrelets depends on the maintenance of a viable marbled murrelet populations that is well distributed throughout Zone 4, along with the other three Zones where increased productivity and stable or increasing population size are needed for survival and recovery.

Conservation Zone 5 extends 25 miles inland, and includes marine waters within 1.2 miles of the Pacific Ocean shoreline between the southern end of Humboldt County, California, and the mouth of San Francisco Bay (USFWS 1997, p. 129). Very little nesting habitat remains in this Zone, mostly in California State Parks and on private lands, though some nesting habitat ingrowth was observed between 1993 and 2012 (Raphael et al. 2016b, p. 75; USFWS 1997, p. 129). Marbled murrelet population estimates in Zone 5 have been correspondingly low, with population estimates of less than 100 individuals in most survey years (McIver et al. 2021, pp. 11-17). The most recent survey, in 2017, resulted in a much higher estimate of 872 individuals, but multiple lines of evidence indicate that this increase was likely the result of unusual migratory patterns from other Zones during the breeding season (Adrean et al. 2018, p. 2; McIver et al., in press, pp. 43-44; Strong 2018, pp. 6-7). However, surveys in Zone 5 are now conducted only once every four years, making the status and trend of this population more difficult to discern. Given the small size of the population during most survey years, and the limited availability of nesting habitat, the ability of this population to survive over the coming decades is questionable, and Zone 5 cannot be counted on to contribute toward long-term survival or recovery of the DPS (USFWS 1997, pp. 129). In the best-case scenario, if nesting habitat ingrowth in this Zone can stimulate the restoration of a larger population in Zone 5 over the long term, this would likely improve connectivity between Zones 4 and 6, provide redundancy, and increase resiliency for the DPS as a whole.

Conservation Zone 6 extends 15 miles inland, and includes marine waters within 1.2 miles of the Pacific Ocean shoreline between the mouth of San Francisco Bay and Point Sur, in Monterey County, California (USFWS 1997, pp. 129-130). Zone 6 is unique among the Zones in that it is not within the NWFP area and is not included in NWFP effectiveness monitoring. Federal land is lacking in Zone 6, and all nesting habitat is located within State or County Parks or on private lands (McShane et al. 2004, p. 4-14). Marbled murrelet population estimates for Zone 6 have averaged around 500 individuals for the period from 1999 through 2019, with a range between 174 and 699 birds across the years (Felis et al. 2020, p. 7). The Zone 6 population is genetically differentiated from the other Zones, likely as a result of the wide gap in the range between the Zone 6 population and the populations to the north (Hall et al. 2009, p. 5078; Peery et al. 2010, p. 703). When the Recovery Plan was written in 1997, it was anticipated that the Zone 6 population would persist long enough to contribute to recovery, but could not be relied upon to contribute to the long-term survival of the species (USFWS 1997, p. 116). Subsequent research has demonstrated that the population in Zone 6 is a demographic sink, with a shrinking breeding population bolstered by the presence of mainly non-breeding individuals originating from other Zones (Peery et al. 2006, p. 1523; Peery et al. 2010, p. 702; Vásquez-Carrillo et al. 2013, p. 177). Demographic effects of large-scale nesting habitat loss and degradation during the 2020 wildfires have not yet manifested, but are expected to be negative. Therefore, it remains unlikely that this population will contribute to recovery. The presence of a marbled murrelet population in Zone 6 is necessary to ensure the future distribution of marbled murrelets throughout their current and historical within the DPS, but it is not clear that this will be possible over the long term, given the vulnerability of this population to stochastic or catastrophic events (USFWS 1997, p. 116). The Recovery Plan identified lands that will be essential for the recovery of the marbled murrelet, including1) any suitable habitat in a Late Successional Reserve (LSR) in Forest Ecosystem Management Assessment Team (FEMAT) Zone 1 (not to be confused with Conservation Zone 1), as well as LSR in FEMAT Zone 2 in Washington, 2) all suitable habitat located in the Olympic Adaptive Management Area, 3) large areas of suitable nesting habitat outside of LSRs on Federal lands, such as habitat located in the Olympic National Park, 4) suitable habitat on State lands within 40 miles of the coast in Washington, or within 25 miles of the coast in Oregon and California, 5) habitat within 25 miles of the coast on county park land in San Mateo and Santa Cruz Counties, California, 6) suitable nesting habitat on Humboldt Redwood Company (formerly Pacific Lumber Company) lands in Humboldt County, California, and 5) habitat within occupied marbled murrelet sites on private lands (USFWS 1997, pp. 131-133).

Marine habitat is also essential for the recovery of the marbled murrelet. Key recovery needs in the marine environment include protecting the quality of the marine environment and reducing adult and juvenile mortality at sea (USFWS 1997, pp. 134-136). Marine areas identified as essential for marbled murrelet foraging and loafing include 1) all waters of Puget Sound and the Strait of Juan de Fuca, and waters within 1.2 miles of shore 2) along the Pacific Coast from Cape Flattery to Willapa Bay in Washington, 3) along the Pacific Coast from Newport Bay to Coos Bay in Oregon, 4) along the Pacific Coast from the Oregon-California border south to Cape Mendocino in northern California, and 5) along the Pacific Coast in central California from San Pedro Point south to the mouth of the Pajaro River.

Summary

At the range-wide scale, annual estimates of marbled murrelet populations have fluctuated, with no conclusive evidence of a positive or negative trend since 2001(+0.5 percent per year, 95% CI: -0.5 to +1.5%) (McIver et al. 2021, p. 4). The most recent extrapolated population estimate for the entire NWFP area was 21,200 marbled murrelets (95 percent CI: 16,400 to 26,000 birds) in

2019 (McIver et al. 2021, p. 3). The largest and most stable marbled murrelet subpopulations now occur off the Oregon and northern California coasts, while subpopulations in Washington have steadily declined since 2001 (-3.9 percent per year; 95% CI: -5.4 to -2.4%) (McIver et al. 2021, p. 4).

Monitoring of marbled murrelet nesting habitat within the NWFP area indicates nesting habitat declined from an estimated 2.53 million acres in 1993 to an estimated 2.23 million acres in 2012, a decline of about 12.1 percent (Raphael et al. 2016b, p. 72). Marbled murrelet population size is strongly and positively correlated with amount of nesting habitat, suggesting that conservation of remaining nesting habitat and restoration of currently unsuitable habitat is key to marbled murrelet recovery (Raphael et al. 2011, p. iii). Given likely future increases in forest disturbances that can cause habitat loss, conservation of remaining nesting habitat is especially important.

The species decline has been largely caused by extensive removal of late-successional and old growth coastal forest which serves as nesting habitat for marbled murrelets. Additional factors in its decline include high nest-site predation rates and human-induced mortality in the marine environment from disturbance, gillnets, and oil spills. In addition, marbled murrelet reproductive success is strongly correlated with the abundance of marine prey species. Overfishing and oceanographic variation from climate events and long-term climate change have likely altered both the quality and quantity of marbled murrelet prey species (USFWS 2009, p. 67).

Although some threats have been reduced (e.g., habitat loss on Federal lands), some threats continue, and new threats now strain the ability of the marbled murrelet to successfully reproduce. Threats continue to contribute to marbled murrelet population declines through adult and juvenile mortality and reduced reproduction. Therefore, given the current status of the species and background risks facing the species, it is reasonable to assume that marbled murrelet populations in Conservation Zones 1 and 2 and throughout the listed range have low resilience to deleterious population-level effects and are at high risk of continuing or renewed declines. Activities that degrade the existing conditions of occupied nesting habitat or reduce adult survivorship or nest success of marbled murrelets will be of greatest consequence to the species. Actions resulting in the loss of occupied nesting habitat, mortality to breeding adults, eggs, or nestlings will reduce productivity, contribute to continued population declines, and prolong population recovery within the listed range of the species in the coterminous United States.

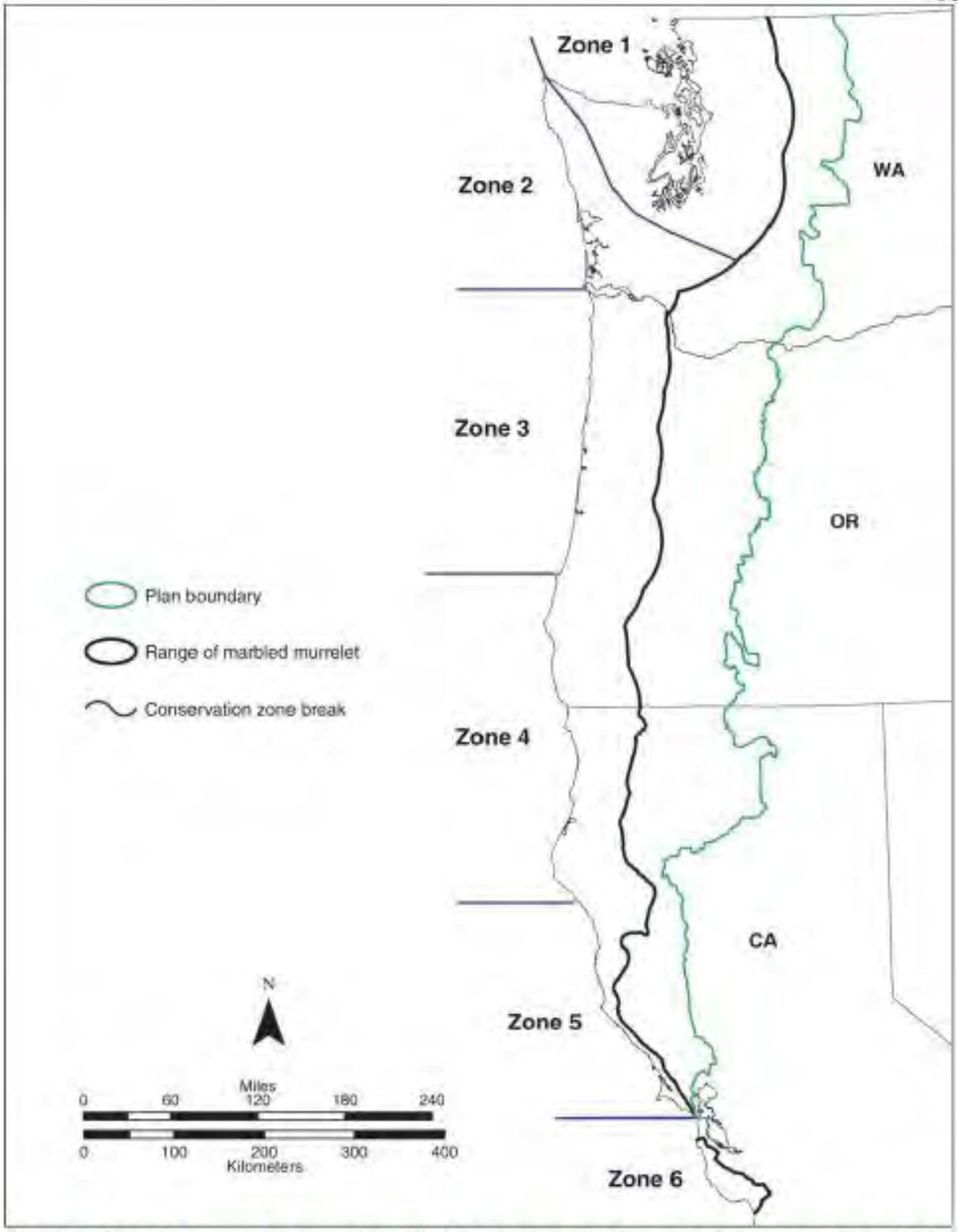

Figure 3. The six geographic areas identified as Conservation Zones in the recovery plan for the marbled murrelet (USFWS 1997). Note: "Plan boundary" refers to the NWFP. Figure adapted from Huff et al. (2006, p. 6).

Environmental Baseline

Environmental baseline refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 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.

Marbled Murrelet Status in the Action Area

The action area includes portions of the current range of the marbled murrelet in nearshore marine and open water marine habitats in Washington and Oregon. The action area includes the marine portions of four marbled murrelet Recovery Units (or "Conservation Zones"): Conservation Zone 1 – Puget Sound, Conservation Zone 2 – Western Washington Coast Range, Conservation Zone 3 – Oregon Coast Range, and Conservation Zone 4 – Siskiyou Coast Range (Figure 4).

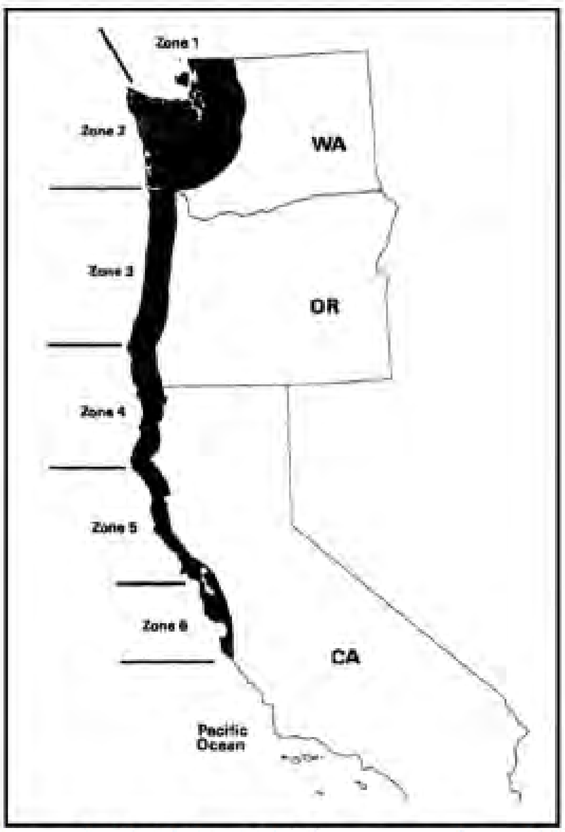

Figure 4. Marbled murrelet Conservation Zones (USFWS 1997, pg. 114).

Conservation Zone 1 (Puget Sound) includes all the waters of Puget Sound and most waters of the Strait of Juan de Fuca south of the U.S.-Canadian border. Within the Inland Water Subunit, marbled murrelets tend to forage in well-defined areas during the breeding season. They are found in the highest densities in the nearshore waters of the San Juan Islands, Rosario Strait, the Strait of Juan de Fuca, Admiralty Inlet, and Hood Canal. They are more sparsely distributed elsewhere in Puget Sound, with smaller numbers observed within the Nisqually Reach, Possession Sound, Skagit Bay, Bellingham Bay, and along the eastern shores of Georgia Strait. In the most southern end of Puget Sound, they occur in extremely low numbers. During the non-breeding season, marbled murrelets typically disperse and are found farther from shore (Strachan et al. 1995, pp. 247-253). Marbled murrelets from Vancouver Island, British Columbia may move into more sheltered waters in Puget Sound and the Strait of Georgia during the non-breeding season, which may contribute to increased numbers of marbled murrelets in Puget Sound in fall and winter (Beauchamp et al. 1999, entire; Burger 1995, pg. 297; Ralph et al. 1995, pg. 9; Speich and Wahl 1995, pg. 325).

Conservation Zone 2 (Western Washington Coast Range) includes marine waters within 1.2 miles (2 km) of the Pacific Ocean shoreline, with the northern terminus immediately south of the U.S.-Canadian border near Cape Flattery along the midpoint of the Olympic Peninsula, and extending to the southern border of Washington (the Columbia River) (USFWS 1997, pg. 126). During the breeding season (April through September), marbled murrelet density in the Offshore Area Subunit is lower than in the nearshore coastal and inland waters. During the summer, it is assumed that 5 percent of marbled murrelets detected by the Northwest Forest Plan Effectiveness Monitoring Program are offshore (the survey effort detects approximately 95 percent of the population, and the remaining 5 percent are assumed to be offshore), but not beyond the continental shelf (37 km, or 20 nm).

Conservation Zone 3 (Oregon Coast Range) extends from the Columbia River south to North Bend, Coos County, Oregon, includes waters within 1.2 miles (2 km) of the Pacific Ocean shoreline, and extends inland a distance of approximately 35 miles (56 km). The boundary encompasses all of the designated marbled murrelet CHUs (USFWS 1997, pp. 126, 127).

Conservation Zone 4 (Siskiyou Coast Range) extends from North Bend, Coos County, Oregon, south to the southern end of Humboldt County, California. It includes waters within 1.2 miles (2 km) of the Pacific Ocean shoreline (including Humboldt and Arcata bays) and, in general, extends inland a distance of 35 miles (56 km) (USFWS 1997, pg. 127).

<u>Current Conditions and Limiting Factors in the Action Area</u>

Current conditions and limiting factors in the action area are the same as those described rangewide below.

- The loss of nesting habitat was a major cause of decline over the past century and may still be contributing as nesting habitat continues to be lost to fires, logging, and windstorms (Miller et al. 2012, pg. 778). Due mostly to historic timber harvest, only a small percentage (approximately 11 percent) of the habitat-capable lands within the listed range contain potential nesting habitat (Raphael et al. 2016b, pg. 69).

- While the direct causes for population declines are unknown, potential factors include the loss of nesting habitat, including cumulative and time-lag effects of habitat losses over the past 20 years, changes in the marine environment reducing the availability or quality of prey, increased densities of nest predators, and emigration (Miller et al. 2012, pg. 778). Marine habitat degradation is most prevalent in the Puget Sound, where human activities (e.g., shipping lanes, boat traffic, shoreline development) are an important factor influencing the marine distribution and abundance in Conservation Zone 1 (Falxa and Raphael 2016, pg. 110).

- Populations are declining in Washington, stable in Oregon, and stable in California where there is a non-significant but positive population trend (McIver et al. 2019, pg. 3). Population size and distribution is strongly and positively correlated with the amount and pattern of suitable nesting habitat (i.e., large contiguous patches); population trend is most strongly correlated with trend in nesting habitat, although marine factors also contribute to this trend (Raphael et al. 2016a, pg. 115).

- While terrestrial habitat amount and configuration (including fragmentation), and the terrestrial human footprint (i.e., cities, roads, development), appear to be strong factors influencing distribution in Zones 2-5; terrestrial habitat and the marine human footprint (i.e., shipping lanes, boat traffic, shoreline development) appear to be the most important factors that influence marine distribution and abundance in Zone 1 (Raphael et al. 2016a, pg. 106).

- Marine bird survival is dependent on the ability to successfully forage in the marine environment. Despite this, it is apparent that the location, amount, and landscape pattern of nesting habitat are the strongest predictors of spatial and temporal distributions at sea during the nesting season (Raphael et al. 2015, pg. 20). Various marine habitat features (e.g., shoreline type, depth, temperature, etc.) apparently have only a minor influence on distribution at sea. Despite this relatively weak spatial relationship, marine factors, and especially any decrease in forage species, likely play an important role in explaining the apparent population declines, but the ability to model these relationships is currently limited (Raphael et al. 2015, pg. 20).

When the marbled murrelet was listed under the Act in 1992, several threats were identified as the likely causes for the species' dramatic decline (57 FR 45328; October 1, 1992) as follows.

- Habitat destruction and modification in the terrestrial environment, from timber harvest and human development, resulting in a severe reduction in the amount of available nesting habitat.
- Unnaturally high levels of predation resulting from forest "edge effects".
- Manmade factors, such as mortality from oil spills and entanglement in fishing nets.
- Existing regulatory mechanisms, such as land management plans, which were considered inadequate to ensure protection of the remaining nesting habitat and reestablishment of future nesting habitat. The regulatory mechanisms implemented since 1992 that affect land management in Washington, Oregon, and California (for example, the Northwest Forest Plan; NWFP), and new gill-netting regulations in northern California and Washington, have reduced these threats (USFWS 2004, pp. 11-12).

However, additional threats were identified by the USFWS's 2009, 5-year review (USFWS 2009b, pp. 27-67) as follows.

- Habitat destruction, modification, or curtailment of the marine environmental conditions necessary to support marbled murrelets, due to elevated levels of contaminants in prey, changes in prey abundance and availability, changes in prey quality, climate change in the Pacific Northwest, and harmful algal blooms that produce biotoxins and cause marbled murrelet mortalities.
- Other human caused factors and stressors in the marine environment, including derelict fishing gear leading to mortality from entanglement, and various forms of disturbance (e.g., lethal and sub-lethal exposures to elevated underwater sound pressure levels caused by impact pile driving and underwater detonations; high vessel traffic).

Conservation Role of the Action Area

The action area in Washington includes the outer marine waters of the Strait of Juan de Fuca, and the nearshore and offshore marine waters of the Washington coast. The action area in Oregon includes the nearshore and offshore marine waters of the Oregon coast.

Marbled murrelets spend most of their lives in the marine environment where they consume a diversity of prey species, including small fish and invertebrates. They occur primarily in nearshore marine waters within 5 km of the coast but have been documented up to 300 km off the coast of Alaska in winter (Nelson 1997, pg. 3). The inland nesting distribution is strongly associated with the presence of mature and old-growth coniferous forests. Marbled murrelets have been detected more than 100 km inland in Washington (70 miles). The inland distribution in the southern portion of the range is associated with the extent of the hemlock/tanoak vegetation zone, which extends 16 to 51 km inland (10 to 32 miles) (Evans Mack et al. 2003, pg. 4).

With consideration for the best available data describing marbled murrelet abundance, distribution, population trends, and reproductive success, the USFWS has concluded that the marbled murrelet populations in the Washington portion of the range currently have little or no ability to self-regulate (as indicated by the significant, annual decline in abundance for Conservation Zones 1 and 2) (USFWS 2019, pg. 12). Populations in Oregon (Zone 3 and part of Zone 4) are apparently more stable, but threats associated with habitat loss and habitat fragmentation continue to occur in those portions of the range. The USFWS expects the species to continue to exhibit further reductions in distribution and abundance into the foreseeable future, largely because threats and stressors present in the marine and terrestrial environments will continue into the foreseeable future (USFWS 2019, pg. 12).

The action area is critically important to marbled murrelet populations in Conservation Zones 1 through 4 (Figure 4 above), and by extension, is also critically important to the rangewide conservation and recovery of the species. The action area provides prey resources that are essential to the health and productivity of marbled murrelet populations in Conservation Zones 1 through 4. The action area also supports individuals from other Conservation Zones and/or British Columbia (i.e., those that seasonally forage and migrate to the north and south, respectively).

The USFWS's recovery plan identifies five marine areas (four in the action area) that support the highest concentrations during the breeding season; these marine areas provide marbled murrelet foraging and loafing opportunities that are regarded as essential and must be protected (USFWS 1997, pg. 135) as follows.

- All waters of Puget Sound and the Strait of Juan de Fuca in Washington, including the waters of the San Juan Islands and river mouths.
- Nearshore waters (within 1.2 miles of the shore) along the Pacific Coast from Cape Flattery to Willapa Bay in Washington, including river mouths.
- Nearshore waters (within 1.2 miles of the shore) along the Pacific Coast from Newport Bay to Coos Bay in Oregon, including Yaquina Bay and river mouths.
- Nearshore waters (within 1.2 miles of the shore) along the Pacific Coast from the Oregon-California border south to Cape Mendocino in northern California, including Humboldt and Arcata Bays, and river mouths (e.g., mouths of the Smith River, Klamath River, Redwood Creek, and Eel River).

The marine environment will play an essential role in the recovery of the marbled murrelet. Protecting the quality of the marine environment is identified in the recovery plan as an integral part of the recovery effort (USFWS 1997, pg. 120). Marbled murrelets spend the majority of their lives in marine areas, usually within five kilometers of the shoreline, where forage fish and other marine prey resources are most abundant (USFWS 1997, pg. 120). If marine areas are degraded and do not provide sufficient prey resources, individual fitness and reproductive success will be reduced.

Climate Change Effects

Marbled murrelets are expected to experience effects of climate change in both their nesting habitat and marine foraging habitat. Natural disturbances of nesting habitat are expected to become more frequent, leading to accelerated habitat losses that may outpace ingrowth even in protected landscapes. Marine food chains are likely to be altered, and the result may be a reduction in food resources for marbled murrelets. Even if food resources remain available, the timing and location of their availability may shift, which may alter marbled murrelet nesting seasons or locations. In addition, health risks from harmful algal blooms, anthropogenic toxins, and perhaps pathogens are likely to increase with climate change.

Within the marine environment, effects on the marbled murrelet food supply (amount, distribution, quality) provide the most likely mechanism for climate change impacts to marbled murrelets. Studies in British Columbia (Norris et al. 2007, entire) and California (Becker and Beissinger 2006, entire) have documented long-term declines in the quality of marbled murrelet prey, and one of these studies (Becker and Beissinger 2006, pg. 475) linked variation in coastal water temperatures, marbled murrelet prey quality during pre-breeding, and marbled murrelet reproductive success. These studies indicate that marbled murrelet recovery may be affected as long-term trends in ocean climate conditions affect prey resources and marbled murrelet reproductive rates. While seabirds such as the marbled murrelet have life-history strategies adapted to variable marine environments, ongoing and future climate change could present changes of a rapidity and scope outside the adaptive range of marbled murrelets (USFWS 2009b, pg. 46).

Summary

The marbled murrelet is generally in decline in the action area (Conservation Zones 1 and 2), and threats and stressors present in the marine and terrestrial environments will continue into the foreseeable future. Marbled murrelet populations in Conservation Zones 1 and 2 and throughout the listed range have low resilience to deleterious population-level effects and are at high risk of continuing or renewed declines. As stated in the Status of the Species section above, Zones 1 through 4 are the four Zones where increased productivity and stable or increasing population size are needed to provide redundancy and resilience that will enable recovery and long-term survival.

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. (See § 402.17).

Effects of the Action on the Marbled Murrelet

The NSF provided the following supplemental analysis (H. Smith, March 24, 2020, and updated March 15, 2021) describing the characteristics of the proposed airgun array as well as a preliminary analysis of the potential effects of the proposed airgun activities on marbled murrelets. [Note: the original heading format and table and figure numbers for this section were updated for consistency.]

Airgun Characteristics

A 36-airgun array with a total discharge volume of 6600 in^3 is proposed for use by R/V *Langseth* to study the Cascadia Margin. Most energy emitted from airguns is at relatively low frequencies, between 2 and 188 Hz. However, the pulses contain energy up to 500–1000 Hz and some energy at higher frequencies (Goold and Coates 2006; Potter et al. 2007; Hermannsen et al. 2015; Kyhn et al. 2019). Nonetheless, the predominant energy is at low frequencies. The resulting downward-directed pulse from an airgun has a duration of only 10–20 ms (Caldwell and Dragoset 2000). Due to reverberation, the pulse duration as received at long horizontal distances can be greater and background sound levels may be elevated between airgun pulses (e.g., Guerra et al. 2011, 2016; Klinck et al. 2012).

The vessel would be traveling at a speed of ~4.1 knots (2.1 m/s), and the shot interval would be every 37.5 m or ~17 s. The nominal source level of the 36-airgun array is 259 dB re 1 μPa · m (0-peak) or 265 dB re 1 μPa · m (peak to peak). These are the nominal source levels applicable to downward propagation. The effective source levels for horizontal propagation are lower than those for downward propagation when the source consists of numerous airguns spaced apart from one another, as is the case here.

Acoustic Modeling

Mitigation zones for the proposed seismic survey were calculated based on both modeling by Lamont-Doherty Earth Observatory (L-DEO) and using empirical measurements from Crone et al. (2014) from the Cascadia Margin; the methodology used varied with water depth category (shallow, intermediate, deep). Received sound levels have been predicted by L-DEO's model (Diebold et al. 2010) as a function of distance from the 36-airgun array using a 9-m tow depth. This 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). The mitigation radii for intermediate water depths (100–1000 m) were derived from the deep-water ones (>1000 m) by applying a correction factor of 1.5. For shallow water (<100 m), radii were based on empirically derived measurements in the Gulf of Mexico (GoM) with scaling applied to account for differences in tow depth (see Appendix A in the Environmental Assessment [EA]). Table 3 shows the distances at which the 160 dB re 1µPa_{rms} sound level is expected to be received for the 36-airgun array, based on the modeling; this information was presented in the EA.

TABLE 3. Predicted distances, based on modeling, to which sound levels ≥160-dB could be received during the proposed surveys in the Northeast Pacific Ocean.

Source and Volume	**Tow Depth (m)**	**Water Depth (m)**	**Predicted distances (in m) to the 160-dB rms Received Sound Level**
4 strings 36 airguns 6600 in^3	12	>1000 m	6,733
		100–1000 m	10,100
		<100 m	25,494

For deep water, 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. Thus, modeled radii have to be used for deep water. However, empirical data from an L-DEO study (Crone et al. 2014) that 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 (up to 200 m water depth) could be analyzed to determine in situ sound levels for shallow and intermediate-water depths. This is summarized below as this information was not included in the EA.

Empirical Data for Estimation of Sound Level Distances

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 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 down to ~200 m. To estimate the distances of different sound levels 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 GoM (Tolstoy et al. 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 (e.g., airgun) 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 and intermediate water, both would be significantly less than the modeled data for this region.

The entire 160 dB_{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 160 dB_{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 (Figure 5).

As noted in Table 4 of Crone et al. (2014), the full range of 160 dB_{rms} measured radii for intermediate waters is 4291 m to 8233 m. The maximum 160 dB_{rms} measured radius of 8233 m (represented by a single shot at ~33750 from Fig. 1) was selected for the 160 dB_{rms} measured radius in Table 4. Only two 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 as the radius is conservative.

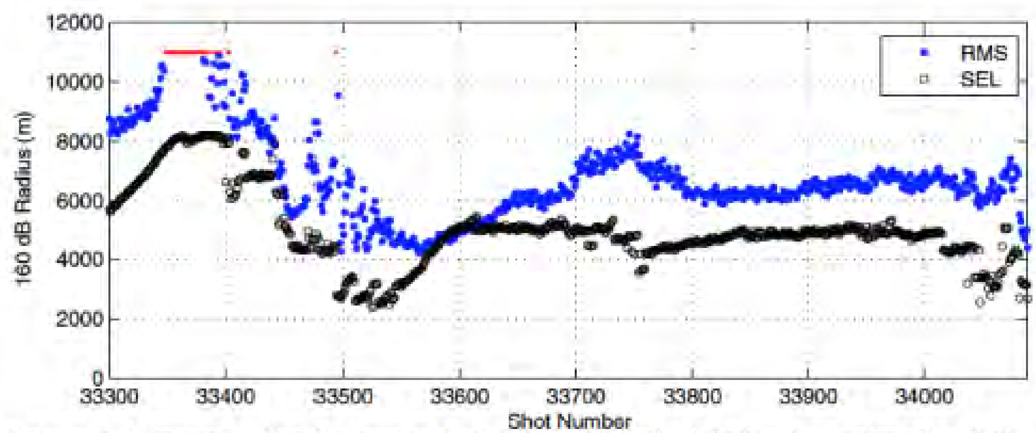

FIGURE 5. Measured radius distances to the 160 dB level for both SEL and rms along line A/T collected in 2012 in Cascadia by R/V *Langseth's* 6600 in^3 airgun array towed at a depth of 9 m (Fig. 12 from Crone et al. 2014). Line A/T extended across the shelf from ~50 m water depth (Shot 33,300), 100 m water depth (Shot # 33,675), out to the shelf break at a depth of 20 0m (~Shot # 34000).

TABLE 4. Comparison of modeled mitigation radii with empirically derived radii from the Cascadia Margin during the 2012 COAST Survey. Radii for both measured 160dB_{RMS} and

$160dB_{SEL}$ are shown with (in red for $160dB_{RMS}$) and without conversion factor for source tow depth. It was not possible to derive deep water radii from the empirical data; thus, the deep-water radius is estimated to be 6733 m, based on modeling.

Array	Water Depth (m)	Proposed CASCADIA PROJECT RADII (using LDEO Modeling)	COAST PROJECT RADII (using LDEO Modeling)	Predicted Cascadia Project Radii using Empirical Data (Crone et al.2014). 160dB RMS Measured distances w/source depth conversion factor are shown in RED			
		Predicted distances (in m) to the 160-dB RMS Received Sound Level Langseth 6600 cu.in @12m	Predicted distances (in m) to the 160-dB RMS Received Sound Level Langseth 6600 cu.in @9m (COAST CRUISE)	Measured Distance (m) @ 160dB SEL from Figure 1 (Figure 12 - Crone et al., 2014)	Measured Distances (m) @160dB SEL w/Conversion Factor (1.15) from 9m to 12m Source Tow Depth	Measured Distance (m) @ 160dB RMS from Figure 1 (Figure 12 -Crone et al., 2014)	Measured Distances (m) @160dB RMS w/Conversion Factor (1.15) from 9m to 12m Tow Depth
4 strings, 36 airguns, 6600 in3	<100 m	25,494	20,550	8,192	9,421	11000*	12,650
	100 - 1000m	10,100	12,200	5478	6300	8233	9468

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

The empirical data collected during the COAST survey on the Cascadia Margin and measured 160 dB_{rms} and 160 dB_{SEL} values demonstrate that the modeled predictions are quite conservative. While we have sought to err on the conservative side for our activities, being overly conservative can dramatically overestimate potential and perceived impacts of the proposed activity.

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.

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[4] 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 ([NSF] have used the mitigation radii based on the empirical data for shallow and intermediate water depths; the deep-water radii are based on modeling (Table 5). 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-dB distance 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.

TABLE 5. Proposed mitigation zone distances for the proposed seismic survey calculated by modeling by L-DEO and using empirical measurements from Crone et al. (2014) from the

[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). [4] The "farfield" describes a sound field beyond the near field limits described above where the sound pressure level (SPL) drops off at the theoretical rate of 6 dB fore very doubling of distance from the source. This rule of thumb is called the Inverse Square Law.

Cascadia Margin; the methodology used varied with water depth category (shallow, intermediate, deep).

Source and Volume	Tow Depth (m)	Water Depth (m)	Distances (in m) to the 160-dB rms Received Sound Level	Distance (in m) to the 202-dB Sound Exposure Level
4 strings 36 airguns 6600 in^3	12	>1000 m 100–1000 <100 m	6,733 9,468 12,650	84

Determination of Cumulative Sound Exposure Levels (SEL_{cum})

The SEL_{cum} for the array was 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. The User Spreadsheet from the National Oceanic and Atmospheric Administration (NOAA) *Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing* was used, but we relied on overriding the default values and calculating individual adjustment factors (dB) based on the modified farfield (see Appendix A of EA). 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). Based on a ship speed of 4.1-4.2 kts and a shot interval of 37.5 m, the radius around the vessel at which marbled murrelets could be exposed to sound levels up to 202 dB SEL was estimated to be 84 m (Table 5).

Seabird Hearing

Depending on received levels (largely a function of distance between source and receiver), portions of the sound frequency spectrum (primarily those in the range of 1-5 kHz) generated by airgun discharges and by the vessel's engine would be audible to seabirds below the water surface. Sounds produced by the other acoustic sources (e.g., multibeam echosounder, sub-bottom profiler, Acoustic Doppler Current Profiler) are believed to be well above the upper frequency limit of bird hearing. As a result, these devices should be inaudible to seabirds. The underwater hearing of seabirds (including loons, scaups, gannets, and ducks) was investigated by Crowell (2016), and the peak hearing sensitivity was found to be between 1500 and 3000 Hz. 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).

Marbled murrelet Distribution

Marbled murrelets are widespread along the Pacific coast and are generally found in nearshore waters, usually within 5 km of shore (Nelson 1997). 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.

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 marbled murrelets (USFWS 2016). Although terrestrial critical habitat has been identified in B.C., Washington, and Oregon, no critical marine habitat has been designated for marbled murrelets to date. Marbled murrelet nesting occurs between late March and August, but the birds remain in the waters of that region 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). They forage near the water surface and in the water column, typically at depths <10 m; however, some birds may dive as deep as 27 m or deeper (USFWS 1997). Foraging dives last from 28–69 seconds (USWFS 1997).

Feeding habitat for marbled murrelets is mostly within 1-2 km of shore in waters up to 50-100 m deep (USFWS 1997). the mean offshore distance over a 3-year tracking study was 1.4 km (Hébert and Golightly 2008). Areas >20 km from shore are hardly used by marbled murrelets (Kuletz 2005; Burger et al. 2008), and Lorenz et al. (2017) noted that pelagic environments >30 km from shore are "never used by marbled murrelets". Nonetheless, marbled murrelets have been observed up to 90 km from shore (Kenyon 2009; Adams et al. 2014; Northrup et al. 2008) on rare occasions. Areas with nesting habitat that was closer to shore and in cool waters had greater probabilities of use than other marine habitat (Lorenz et al. 2016). Adams et al. (2014) reported a density of <0.01 marbled murrelets/km^2 for the continental slope, where waters are 200–2000 m deep.

Potential Effects on Marbled murrelets

The effects of sounds from airguns could include one or more of the following: direct effects such as behavioral disturbance, and at least in theory, temporary threshold shift (TTS) or permanent hearing impairment or threshold shift (PTS), and non-auditory physical or physiological effects, as well as indirect effects. However, investigations into the effects of airguns on seabirds are extremely limited. Much of the information presented below is from 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 here as the PEIS.

Disturbance

There is potential for localized, temporary displacement and disruption of feeding during seismic surveying. However, such displacements could be similar to those caused by other large vessels that pass through the area. Stemp (1985) conducted opportunistic observations on the effects of seismic exploration on seabirds. He did not find any conclusive evidence that seismic surveying affected the distribution or abundance of northern fulmars, black-legged kittiwakes, or thick-billed murres. However, he cautioned that his observations should not be extrapolated to areas with large concentrations of feeding or molting birds. In a more intensive and directed study, Lacroix et al. (2003) investigated the effect of seismic surveys on molting long-tailed ducks in the Beaufort Sea, Alaska. They did not detect any effects of nearshore seismic exploration on molting long-tailed ducks in the inshore lagoon systems of Alaska's North Slope. Both aerial surveys and radio-tracking indicated that the proportion of ducks that stayed near their marking location from before to after seismic exploration was unaffected by proximity to seismic survey activities. Seismic activity also did not appear to significantly change the diving intensity of long-tailed ducks. Neither Stemp (1985) nor Lacroix et al. (2003) observed any bird injuries or mortalities resulting from seismic surveying with airguns. However, African penguins 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.

As it is not possible to determine the distance for the 150 dB re 1 μPa_{rms} rms level from the empirical data, here we can use the conservative modeled 160 dB rms distance as a proxy for shallow water areas. Modeling showed that the 150 dB rms level could be 52.6 km. If the 160 dB rms empirically determined distance is compared to the 160 dB rms modeled distance, it is ~ ½ the size. Thus, we can assume that the empirically derived distance for the 150 dB level would also be ~ ½ of the modeled one, or in this case ~26 km, which aligns with the modeled 160 dB distance of 25.5 km, thus supporting our use of it as a proxy. Sound levels up to 150 dB_{rms} are expected to ensonify nearly all of the marbled murrelet habitat along the coasts of Washington and Oregon (see Fig. 2). Based on a behavioral disturbance radius of 25.5 km, and a vessel speed of 4.1-4.2 knots, it would take the vessel ~7 hrs to travel 51 km or the full diameter of the behavioral disturbance zone. Thus, any location along the coast is expected to be exposed to sound levels >150 dB_{rm} for that amount of time. Also, it is expected that most locations along the coast of Washington could be ensonified only once, but that some locations along the coast of Oregon could be esonified up to two times (during two separate vessel passes) but these passes would occur several days apart [see Description of the Proposed Action, Figure 1].

Using the modeled radii for the 160 dB_{rms} sound level (Table 3), buffers were drawn around all of the transect lines using GIS; the resulting ensonified areas are shown in Table 6. In our analysis, we used within and outside of 8 km as a distance category, as most marbled murrelets are thought to occur within 8 km from shore (as described above). We also used 30 km as a distance category, as marbled murrelets are not expected to occur farther than that offshore (see above). The densities within 8 km from shore are from McIver et al. (2019); densities for areas farther from shore were calculated based on the extent of the marine area and the assumption that ~5% of the marbled murrelet population occurs outside of the areas that are regularly surveyed by USFWS (i.e., farther than 8 km from shore) (Table 6). Population sizes were assumed to be 5600 marbled murrelets for Washington and 11,100 marbled murrelets off Oregon (McIver et al. 2019). Multiplying the ensonified areas with the densities resulted in no exposed marbled murrelets in nearshore waters off Washington, 8,085 exposures in nearshore waters off Oregon, and 458 birds in offshore waters. Thus, we estimate that a total of 8,453 marbled murrelets could be exposed to sound levels equal to or greater than 160 dB_{rms} during the survey.

Table 6. Ensonified areas out to 160 dBrms, and densities for the area off Washington and Oregon.

State	Distance Category	Density (marbled murrelets/km^2)	Ensonified Area (km^2)

Washington	<8 km from coast	1.08[1]	0
Oregon	<8 km from coast	5.34[1]	1514
Washington	8-30 km from coast	0.05[2]	1390
Oregon	8-30 km from coast	0.05[2]	8769

[1]McIver et al. (2019). [2] Based on 5% of the population (835 of 16,700 marbled murrelets) in an area of 16,697 km^2 off Washington and Oregon, between 8-30 km from shore.

However, not all of these individuals would be exposed at the same time and depending on the marbled murrelet's behavior at the time the vessel passes, it may or may not be affected, depending on whether it is foraging or not, as well as other factors. Also, the airguns are expected to operate 24 hours a day off the coast of Oregon, as well as in water >200 m deep off Washington, but marbled murrelets may not forage as much at night (Northrup et al. 2018); in water <200 m deep off Washington, seismic operations would only occur during daytime. In order to determine the risk of an individual being exposed and behaving in response to increased sound levels, it would be important to know the activity budget of individuals (time spent diving/foraging per day). Also, the sound levels are likely to be reduced near the water surface where marbled murrelets forage (typically within 10 m of the surface). In addition, at distances far from the vessel (>8 km) and near the coast, ambient noise from other vessel traffic would be substantial, and airgun sounds would not be expected to add much additional noise.

<u>Acoustic Effects</u>

Marbled murrelets feed by diving to depths of several meters or more, and alcids often escape from approaching boats by diving. Therefore, it is theoretically possible, though considered highly unlikely, that during the course of normal feeding or escape behavior, some birds could be near enough to an airgun to experience a threshold shift by a pulse if they dove relatively deep (>10 m) directly beneath the array. However, there is no evidence for such effects if they occur, and there is no specific information available about the circumstances (if any) where this might occur. Furthermore, it is considered highly unlikely that marbled murrelets would dive near enough to a sound source to experience hearing impairment. Lloyd's Mirror Effect further reduces the potential for PTS and TTS. Lloyd's Mirror Effect serves to reduce acoustic energy (i.e., sound levels) at and just below the water surface where seabirds occur and/or feed. In addition, the received level at the ears of the marbled murrelet would be a lot lower than the level in the water because there is a 'bubble curtain' around the birds held by their feathers.

Although there appears to be minimal risk of an acoustic effect or injury on diving marbled murrelets, it was determined how many marbled murrelets may occur within the zone around the vessel where sound levels could be loud enough (202 dB SEL) to cause potential injury. Within this distance (~84 m; see above), it is thought there is potential risk for injury or PTS. As all vessel transects occur farther than 8 km from shore (and farther than 21 km from shore off Washington), sounds at this level are not anticipated to impact the majority of habitat used by marbled murrelets along the coasts of Washington and Oregon. Thus, no injurious effects are expected to occur within 8 km from shore, where densities are highest. Although most marbled murrelets occur within 2 km from shore (as noted above), we are using 8 km here, as that is the maximum distance from shore that marbled murrelet surveys occur (Raphael et al. 2007). In addition, USFWS noted that marbled murrelets generally occur within 8 km from shore and in water <60 m deep.

Using GIS, the 84 km buffer was drawn around all proposed seismic transects in U.S. waters. None of the ensonified area is located within 8 km from shore. If the offshore density (0.05 marbled murrelets/km^2) is multiplied by the area expected to be ensonified during the survey at a distance of 8 to 30 km from shore (106 km^2), that results in an estimate of 5 marbled murrelets that could potentially be exposed to sound levels of 202 dB SEL or greater.

Depending on the marbled murrelet's behavior at the time the vessel passes, it may or may not be affected, depending on whether it is foraging or not, as well as other factors. Also, the airguns are expected to operate 24 hours a day off Oregon and in water >200 m deep off Washington, but marbled murrelets may not forage as much at night (Northrup et al. 2018). In order to determine the risk of an individual being exposed and behaving in response to increased sound levels, it would be important to know the activity budget of individuals (time spent diving/foraging per day). Also, the sound levels are likely to be reduced near the water surface where marbled murrelets forage (within 10 m of the surface), and because there is a 'bubble curtain' around the birds held by their feathers. For these reasons, even though 9 takes were calculated based on density and area potentially ensonified, injurious takes would not be anticipated by the proposed action.

Indirect Effects

If airguns disorient, injure, or kill prey species, or otherwise increase the availability of prey species to marbled murrelets, a seismic survey could attract birds to within ~10 m of active airguns. Birds very close to an airgun may be at risk of induced PTS or other injury due to the intense pressure pulses of the airgun discharges at such close range. However, available evidence from other seismic surveys utilizing airguns has not shown a pattern of fish (or other prey) kills from airguns (see Section 3.3, in PEIS). Also, during thousands of hours spent conducting biological observations from operating seismic vessels, observers have seldom seen birds being attracted to an airgun array.

Summary

There are no scientific data indicating or suggesting that seabirds are adversely affected by seismic airguns or other sound sources used during the proposed seismic surveys. Moreover, thousands of hours of observational data by protected species observers during numerous seismic surveys throughout the world suggest that seabirds do not remain in the water near the airgun array where they would be at potential risk of injury. No marbled murrelets, or impacts to this species, were observed during a similar seismic survey conducted in 2012 or a low energy survey conducted in 2017. In decades of seismic surveys carried out by R/V *Langseth* and its predecessor, the R/V *Ewing*, observers and other crew members have seen no seismic sound-related seabird injuries or mortality. In addition, the Lloyd's Mirror Effect serves to reduce acoustic energy (i.e., sound levels) at and just below the water surface where seabirds occur and/or feed. Thus, the potential for acoustic sources associated with the proposed seismic surveys to injure seabirds is considered insignificant. Although these activities could affect marbled murrelet behavior above the water, such effects are considered short-term and negligible to individuals and populations. 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 unlikely event an ESA-listed seabird was observed diving or foraging within the designated EZ.

[End of NSF analysis.]

Additional USFWS Analysis

The following analysis addresses USFWS assumptions, analysis, and conclusions specifically with regard to observer success, sound impacts, marbled murrelet foraging behavior, marbled murrelet density estimates, and resulting effects that vary from that of the NSF analysis above.

The NSF analysis above provides an exposure analysis and estimates the number of marbled murrelets that may be exposed to SPLs that are likely to cause physical injury or behavioral responses. The below analysis will address whether that exposure is likely to lead to actual adverse effects and take of marbled murrelet. The Service does not agree with the NSF assessment that there is minimal risk of an acoustic effect or injury on diving marbled murrelets, that 202 dB SEL is expected to cause potential rather than actual injury, or that no injurious effects are expected to occur within 8 km from shore where marbled murrelet densities are highest. Furthermore, the Service does not concur with the NSF assessment that there is no scientific data indicating or suggesting that seabirds are adversely affected by seismic airguns. Nor does the Service concur with the NSF conclusion that the potential for acoustic sources associated with the proposed seismic surveys to injure seabirds is considered insignificant.

Injurious Effects of Underwater Sound Pressure

Data specific to seabirds is primarily limited to evaluations of the effects of underwater blasting and seismic testing (Yelverton and Richmond 1981, p. 3; Cooper 1982; Stemp 1985; Flint et al. 2003; Lacroix et al. 2003). Monitoring of seabird response to pile driving for bridge and ferry terminal projects in Washington has generated some information on seabird responses to pile driving and has documented behaviors that could be indicative of physiological effects. During replacement of the Hood Canal Floating Bridge a pigeon guillemot (*Cepphus columba*) dove within 75 meters of impact pile driving, surfaced quickly, was shaking its head, and appeared to have difficulty getting airborne (Entranco and Hamer Environmental 2005,p. 21). In 2007, monitoring staff at the Anacortes Ferry Terminal replacement project detected a marbled murrelet within 20 meters of active pile driving. The bird was behaving aberrantly. It drifted very close to shore, was listing to one side, and was paddling with only one foot. While most seabirds were leaving the area during pile driving this bird did not dive or fly. After a few minutes the marbled murrelet attempted to fly but had difficulty getting airborne (WSF 2007, pp. 4-57). These observations suggest how affected seabirds might behave when exposed to elevated underwater sound pressure levels. It is impossible to estimate the exact "dose" of underwater sound pressure that these observed seabirds might have received, other than to note that they were detected within a zone where we would have expected exposure to injurious levels of underwater sound.

Faced with the absence of controlled studies of underwater sound and pressure effects from explosions specific to seabirds we utilize evaluations of the effects of other types of underwater sounds on a variety of vertebrate species provide the basis for evaluating the effects of the high SPLs generated by pile driving on marbled murrelets. High levels of underwater sound are known to have negative physiological and neurological effects on a wide variety of vertebrate species (Yelverton et al. 1973; Yelverton and Richmond 1981; Gisiner et al. 1998; Cudahy and Ellison 2002; U.S. Department of Defense 2002; Hastings and Popper 2005). Experiments using underwater explosives found that rapid change in underwater SPLs resulted in internal hemorrhaging and mortality in submerged mallards *(Anas platyrynchos)* (Yelverton et al. 1973, p. 49). During seismic explorations, it has been noted that seabirds were attracted to fishes killed as a result of the seismic work (Fitch and Young 1948; Stemp 1985). Fitch and Young (Fitch and Young 1948) found that diving cormorants were consistently killed by seismic blasts, and pelicans were frequently killed, but only when their heads were below water.

In general, risk of injury from exposure to underwater SPLs appears related to the effect of rapid pressure changes, especially on gas-filled spaces in the bodies of exposed organisms (Turnpenny et al. 1994; Gisiner et al. 1998, p. 61). Examples of gas-filled structures in vertebrate species are swimbladders, bowel, sinuses, lungs, etc. As a sound travels from a fluid medium into these gas-filled structures there is a dramatic drop in pressure which can cause rupture of the hollow organs (Gisiner et al. 1998, p. 61). Biologically, key variables that factor into the degree to which an animal is affected include size, anatomical variation and location in the water column (Gisiner et al. 1998, p. 61). Observation of foraging marbled murrelets during impact pile driving at one project in Washington revealed that marbled murrelets will come fairly close (within 300 m) to active pile driving operations and continue to dive and forage despite elevated underwater sound (Entranco and Hamer Environmental 2005), thus there is a potential for exposure to injurious SPLs.

Injuries from high underwater SPLs can be thought of as occurring over a continuum of potential effects ranging from mortality to sub-lethal physical effects including TTS. At the most severe end of the spectrum, direct mortality or obvious injuries can occur. .

In July 2011, a Science Panel recommended thresholds for marbled murrelets for onset of non-injurious TS in hearing, onset of auditory injury, and onset of non-auditory injury (barotrauma) (SAIC 2011). In March 2012, in response to the lack of data regarding non-injurious threshold shift (TS) and masking effects that occur to marbled murrelets from pile driving, the Service and the Navy convened Science Panel II to evaluate the onset of non-injurious TS (SAIC 2012). Thresholds recommended were:

- Non-injurious TS of 187 dB SEL re: 1 µPa2-sec
- Auditory injury threshold of 202 dB SEL re: 1 µPa2-sec
- Barotrauma at 208 SEL re: 1 µPa2-sec

In the absence of established thresholds related to effects from underwater explosions, the Service has in the past used these thresholds, derived specifically for pile driving, for the few consultations and/or technical assistance recommendations provided for projects involving explosives.

For purposes of this analysis, effect thresholds for underwater explosions are used because application of the pile-driving effect thresholds is not entirely appropriate. While both explosive and airgun stressors differ both in magnitude and the mechanism of effect, explosives more closely emulate airgun effects. Like an underwater explosion, an airgun produces a pressure wave that radiates quickly from the detonation site. However, the strength of this wave depends on the type and amount of explosive force, the location of the airgun in the water column, and the distance from the source (the strength of the airgun pressure wave dissipates with increasing distance). The typical blast pressure wave from an explosive source consists of an instantaneous increase of the peak pressure, followed by a slower (but still very rapid) logarithmic decrease to ambient pressure.

The pressure wave can be displayed as a waveform that describes the pressure-time history, where time is measured in milliseconds or seconds and pressure is measured in micropascals (μPa).

Underwater exposure to explosions can result in barotrauma, mortality, and auditory damage, but severity of injury may vary based on type of explosion and distance from the explosion. For example, if animals are close enough to the detonation, resulting SPLs may cause injuries to lungs, livers, eyes, gastrointestinal tract, ears, kidneys, air sacs and other organs. The animals' proximity to the explosion will influence the severity and nature of their injuries. Explosive impulses behave differently underwater than in the air because of the different properties of air versus water. Sound travels much faster underwater than in air, so the potential "areas where injury may occur" or "ranges to thresholds" are different when explosions occur in the air versus underwater. Animals will be similarly injured by exposure to an explosion depending on 1) their physiological characteristics, 2) proximity to the explosion, 3) charge weight of the explosive and the energy released upon detonation, and the 4) medium the explosion occurs in (air or water, or both).

When animals are exposed to explosions, behavioral responses can range from stress to avoidance or fleeing the area. Allostasis is the process through which organisms maintain stability by actively adjusting behaviorally and physiologically to both predictable (e.g. seasonal changes) and unpredictable events (e.g. storms, predation) (Korte et al. 2005; Mcewen and Wingfield 2003). A classic stress response begins when an animal's central nervous system perceives a potential threat to its homeostasis, thereby triggering a biological response that consists of a combination of behavioral responses, autonomic nervous system responses, and neuroendocrine responses (Buchanan 2000). When stress responses are repeated or chronic, allostatic loading occurs. Allostatic load refers to the cumulative wear and tear on the body as adrenal hormones, neurotransmitters, or immuno-cytokines are released in response to the event. The benefits of allostasis and the costs of allostatic load produce trade-offs in health and disease. In the case of many stressors, an animal's first and most economical response (in biotic terms) is behavioral avoidance of the potential stressor or avoidance of continued exposure to a stressor. An animal's second line of defense to stressors involves the autonomic nervous system and the classical "fight or flight" response which produces changes in heart rate, blood pressure, and gastrointestinal activity (Buchanan 2000; Korte et al. 2005; Mcewen and Wingfield 2003) that humans commonly associate with stress. These responses are relatively short in duration and may or may not involve significant long-term effects on an animal's fitness. When an animal does not have sufficient energy reserves to satisfy the energetic costs of a stress response, energy resources must be diverted from other biotic functions, which, in turn, impair those functions that experience the diversion. For example, when a stress response diverts energy away from growth in young animals, those animals may experience stunted growth. A stress response diverts energy away from egg production, an animal's reproductive success and its fitness may suffer.

The behavioral and physiological reactions to short- versus long-term stress can vary in extent and consequence. The rapid onset of an unpredictable event, such as a predatory attack, will bring on stress responses that are designed to aid an animal immediately. Stress continuing over longer periods (i.e. days to weeks) may result in deleterious chronic effects like increased susceptibility to fatigue and disease (Buchanan 2000).

Relationships between the physiological response mechanisms, animal behavior, and the costs of stress responses have been documented in seabirds (Holberton et al. 1996; Hood et al. 1998; Kitaysky et al. 1999) and a variety of other vertebrates (Jessop et al. 2003; Krausman et al. 2004;

Romano et al. 2004; Smith et al. 2004a; Smith et al. 2004b). These stress responses are expected from exposure to the following events in which multiple-per-day activities occur; detonations, helicopters in marine waters, and the overflights occurring over nesting habitat in the terrestrial environment. We anticipate that when birds experience permanently reduced hearing sensitivity (TS) or repeated exposure to detonations, they may experience additional physiological effects, including increased risk of predation, reduced reproductive success, and reduced foraging efficiency. Marbled murrelets experiencing TS may not be able to detect biologically relevant sounds such as approaching predators or prey, and/or hear their mates or young attempting to communicate. Marbled murrelets that lose their hearing sensitivity are at increased risk of predation and reduced foraging efficiency. Some affected marbled murrelets may regain some or all of their hearing sensitivity; however, they are still temporarily at risk while experiencing TS

The NSF use of airguns will be repetitive but interspersed over a large area. The stressors associated with explosives are typically short in duration. In the event that marbled murrelets are exposed to airguns and not injured or killed, we expect that they will respond with a startle response, flushing, and/or avoidance behaviors (i.e., diving, or leaving the area). Whether these behavioral responses result in a measurable effect to individuals depends largely on the duration of the exposure.

Behavior of Compressed Air Seismic Sources

It is important to acknowledge that "airguns" are not guns in that they do not produce an explosive type of force, and while airguns do emit high SPLs, they do not produce the same energy as a typical explosion (e.g., from ordinance), nor in this case are they used in open air; rather they are more accurately characterized as "compressed air underwater seismic sources." Typically, a compressed air source (airgun) has two air chambers around a piston. Air from one chamber is redirected, pushing the piston out of the way and allowing the release of air which forms a bubble, thereby generating sound created by the expansion and contraction of the bubble (Gisiner 2016, pg. 11). However, the bubble has little to do with the propagation of the sound; rather most of the acoustic energy coming from the compressed air source occurs the fraction of a second before the air expands (Gisiner 2019, entire). The compressed air pushing water out of the way initiates the sound or pulse. A directed pulse of air (or sound) is only achieved when multiple airguns are configured in an array (Massa 1989, entire) combining the pulses from multiple sources and has the effect of cancelling out high frequency sound (Gisiner 2019, entire). While the sound is directed at the sea floor, lateral sound is also expected at multiple low frequencies. The sound propagation effects from a compressed air source behave differently than that of an underwater ordinance explosion or pile-driving in that sound levels near the sound source are relatively "slow" and do not produce a shock wave compared to that of an explosive or pile strike (Gisiner 2019, entire). Lack of a significant shock wave limits the barotrauma effect on animals compared to explosives or pile-driving. The sound also tends to spread out and becomes less "peaky" over distance, which has the effect of minimizing the impact on "masking" the ability of animals to communicate (Gisiner 2019, entire). The seismic source is focused on generating low frequency energy, well below the hearing limit of most animals. Therefore, impacts from the seismic sound source result primarily from the particle motion of the pulse nearest to the source (Gisiner 2019, entire). In the water column, as the sound moves further away from the source, it attenuates significantly from a sharp pulse to a tone (Gisiner 2019, entire). These differences between explosive ordinance and airgun effects are expected to affect exposure distances and level of injurious effect. However, the SPLs produced by airguns have been shown to cause significant injury to seabirds at close range, and the Service concludes marbled murrelets exposed to the SPLs referenced above are reasonably likely to be injured or killed.

Observer Success

During a 2019 seismic survey of the Axial Seamount (RPS 2019, pg. 3), which is located within the action area of the proposed action herein, there were no sightings of protected ESA-listed seabirds. However, the likelihood of listed seabird presence and risk of exposure is exponentially greater for the proposed west coast seismic survey because the scope of this action is much greater (6,540 km of transect lines covered for 37 days of seismic operations). Furthermore, due to the detectability factors discussed above and below, the lack of observed marbled murrelets during prior surveys does not sufficiently predict the exposure risk. Marbled murrelets could be foraging in the area of greatest sound/impact when the operations are within their marine habitat use areas. Survey activities are operating 24 hrs per day, with only passive acoustic monitoring during hours of darkness. Passive acoustic monitoring does not detect seabirds. We know that marbled murrelets primarily forage at night, in particular we know that adults feeding chicks are obtaining fish prior to predawn flights inland during the breeding season (when this project is occurring). Operations can occur in sea conditions (> Beaufort sea state 2) that result in reduced ability of observers to detect marbled murrelets. Marbled murrelets are unlikely to be detected during nighttime operations (pre-dawn and post-sunset foraging times) and may go undetected by observers during daytime operations; power down/shut down procedures would not occur when marbled murrelets go undetected. Generally, detection of marbled murrelets will be limited by vessel speed, visibility, sea state, observer experience and the number of observers, and observations can be expected to drop off with distance (Raphael et al. 2007; Mack and Raphael 2002; Becker et al. 1997). These assumptions suggest that the validity of marbled murrelet density survey results and observer detection success may be enhanced if more observers are involved. Hoekman et al. (2011) recommend the use of two observers, periodic calibration of detection near the transect center line and its incorporation into density estimates, and the use of skilled observers coupled with analytic methods to account for unidentified marbled murrelets.

It is likely in relatively good conditions that the observers should be able to effectively monitor and implement shut down procedures in the zone where the greatest potential for marbled murrelet injury may occur at a distance of ~84 m from the source where they would be exposed to sound levels of 202 dB SEL or greater sound levels at distances closer to the source. However, detection success is expected to be limited in poor visibility conditions when marbled murrelets may be most actively foraging (twilight and dawn).

NSF also claims that thousands of hours spent conducting biological observations from operating seismic vessels, observers have seldom seen birds being attracted to an airgun array. While we find it reasonable to assume birds may not be attracted to an airgun array, particularly one in operation, it is reasonable to assume birds would be attracted to the vessel lighting. Under the proposed action, the vessels will have downward pointing lighting which is expected to limit physical seabird interactions with the vessels. While observers will be present on the R/V *Langseth* to make note of any seabird interactions with the vessel, the R/V *Oceanus* would not be involved in the seismic survey other than instrument deployment/retrieval and this work will be done when the vessel is in a stationary position. On that basis, we do not anticipate significant adverse effects resulting from marbled murrelet interactions with the R/V *Oceanus*. However, it is possible that a very limited number of marbled murrelets that may be present could be attracted to and disoriented by vessel lighting, resulting in collisions and potential injury. In the event of such events, we anticipate a likelihood that a marbled murrelet will be handled by trained observers if it becomes injured and unable to fly away on its own. Although we cannot predict to what extent vessel/marbled murrelet interactions may occur, if at all, observers onboard the R/V *Langseth* will be expected to report any such instances. Based on the above discussion, the Service anticipates the ability of the observer program to minimize marbled murrelet exposure to injurious effects from airguns will have limited success.

Influence of Climate on Action Affects and Prey Availability

Variability in winds, sea surface temperatures, and sea level pressures affect upwelling and marine productivity in the CCS. Year-to-year variability (e.g., El Niño) and longer-term regime shifts (e.g., Pacific Decadal Oscillation) can have consequences for seabird diet and foraging areas. During strong El Niño events, coastal upwelling winds are reduced, there is an intrusion of offshore subtropical water, surface waters are warmer and more nutrient-poor than usual, and there can be dramatic declines in primary and secondary production that can lead to poor recruitment, growth, and survival for many resident species. It is common to have northward range extensions of many tropical species during El Niño events. During La Niña events, the reverse is generally true, with colder, more nutrient-rich waters present. Many studies have shown that reliance on different suites of prey species due to environmental conditions can impact seabird productivity (e.g., Ainley et al. 1995, Sydeman et al. 2006, Wells et al. 2008, Wolf et al. 2009, Cury et al. 2011, Thompson et al. 2012). In general, cold water events or cold ocean phases have been linked to greater prey availability for breeding seabirds (Ainley et al. 1995, Veit et al. 1997, Hyrenbach and Veit 2003, Ainley and Hyrenbach 2010), though a combination of ocean processes operating at various temporal and spatial scales ultimately determine foraging opportunities. The 2020-2021 La Niña event appears to have peaked in October-December as a moderate strength event (WMO 2021, pg. 1). The latest forecasts for waters off Oregon and Washington suggest upwelling, surface temperatures, and bottom oxygen will return to near "characteristic" or normal conditions by the April-June 2021 season (WMO 2021). Lower sea surface temperatures and strong upwelling events have strong positive influences on fish populations (Desimone 2016). Marbled murrelets are likely to forage farther from nesting sites during El Niño years when prey availability is low for reasons other than a lack of upwelling (Becker and Beissinger 2003). Given this project will be occurring from late-May through July of 2021, it is reasonable to suggest that relatively neutral or improved nearshore foraging conditions will be present for the marbled murrelet during this time frame due to the lack of a negative El Niño effect on these resources, thereby reducing the potential for higher exposure levels predicted by NSF. While not expected to eliminate significant marbled murrelet exposure to SPLs, it is reasonable to assume a greater concentration of marbled murrelets are likely to be foraging within nearshore waters and further away from the sound source.

NSF makes a somewhat misleading claim that available evidence from other seismic surveys utilizing airguns has not shown a pattern of fish (or other prey) kills from airguns. While research has not shown fish mortality from airguns, temporary threshold shifts (hearing loss) have been demonstrated repeatedly (Popper et al. 2005, pg. 1; Song et al. 2008, pg. 1), and these studies cannot not be extrapolated to other fish species and or exposure to a larger number of airgun shots in deeper water and over a longer period of time (Popper et al. 2005, pg. 1). As such, the primary concern with airguns and forage fish availability for marbled murrelets is not mortality, but the temporary loss of hearing (TS) in the affected fish causing a behavioral response by the fish, such as diving into deeper water until the sound source has diminished. This in turn could lead to reduced overall marbled murrelet foraging success rates, which is likely to increase the likelihood of also negatively affect breeding success (reduce individual fitness). Overall, while it is likely marbled murrelet foraging bouts are likely to be interrupted when birds are exposed to significant SPLs, the effects of the proposed action on prey availability is expected to be temporary and limited.

Likelihood of Exposure and Response to Effects of Airguns

In developing their exposure estimates, the NSF analysis does not consider the potential for reduced exposure due to shut down procedures should a marbled murrelet be detected, thereby assuming only a potential for successful detections. Marbled murrelets forage near the water surface and in the water column, and as mentioned in the NSF analysis above, typically at depths <10 m. However, marbled murrelets may dive as deep as 27 m or deeper (USFWS 1997, entire). It is possible they are capable of diving to a depth of 47 m (157 ft) based on their body size and diving depths observed for other alcid species (Mathews and Burger 1998, p. 71). The NSF analysis also suggested the sound level received at the ears of the marbled murrelet would be a lot lower than the level in the water because there is a 'bubble curtain' around the birds held by their feathers. The Service concludes this factor may provide far more limited protection than appears to be presumed by the NSF, it remains likely that some marbled murrelets are likely to be exposed to significant injurious effects when diving within 84 m of airgun operations. However, while not proposed by the NSF, research has shown that an induced bubble curtain concentrated around the air-gun ports could be an efficient and practical solution to reduce the high-frequency acoustic emission from air guns (Wehner and Landro, 2020, pg. 1; Teachout, 2012, entire).

Permanent Injury or Mortality - Using the 84 km buffer drawn around all proposed seismic transects in U.S. waters where sound levels would be 202 dB SEL or greater, NSF asserted none of the ensonified area is located within 8 km from shore. NSF used this information to estimate 5 marbled murrelets would be potentially exposed based on their offshore density (0.05 marbled murrelets/km^2) multiplied by the area expected to be ensonified during the survey at a distance of 8 to 30 km from shore (106 km^2). Then NSF inexplicably suggested that their exposure analysis results indicated 9 potential takes based on marbled murrelet density and area potentially ensonified, and that injurious takes would not be anticipated by the proposed action. We have to assume the "9" takes was a typo, and the "takes" would have been more correctly assessed by NSF as the number of birds potentially exposed to adverse effects that may lead to incidental take; and although exposure does not directly extrapolate to an adverse effects leading to incidental take, NSF offers no support for their finding that this level of exposure would not result in any injurious effects. Furthermore, the NSF failed to acknowledge the proposed action would occur in waters 60 to100 m deep (only off a portion of the coast of Oregon), well within the area known to be commonly used by marbled murrelets likely exposing a greater proportion individual birds there to 202 dB SEL or greater.

These exposure estimates are offset by the fact that not all marbled murrelets are on the water at all times, not all marbled murrelets on the water will be diving, and birds some may simply move away from the sound source. However, based on the above information and analysis, we believe it is reasonably likely that one or more marbled murrelets across the entire survey area are likely to be exposed significant injury due to high SPLs, but this level of impact will not significantly reduce marbled murrelet numbers or distribution in the action area or range wide.

Temporary Injury or Behavioral Changes - Areas may be ensonified more than once and any single point may be ensonified at or above the 160 dB behavioral response threshold for a maximum of 6.5 hours. The Service established thresholds for onset of behavioral changes to marbled murrelets from underwater explosions at 150 dB. However, the NSF were unable to provide model results to the 150 dB level as the overly conservative inputs combined with the exponential factoring result in exaggerated and unrealistic results. The NSF cited strong empirical data that supports analysis to the 160 dB isopleth and noted the empirical data does not readily support deriving the 150 dB isopleth. Also, given that the behavior of underwater compressed air explosions is less violent compared to the detonation of underwater ordinance or pile-driving, the exposure threshold for significant marbled murrelet behavioral changes in response to compressed air emissions from airguns at 150 dB appears reasonable if not conservative. Marbled murrelets that experience TS from exposure to airgums at 150 dB are expected to have damaged hair cells in their inner ears and, as a result, may not be able to detect biologically relevant sounds such as approaching predators or prey, and/or hear their mates or young attempting to communicate. Marbled murrelets that lose their hearing sensitivity are at increased risk of predation and reduced foraging efficiency. Some affected marbled murrelets may regain some or all of their hearing sensitivity; however, they are still temporarily at risk while experiencing TS. Even birds not experiencing TS are likely to experience interrupted foraging bouts or resting attempts, which creates a likelihood of injury by significantly disrupting normal behaviors (as a result of their diving repeatedly or vacating the area). Foraging efficiency is likely to be reduced, and energy expenditures are likely to be increased above normal when they flush and/or relocate out of the area. Marbled murrelets are also likely to increase their diving efforts in response to these lost foraging opportunities, or to replace prey dropped or swallowed, or to escape from perceived predator.

NSF estimates that a total of 8,453 marbled murrelets may be potentially exposed to sound levels equal to or greater than 160 dBrms during survey operations. This level of exposure is based on prior marbled murrelet density estimates that typically vary across years and are subject to assumptions as well. Furthermore, a behavioral response to exposure at these sound levels may not always directly translate to adverse impacts because many of these responses are expected to be insignificant. Although marbled murrelets may not generally be expected to move away when approached by an oncoming vessel or increasing sound levels, it is not unreasonable to assume a number of birds may simply move away from the oncoming sound source as it comes closer and the airguns are firing at short intervals. As discussed above, except in the hours before sunrise and after sunset, nesting marbled murrelets are not expected to be on the water at night. It is not reasonable to assume all 8,453 potentially exposed marbled murrelets will be on the water 24 hours per day, or for those that are on the water, diving 24 hours per day, as they may spend substantial time periodically loafing. For these reasons, during the course of the survey it is unlikely that all 8,453 marbled murrelets will be exposed in a manner that results in significant impacts to individual birds from behavioral changes that may temporarily reduce foraging or reproductive success. However, for a subset of marbled murrelets, it is reasonable to assume exposure will lead to a likelihood of adverse behavioral effects.

Individual marbled murrelets that experience TS from exposure to explosions are expected to have damage to the hair cells in their inner ears and may not be able to detect biologically relevant sounds such as approaching predators or prey, and/or hear their mates attempting to communicate. Birds with reduced hearing sensitivity are at increased risk of predation and reduced foraging efficiency. Some birds may regain some or all of their hearing sensitivity; however, they are still temporarily at risk while experiencing TS. Additionally, marbled murrelets that are exposed to explosives but do not experience TS may respond by flushing or temporarily ceasing to forage; however, these birds are expected to return to normal behaviors in a short period of time. For individual marbled murrelets that are exposed to explosions but not injured or killed, we expect a startle response, flushing, or avoidance (i.e., diving, or leaving the area).

For uninjured individuals exposed to single unwater explosive events, these responses would be short term and we would not expect significant disruptions to their normal behavior that would create a likelihood of injury. However, since the seismic survey will result in repeated SPLs in close proximity along a transect, it may result in significant disruptions to a marbled murrelet's normal foraging behavior, potentially reducing individual fitness or their ability to feed a chick. As such foraging success may be temporarily reduced for birds that are actively foraging in areas where the proposed action is producing sound at or above the 160 dB behavioral response threshold. However, due to the unpredictable variables discussed above, the actual number of marbled murrelets likely to be adversely affected in this manner is difficult to estimate with any credible precision. Therefore, we anticipate the number of marbled murrelets adversely affected is likely to be much less than the number potentially exposed as calculated by NSF in the above analysis.

<u>Effects of other Acoustic Sources</u>

In addition to the operations of the airgun array, a multibeam echosounder (MBES), a sub-bottom profiler (SBP), and an 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. The R/V *Oceanus* would operate a single-beam dual-frequency echosounder (4 and 12 kHz) and an ADCP.

The NSF EA and the PEIS did not indicate there was a potential for effects from use of MBES, SBP and ADCP on seabirds, focusing primarily on marine mammals, sea turtles and invertebrates (NSF 2019; USGS 2011). MBES instruments have been used to track fish schooling, detection of deep-sea animals, and predator-prey interactions of marine animals (Williamson et al 2016, entire; Dunlop et al. 2018, entire; Waggitt et al. 2016, entire). The PEIS suggested sounds produced by the MBES, SBP, and ADCP are believed to be well above the upper frequency limit of bird hearing, suggesting these devices should be inaudible to seabirds, but due to the lack of underwater audiograms for seabirds, this cannot be known with certainty (USGS 2011).

The ocean floor would be mapped with the Kongsberg EM122 MBES. The Kongsberg EM122 MBES operates at 10.5–13 kHz and is hull-mounted on the R/V *Langseth*. The maximum source level is 242 dB re 1 µPa·rms. Each ping consists of eight (in water >3,281 ft [1,000 m] deep) or four (<3,281 ft [1,000 m]) successive fan-shaped transmissions, each ensonifying a sector that extends 1° fore–aft. Continuous-wave signals increase from 2 to 15 ms long in water depths up to 8,530 ft (2,600 m), and FM chirp signals up to 100 ms long are used in water >8,530 ft (2,600 m) in depth. The successive transmissions span an overall cross-track angular extent of about 150°, with 2-ms gaps between the pings for successive sectors. The high frequency sound emitted by the MBES (10.5-13 kHz) is expected to be within the hearing range of marbled murrelets (10 and 11.5 kHz, see Nelson 1997; Sanborn et al. 2005; SAIC 2012). Furthermore, the maximum source level of 242 dB is well within the range (202 dB) expected to cause similar auditory and other physical injuries to marbled murrelets as described above for the airguns, so marbled murrelets diving near the source are likely to be significantly affected. However, depending on the distance the airgun array is towed behind the vessel (50-200 m) the effects of the airguns on marbled murrelets at the source could be greater.

The ocean floor would also be mapped with the Knudsen 3260SBP which transmits a beam as a 27° cone directed downward by a 3.5-kHz transducer in the hull of the R/V *Langseth*. The nominal power output is 10 kilowatts (kW), but the actual maximum radiated power is 3 kW or 222 dB re 1 µPa-m. The ping duration is up to 64 ms, and the ping interval is 1 s. A common mode of operation is to broadcast five pulses at 1-s intervals followed by a 5-s pause. The low frequency sound emitted by the SBP is not withing the hearing range of marbled murrelets (10 and 11.5 kHz, see Nelson 1997; Sanborn et al. 2005; SAIC 2012), though the maximum sound source level of 222 dB is well within the range (202 dB) expected to cause similar physical injuries to marbled murrelets as described above for the airguns, so marbled murrelets diving near the source are likely to be significantly affected. However, the exposure is mitigated by the narrowly directed beam (27° cone), and depending on the distance the airgun array is towed behind the vessel (50-200 m) the effects of the airguns on marbled murrelets at the source could be greater.

An ADCP would be used to calculate speed of the water current, direction of the current, and the depth in the water column of the current. The ADCP would transmit frequencies at 35-1,200 kHz, also not expected to be within the hearing range of marbled murrelets. Some research has occurred for effects of ADCP instrument (sonar or "pingers") operations on seabirds. For example, Melvin et al. (1999) found that underwater acoustic pingers operating at 1.5 kHz (±1 kHz) at a signal duration of 300 ms (±10%) every 4 s (±10%) at 120 dB re 1 µPa deterred diving seabirds (common murre and rhinoceros auklet; family Alcidae) from gill nets used to catch salmon. When high-frequency sonar (greater than 10 kHz) is used, we expect that marbled murrelets can hear the sonar when the frequencies are between 10 and 11.5 kHz (Nelson 1997; Sanborn et al. 2005; SAIC 2012). Therefore, we do not anticipate marbled murrelets will be able to hear the sound produced by the ADCP, nor is the sound pressure level expected to result in significant behavioral changes (TS or TTS) near the source of the ADCP transmitter.

The effects of some of the other acoustic sources addressed above are expected to result injury ot behavioral impacts to individual marbled murrelets. However, since these effects will be taking place in the same area where airgun effects will occur, we anticipate little to no additional significant impacts to individual marbled murrelets are likely to occur beyond that discussed for the airguns.

Other Possible Effects of Seismic Surveys

Other possible effects of seismic surveys on marbled murrelets could 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 marbled murrelets in the proposed survey area. The vessel will be traveling at a fairly slow speed of 4.1-4.2 knots (~6 mph) during seismic surveys. 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. Vessels have combustion engines which produce low-frequency, broadband underwater sound. 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). While the sound levels originating from operation of the vessels may be detectable by marbled murrelets, these sounds are transient and of a relatively short duration such that measurable effects are not anticipated. Therefore, effects of vessel noise on marbled murrelet are considered insignificant.

Summary of Key Findings of Effects of the Proposed Action on the Marbled murrelet

In the analyses presented above, the estimated areas of exposure encompass the full range of adverse effects, from temporary threshold shift to direct mortality. A very small number of individual marbled murrelets that are exposed to elevated sound pressure levels caused by the seismic surveys are likely to be killed or injured depending on their proximity to the source of these stressors. Possible injuries include loss in hearing sensitivity (TS), scarred or ruptured eardrums, or gastrointestinal tract lesions. Although affected marbled murrelets may survive their exposure to these and other stressors, they are likely to have a reduced level of fitness and reproductive success and have a higher risk of predation. Exposed individuals may also experience lethal injuries that occur instantaneously or over time, direct mortality, lung hemorrhaging, ruptured livers, hemorrhaged kidneys, ruptured air sacs, and/or coronary air embolisms.

Marbled murrelets that are expected to experience TS are expected to have damaged hair cells in their inner ears and, as a result, may not be able to detect biologically relevant sounds such as approaching predators or prey, and/or hear their mates or young attempting to communicate. Marbled murrelets that lose their hearing sensitivity are at increased risk of predation and reduced foraging efficiency. Some affected marbled murrelets may regain some or all of their hearing sensitivity; however, they are still temporarily at risk while experiencing TS.

Marbled murrelets that are expected to be exposed to other stressors caused by seismic surveys, but do not experience TS, are likely to experience interrupted foraging bouts or resting attempts, which creates a likelihood of injury by significantly disrupting normal behaviors (as a result of their diving repeatedly or vacating the area). Foraging efficiency is likely to be reduced, and energy expenditures are likely to be increased above normal when they flush and/or relocate out of the area. Marbled murrelets are also likely to increase their diving efforts in response to these lost foraging opportunities, or to replace prey dropped or swallowed, or to escape from perceived predator. Of the thousands of marbled murrelets potentially exposed, up to several hundred marbled murrelets are likely to be temporarily adversely affected in this manner across the entire survey area.
NSF established that the proposed action may expose thousands of marbled murrelets to injurious sound pressure levels based on marbled murrelet density and distance from the source. While the Service concludes some individual marbled murrelets will be exposed to injurious sound pressure levels, we have also determined that the actual number of marbled murrelets adversely impacted is likely to be low. We have reached this determination for the following reasons:

- Not all marbled murrelets upon which the density estimates are based are expected to be on the water at any given point in time during survey operations.

- Many marbled murrelets on the water may be loafing or resting instead of diving where they would be most likely affected by significant underwater sound pressure levels.
- Except during for a short period during pre-dawn and after sunset, marbled murrelets are not expected to be foraging during nighttime operations so will not be exposed to increased sound pressure levels during a significant period of the survey.
- Ocean conditions during the survey period are likely to promote marbled murrelet foraging activities closer to shore, likely resulting in fewer birds actually exposed to significant effects from increased sound pressure levels beyond 8 km from shore.
- The effect of increased sound pressure levels on marbled murrelet prey availability is expected to be short-term or insignificant limiting the risk of missed foraging attempts.
- Not all marbled murrelets actually exposed to increased sound pressure levels known to cause behavioral changes will experience temporary threshold shift or behavioral changes that result in a significant effect.

Cumulative Effects

Cumulative effects include the effects of future State, tribal, local or private actions that are reasonably certain to occur in the action area considered in this biological opinion. 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. The States of Oregon and Washington manage and authorize activities in territorial waters from the shoreline out to 3 nm from shore.

Many activities in State waters are managed by States, tribes, and local jurisdictions in a manner consistent with those in Federal waters (e.g., under fisheries management plans, and oil spill response plans). The USFWS, 2019 5-year status review for the marbled murrelet (2019, pg. 33-35) addressed threats related to the reduction of high-quality marbled murrelet food sources; that review is herein incorporated by reference. That review noted that Pacific herring and anchovy stocks may have been significantly reduced in part by overfishing, though little is known about these stocks due to limited sampling. Recreational fisheries are allowed, although rare, in marine waters. Until there is sufficient data available, Oregon is prohibiting development of new directed commercial harvest of forage fish, including the Pacific herring. In Washington and Oregon, there is no northern anchovy stock abundance information. However, there are commercial fisheries in State waters off the southern Washington coast, Grays Harbor, and Willapa Bay that provide live and packaged bait for recreational and commercial use. Since 2000, the highest reported landings of anchovy were in 2009 with over 800 metric tons being harvested; however, since 2010 the harvest levels have been below 300 metric tons. Pacific sardine fisheries have been closed more often than not in the recent past due to significant reduction in sardine biomass. While non-treaty sardine fisheries are closed, a small harvest amount was allocated to the Quinault Indian Nation that has conducted a commercial purse seine fishery within their usual and accustomed fishing grounds directly off Westport/Grays Harbor, Washington since 2012. Lesser quality marbled murrelet forage base includes surf smelt and sand lance. There continues to be no rigorous assessments of Washington's surf smelt stocks. Although there continues to be commercial and recreational fisheries for surf smelt in Washington, there are bycatch restrictions in place. We have no new information on the status of the sand lance in Washington. In Oregon, recreational fisheries are allowed, and sand lance may be incidentally taken during herring fishing, but the State has prohibited development of new directed commercial harvest of forage fish, including the Pacific sand lance.

Urbanization and residential development have led to the significant loss or physical alteration of intertidal and shoreline habitats, as well as to the contamination of many estuarine and nearshore areas (75 FR 63935; dated October 18, 2010). We are also incorporating by reference the analysis of cumulative effects prepared in 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, section 4-1); that document includes a summary of cumulative effects affecting the marbled murrelet and its habitat within the action area, including fishing pressure, and other sources of underwater sound.

Conclusion

After reviewing the current status of the marbled murrelet, the environmental baseline for the action area, the effects of the proposed 2021 West Coast Seismic Survey and cumulative effects, it is the Service's biological opinion that the 2021 West Coast Seismic Survey, as proposed, is not likely to jeopardize the continued existence of the marbled murrelet. Therefore, the Service has concluded the level of take anticipated from the proposed NSF seismic survey is not likely to appreciably reduce the likelihood of its survival and recovery by reducing marbled murrelet numbers, reproduction, or distribution in the wild. We based this determination on the following factors:

- The effect of increased sound pressure levels on marbled murrelet prey availability is expected to be short-term or insignificant, and successful foraging bouts are likely to be only temporarily delayed, thereby posing limited risk of significant impacts resulting from missed foraging attempts.
- The presence of multiple onboard PSOs and associated protocols including shut down procedures is likely to avoid some risk of marbled murrelet exposure to increasing sound pressure levels in good visibility conditions.
- The vessels will have downward pointing lighting to limit the risk of significant injury to marbled murrelets due to vessel strikes.
- Due to the nature of the proposed action and the affected environment, we anticipate (1) a small number of marbled murrelets are likely to injured by increased sound pressure levels known to cause behavioral changes (threshold shift), and (2) relatively few marbled murrelets likely to be actively foraging in the areas where physical injury or mortality from increased sound pressure levels are expected because:
    - Marbled murrelets are not expected to be foraging during nighttime operations so will not be exposed to increased sound pressure levels during a significant period of the survey.
    - We anticipate stationary marbled murrelets will have substantial time to discern repetitive, increasing sound pressure levels coming toward them, and are likely to move away from oncoming survey vessels before sound pressure levels pose significant risk of injury.
    - The effects of the proposed action will be transitory in nature and dispersed across a wide area off the coast of Oregon and Washington, and in very few instances will the survey cover the same area more than once.
    - Ocean conditions during the survey period are likely to promote marbled murrelet foraging activities closer to shore, likely resulting in a low number of birds actually exposed to significant effects from increased sound pressure levels

beyond 8 km from shore.

Critical habitat for the marbled murrelet has been designated within terrestrial areas adjacent to the entirely marine-based 2012 West Coast Seismic Survey. However, the proposed action does is not likely to affect that area, therefore, no destruction or adverse modification of marbled murrelet critical habitat is anticipated as a result of implementing the proposed action.

INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulation pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined under section 3(19) of the ESA to mean "…harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." Harm is further defined by the Service as an act which actually kills or injures wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavior patterns, including breeding, feeding, or sheltering (50 CFR 17.3). Harass is defined by the ESA as an intentional or negligent act or omission that creates 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 (50 CFR 17.3). Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2) of the ESA, taking that is incidental to and not intended as part of the agency action is not considered to be a prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement (ITS).

The measures described below are non-discretionary and must be undertaken by the NSF for the exemption in section 7(o)(2) to apply. The NSF has a continuing duty to regulate the activity covered by this Incidental Take Statement. If the NSF (1) fails to assume and implement the terms and conditions or (2) fails to adhere to the terms and conditions of the incidental take statement, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the NSF must report the progress of the action and its impact on the species to the Service as specified in this Incidental Take Statement pursuant to the requirements of 50 CFR 402.14(i)(3).

Amount or Extent of Take

Based on the *Effects of the Action* analysis above, incidental take of the marbled murrelet is reasonably certain to occur in the form of harm. Pursuant to the authority of section 402.14(i)(1)(i) of the implementing regulations for section 7 of the ESA, a surrogate can be used to express the amount or extent of anticipated take if the following criteria are met: the causal link between the surrogate and take is described; an explanation is provided as to why it is not practical to express the amount or extent of take or to monitor take-related impacts in terms of individuals of the listed species; and a clear standard is set for determining when the level of anticipated take has been exceeded. The Service revised the ESA implementing regulations to clarify the use of surrogates to express the amount or extent of anticipated incidental take, including circumstances where project impacts to the surrogate are coextensive with at least one aspect of the project's scope (80 FR 26832, May 11, 2015). The Service supported this clarification of the ESA implementing regulations by noting that Congress has also recognized that a numerical value would not always be available and intended that such numbers be established only where possible [H.R. Rep. No. 97-

567, at 27 (1982)]. Also, noted in the above 2015 final rule, the preamble to the final rule that set forth the 1986 regulations also acknowledges that exact numerical limits on the amount of anticipated incidental take may be difficult to determine and the Services may instead specify the level of anticipated take in terms of the extent of the land or marine area that may be affected (51 FR 19926, June 3, 1986). The courts also have recognized that it is not always practicable to establish the precise number of individuals of the listed species that will be taken and that "surrogate" measures are acceptable to establish the impact of take on the species if there is a link between the surrogate and take (see Arizona Cattle Growers' Ass'n v. U.S. Fish and Wildlife Service, 273 F.3d 1229, 9th Cir. 2001). Furthermore, it is often more practical and meaningful to monitor project effects upon surrogates, which can also provide a clear standard for determining when the amount or extent of anticipated take has been exceeded and consultation should be reinitiated. Accordingly, a coextensive surrogate based on specific project components is necessary to express the extent of take because, based on the above analysis of effects, it is not practical to accurately estimate the actual number of marbled murrelets that may be incidentally taken or effectively monitor take impacts in terms of individual marbled murrelets due to the extremely low likelihood of finding dead or injured individuals in the aquatic environment. The coextensive surrogate is the direct source of the stressors causing the taking, and a clear standard for take exceedance can be established under the monitoring requirements (below) using this surrogate. On that basis, the extent of take of the marbled murrelet covered under this Incidental Take Statement is described using a coextensive surrogate: the proposed survey area in U.S. waters, survey length (6,306 km), total number of days (37), and placement of transects described in the proposed action description herein (Figures 1 and 2 herein).

As described in the effects analysis, we anticipate that the action will result in the incidental take in the form of harm within the proposed NSF seismic survey area. It is unlikely that all of these birds will be incidentally taken at the same location, rather the takings will be dispersed across the survey area. Based on the effects of the action analysis above, a very limited number of marbled murrelets are likely to be present in close proximity to the airgun arrays or survey vessels, exposed to significant sound pressure levels, and respond in a manner that conforms to take.

Effect of the Take

Based on the effects of the action analysis above, a very limited number of marbled murrelets are likely to be present in close proximity to the airgun arrays or survey vessels, exposed to significant sound pressure levels, and respond in a manner that conforms to take. In the accompanying Opinion, the Service determined that this level of anticipated take is not likely to result in jeopardy to the marbled murrelet.

Reasonable and Prudent Measures

The Service finds the following reasonable and prudent measures (RPMs) are necessary and appropriate to minimize the impacts of the taking on the marbled murrelet.

1. The NSF shall monitor the impacts of incidental take and report the progress of the action and its impact on the species.

2. The NSF shall implement required procedures to report, handle, or dispose of any individuals of an ESA-listed species actually taken.

Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the ESA, the NSF must comply with the following terms and conditions, which implement the RPMs described above and outline required reporting/monitoring requirements. These terms and conditions are non-discretionary.

1. To implement RPM 1, the NSF shall implement the measures identified in the Proposed Monitoring and Reporting section herein. If any of the above monitoring requirements indicate the amount or extent of take has been exceeded, NSF shall discontinue the survey and immediately report this information to the Service. The Service requests NSF to provide the required report to the Assistant Regional Director, Ecological Services, U.S. Fish and Wildlife Service, 911 NE 11th Avenue, Portland, Oregon 97232.

2. To implement RPM 2, the NSF shall notify the Service within three working days upon locating any dead, injured, or sick endangered or threatened species specimens during project operations. Initial notification shall be made to the nearest U.S. Fish and Wildlife Service Law Enforcement Office (see below). Notification shall include the date, time and precise location (latitude/longitude); condition of the animal(s) (including carcass condition if the animal is dead); observed behaviors of the animal(s), if alive; if available, photographs or video footage of the animal(s); general circumstances under which the animal was discovered. Care should be taken in handling sick or injured specimens to preserve biological materials in the best possible state for later analysis of cause of death, if that occurs. In conjunction with the care of sick or injured endangered or threatened species or preservation of biological materials from a dead animal, the finder has the responsibility to ensure that evidence associated with the specimen is not unnecessarily disturbed. Contact information: the telephone number for the U.S. Fish and Wildlife Service Law Enforcement Office is (503) 682-6131, and for the Service's Columbia-Pacific Northwest Regional Office is (503) 702-5922.

The Service finds no more than the number or extent of species identified above will be incidentally taken as a result of the proposed action. The reasonable and prudent measures, with their implementing terms and conditions, are designed to minimize the impact of incidental take that might otherwise result from the proposed action. If, during the course of the action, this level of incidental take is exceeded, such incidental take represents new information requiring reinitiation of consultation and review of the reasonable and prudent measures provided. The Federal agency must immediately provide an explanation of the causes of the taking and review with the Service the need for possible modification of the reasonable and prudent measures.

CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act directs Federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

The Service provides the following recommendations:

1. Please note that the Service is currently conducting a status review in response to a substantial listing petition for the tufted puffin (*Fratercula cirrhata*), which was also mentioned in your request for consultation. The puffin is listed as endangered by the State of Washington and could be present in the survey area during the survey period along with a number of migratory birds not listed under the ESA. We recommend the NSF apply the proposed conservation and mitigation measures identified in the Description of the Proposed Action section above to the tufted puffin.

2. As mentioned in the Effects of the Action section above, a bubble curtain concentrated around the air-gun ports could be an efficient and practical solution to reduce the high-frequency acoustic emission from air guns that may impact diving seabirds and other marine animals. The Service recommends that NSF consider use of bubble screens surrounding airgun arrays as a standard protocol to further reduce the low number of diving birds.

REINITIATION NOTICE

This biological opinion concludes formal consultation on the effects of the proposed action on the marbled murrelet. As provided in 50 CFR §402.16, reinitiation of consultation is required and shall be requested by the NSF or the Service, where discretionary Federal involvement or control over the action has been retained or is authorized by law and: (1) if the amount or extent of taking specified in the incidental take statement is exceeded; (2) if new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered in this biological opinion; (3) if the identified action is subsequently modified in a manner that causes an effect to listed species or critical habitat that was not considered in this biological opinion or concurrence determination; or (4) if a new species is listed or critical habitat designated that may be affected by the identified action.

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APPENDIX A

Analysis Supporting a "May Effect, but Not Likely to Adversely Affect" Determination for the Bull Trout and its Designated Critical Habitat

Bull Trout Status in the Action Area

The marine waters of Washington State provide important FMO habitat for anadromous subadult and adult bull trout. The action area overlaps marine habitat that provides important FMO habitat located outside of the three core areas of the Olympic Peninsula: Hoh River, Queets River, and Quinault River core areas.

Marine Habitat Use

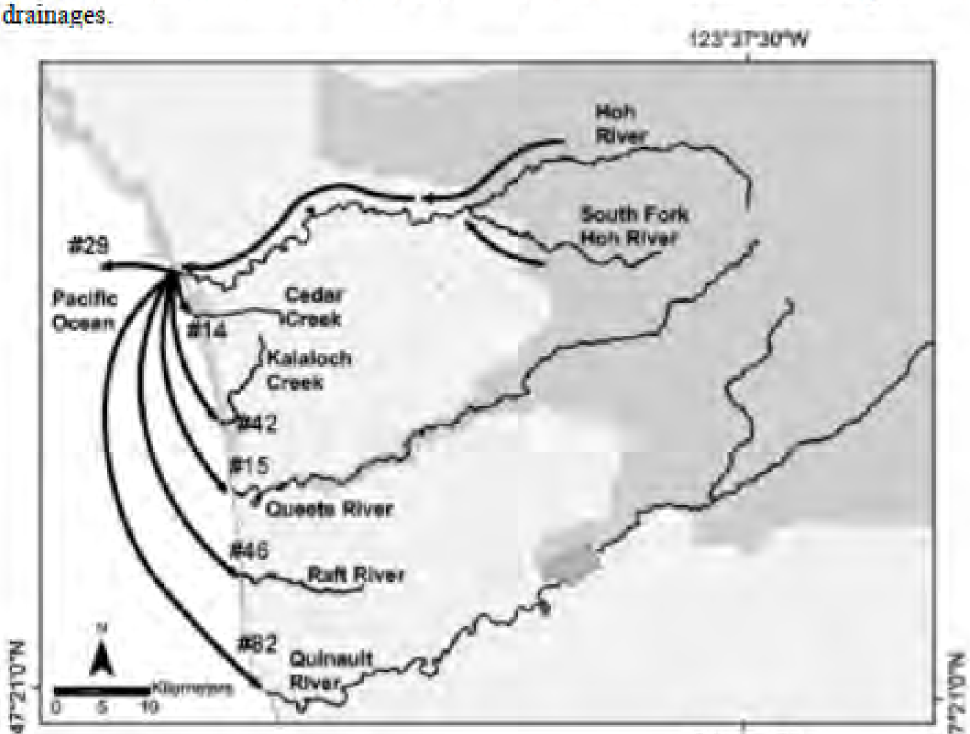
To understand exposure to effects of the action we must first reconcile that we understand very little about use of the outer coast marine environment by the bull trout. As such, effects of the action will be challenging to estimate. Studies conducted in the Hoh River have indicated between 57% and 85% of the fish exhibited anadromy at least once, and that 75% had migrated from fresh water to the sea multiple times (Brenkman and Corbett 2005, pg. 1075; Brenkman et al. 2007, pg. 1). Adjacent to the action area, other studies have demonstrated bull trout anadromy in Puget Sound (Hayes et al 2011, entire; Goetz et al. 2004, entire). These populations are thought to be found in marine habitats at any time of year (Hayes et al. 2011, pg. 403; Goetz et al. 2016, pg. 103).

The nearby Skagit River, Washington, has been identified as one of the more robust populations of bull trout in the Coastal RU, where Hayes et al. (2011, pg. 402) demonstrated extent of marine habitat use by individual bull trout for up to 133 days. In this study, 60% of the river tagged bull trout moved into Skagit Bay from March until May and were back in the river from May to August. Other studies showed marine habitat use from April until July in the Puget Sound (Goetz et al. 2004, entire; 2007, pg. 8; 2016, pg. 90). Goetz (2016, pg. 104) found this timing of the bull trout return to streams was synchronous in several rivers despite differences in thermal regimes, and noted this is typical of partial migration patterns of other iteroparous species that do not typically use marine waters over winter.

However, subadult bull trout from the Hoh River were detected in the Pacific Ocean between September and December (Brenkman et al. 2007, pg. 5). In another study, bull trout migrated down from the Snohomish River in November entered into the Duwamish River in December and returned to the Snohomish River in January (Goetz 2012, pg. 10) demonstrating bull trout are in the marine waters after spawning. Fish were detected moving between rivers in Puget Sound rather than residing there, during the fall and winter period, similar to behaviors seen in Pacific Ocean bull trout (Goetz 2016, pg. 104; Brenkman and Corbett 2005, pg. 2). In 2003, sub-adult and adult bull trout were observed in the Skagit River delta and bay in late fall and winter (Goetz 2016, pg. 104). A total of 39 of 73 tagged bull trout in the Hoh River basin moved into the ocean during various months (Brenkman and Corbett 2005, pg. 1075); and some fish were detected later in coastal streams located between 5 and 47 km to the south of the Hoh River. This includes Cedar Creek, Kalaloch Creek, the Queets River, the Raft River, and the Quinault River (Figure 1). One recent survey (Smith and Huff 2019, pg. 3) further demonstrated bull trout use of marine habitats in the action area, where from May to September 2019, movements of six bull trout were monitored after being tagged in the Hoh River, and 11 in Kalaloch Creek. However, in this study only one tagged bull trout was detected (in August) in marine habitat. This variation of the data in these studies could be due in part to differences in survey method but is also likely attributed to habitat or behavioral differences between populations. For instance, Skagit fish were tagged in the lower river (Hayes et al. 2011, pg. 403), while Hoh River fish in one study were tagged in the lower and upper river (Brenkman et al. 2007, pg. 3). Nevertheless, the data seems to indicate bull trout use of the nearshore marine environment is variable and may be extensive. It is reasonable to assume adult spawning fish would return to the natal rivers to spawn, while juveniles, smaller sub-adults, and the occasional non-breeding adult may remain in the marine environment.

Several of these studies have shown bull trout travel distances upwards of 60 km (Hayes et al 2001, pg. 403; Brenkman and Corbett 2005, pg. 1075; Goetz et al. 2004, pg. 44) and one study demonstrated a minimum travel distance of 100-160 km (Goetz et al. 2004, pg. 44). Bull trout tagged in previous years have also been shown to make multiple migrations into marine habitats (Brenkman et al. 2007, pg. 5). Brenkman and Corbett (2005, pg. 1078) demonstrated typical movement in the action area in Figure 1.

Figure 1. From Brenkman and Corbett (2005, pg. 1078). Downstream movements of anadromous bull trout from the Hoh River basin to the Pacific Ocean and nearby coastal drainages.



Adult and subadult bull trout may primarily use that surf zone area of the action area at any time of year. However, an estimate of the number of bull trout that use marine waters to forage, migrate, and overwinter in the action area is not available, and limited abundance data is available for bull trout use of rivers adjacent to these marine habitat areas (see Table 1). The Service expects that low numbers of bull trout are likely to forage, migrate, and overwinter in the surf zone area of the action area, and it is possible bull trout may forage further offshore.

Table 1. Olympic Peninsula geographic region, outer coastal core area local population adult abundance size estimates, short-term trend, and ranking for risk of extirpation (USFWS 2015a, entire; 2008 entire).

Core Area	Population Abundance – Individuals	Short-Term Abundance Trend	Final Ranking for Risk of Extirpation
Hoh River	250-1000	Increasing	At Risk
Queets River	Unknown	Unknown	Potential Risk
Quinault River	Unknown	Unknown	At Risk

Threats and Conservation Needs

The Coastal Recovery Unit Implementation Plan for the bull trout suggests core areas along the Pacific Coast of Washington likely have the best demographic status in the Olympic Peninsula region (USFWS 2015a, pg. A-7). Although abundance and trends are unknown for the Quinault River core area, it was identified as the one stronghold in this region (FWS 2015, p. A-3). However, direct and incidental catch of bull trout from commercial gill net and popular recreational angling fisheries on the coast can have significant selective pressure on older and larger bull trout. Incidental catch has been amplified by regional salmon and steelhead ESA listings that have shifted regional recreational angling effort to coastal streams; and has been demonstrated to be significant in some Tribal fisheries (USFWS 2015a, pg. A-18). Development and implementation of strategies to reduce incidental mortality of larger spawners caught in fisheries is needed to conserve core area populations along the Pacific Coast. To resolve the lack of data regarding population numbers and FMO habitat use, overwintering index areas should be established.

Although these small independent streams along the Pacific Coast have been identified as either medium or low priority watersheds for salmon compared to larger natal watersheds, these are key shared FMO habitats for anadromous bull trout (USFWS 2015a, pg. 71). Many of these small streams whose estuaries and lower reaches are used by anadromous bull trout have been heavily impacted by past forest practices. Associated impacts cause degradation to a number of small, nonnatal, independent Pacific Coast streams and their estuaries that are essential for overwintering and foraging by the anadromous life history form (USFWS 2015a, pg. A-21). Improved roads paralleling the coastal rivers continue to impact habitat within stream corridors through loss of riparian areas, bank stability efforts, channel simplification of FMO habitat, and altered tributary connectivity (USFWS 2015a, pg. A-18). Recovery implementation goals include appropriate protection and restoration actions and identifies numerous partners in this effort (USFWS 2015a, pg. 116).

The Service has consulted with the Navy on a number of actions related to training, operations, and facilities maintenance, including pile driving, sonar and underwater explosions in the action area. We completed consultations with the Army Corps of Engineers on a number of boat ramp, bulkhead, and riprap installation projects that resulted in temporary and permanent shoreline habitat modification. We have completed consultations with NMSF on salmon, halibut and groundfish fisheries management plans that may result in bycatch of the bull trout.

Bull Trout Critical Habitat Status in the Action Area

In marine nearshore areas, the inshore extent of critical habitat is the mean higher high-water (MHHW) line, including the uppermost reach of the saltwater wedge within tidally influenced, freshwater heads of estuaries. Critical habitat extends offshore to the depth of 10 meters (m) (33 feet (ft)) relative to the mean low low-water (MLLW) line (USFWS 2010, pg. 63935). The quality of marine habitat along shorelines is intrinsically related to the character of adjacent features, and human activities that occur outside of the MHHW line and can have major effects on the physical and biological features of the marine environment. The offshore extent of critical habitat for marine nearshore areas is based on the extent of the photic zone, which is the layer of water in which organisms are exposed to light (USFWS 2010, pg. 63973). This area between the MHHW line and minus 10 m MLLW line is considered the habitat most consistently used by bull trout in marine waters based on known use, forage fish availability, and ongoing migration studies and captures geological and ecological processes important to maintaining these habitats.

The action area includes designated bull trout critical habitat from Unit 1 (Olympic Peninsula). With our revised designation of bull trout critical habitat (75 FR 63935; October 18, 2010) the USFWS identified a number of marine and mainstem river habitats outside of bull trout core areas that provide the PCEs of critical habitat. These areas do not provide spawning and rearing habitat but do provide FMO habitat that is typically shared by bull trout originating from multiple core areas. These shared FMO areas support the viability of bull trout populations by contributing to successful overwintering survival and dispersal among core areas (USFWS 2015, pg. 35).

There is widespread agreement in the scientific literature that many factors (mostly related to human activities) have impacted bull trout and their habitat and continue to do so. Among the many factors that individually and cumulatively degrade the current function of the PCEs of designated bull trout critical habitat, those that appear to be particularly significant and have resulted in a legacy of degraded habitat conditions are as follows.

Fragmentation and isolation of local populations due to the proliferation of dams and water diversions that have eliminated habitat, altered water flow and temperature regimes, and impeded migratory movements (Dunham and Rieman 1999, pg. 652; Rieman and McIntyre 1993, pg.7).
Degradation of spawning and rearing habitat in upper watershed areas, particularly alterations in sedimentation rates and water temperature, resulting from forest and rangeland practices and intensive development of roads (Fraley and Shepard 1989, pg. 141; The Montana Bull Trout Scientific Group 1998, pp. ii-v, 20-45).
The introduction and spread of nonnative fish species, particularly brook trout (*S. fontinalis*) and lake trout (*S. namaycush*), as a result of fish stocking and degraded habitat conditions, which compete with bull trout for limited resources and, in the case of brook trout, hybridize with bull trout (Leary et al. 1993, pg. 857; Rieman et al. 2006, pg. 73).
Degradation of mainstem river FMO habitat, and the degradation and loss of marine nearshore FMO habitat due to urban and residential development.
Degradation of FMO habitat resulting from reduced prey base, roads, agriculture, development, and dams.

The final rule designating bull trout critical habitat identified nine Primary Constituent Elements (PCEs) essential for the conservation of bull trout. Five of the nine PCEs are found in the marine waters of the action area:

PCE 2. Migratory habitats with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and freshwater and marine foraging habitats, including but not limited to permanent, partial, intermittent, or seasonal barriers.
Within the action area, migratory habitat functions are variable. Conditions range between mostly intact and undisturbed, and substantially disturbed and impaired. The current condition and function of this PCE in the action area may be described generically as moderately impaired.

PCE 3. An abundant food base, including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish. Within the action area, food base functions are variable. Conditions range between mostly intact and undisturbed, and substantially disturbed and impaired. The current condition and function of this PCE in the action area may be described generically as moderately impaired.

PCE 4. Complex river, stream, lake, reservoir, and marine shoreline aquatic environments and processes with features such as large wood, side channels, pools, undercut banks and substrates, to provide a variety of depths, gradients, velocities, and structure. Within the action area, shoreline environments, processes, and functions are variable. Conditions range between mostly intact and undisturbed, and substantially disturbed and impaired. The current condition and function of this PCE in the action area may be described generically as moderately impaired.

PCE 5. Water temperatures ranging from 2 °C to 15 °C (36 °F to 59 °F), with adequate thermal refugia available for temperatures at the upper end of this range. Specific temperatures within this range will vary depending on bull trout life-history stage and form; geography; elevation; diurnal and seasonal variation; shade, such as that provided by riparian habitat; and local groundwater influence. Within the action area, water temperatures and thermal refugia functions are variable. Conditions range between mostly intact and undisturbed, and substantially disturbed and impaired. The current condition and function of this PCE in the action area may be described generically as moderately impaired.

PCE 8. Sufficient water quality and quantity such that normal reproduction, growth, and survival are not inhibited. Within the action area, conditions range between mostly intact and undisturbed, and substantially disturbed and impaired. The current condition and function of this PCE in the action area may be described generically as moderately impaired.

Effects of the Action on the Bull Trout

The proposed action involves exposure to underwater sound (repeated explosions) in waters deeper than 200 m, but that will likely esonify up to the shoreline. We demonstrated in the Environmental Baseline section bull trout use of marine habitats, to understand level of exposure it is important to estimate bull trout behavior at sea. While most studies have indicated bull trout more commonly stay near the shoreline, a single bull trout tagged in Kalaloch Creek, WA, was detected multiple times on August 25, 2019, at a location 5.6 nautical miles from shore between the Queets River and Quinault River (Smith and Huff 2020, pg. 3). Another exceptional

Snohomish River fish on a 95 km one-way journey, crossed Puget Sound twice (minimum distance 6.5 km) (Goetz 2012 et al., pg. 12). In the Skagit study, most fish were detected within 400 m of the shoreline and in waters less than 4 m (Hayes et al. 2011, pg. 403). Goetz et al. (2004, pg. 58) similarly showed bull trout densities were greatest at depths between 2–5 m. It is reasonable to assume most adult spawners will be in the streams adjacent to the action area during the proposed action timeframe, while an unknown number of adults, sub-adults and juveniles may use marine waters at any time of the year.

In the NSF-updated project description, track lines were modified adjacent to the Washington coast such that the tracklines will come no closer than 21 km (11 nm) from shore, in waters greater than 100 m depth, the exposure risk is minimized for bull trout from proposed action consequences. According to the NSF, the ensonified area (the Level B 160dB zone) would also remain outside of the 100 m isobaths. Most of the fish in the action area are likely to be from the three coastal core areas in Washington: Hoh, Queets, and Quinault Rivers. Based on prior status reviews (USFWS 2008, entire; 2015, entire), it is estimated approximately 250-1000 bull trout may occur in the Hoh River, and while population numbers were thought to be increasing at that time, in the long term, given the small population size, the Hoh River core area was also considered at risk of extirpation. There are no population estimates for the Queets and Quinault Rivers, but these drainages were identified by the Service as "potentially at risk" and "at risk" respectively (USFWS 2008, entire; 2015, entire). Lower population numbers may be depressed by slow growth and reproduction rates, and susceptibility to overharvest in recreational fisheries (Brenkman and Corbett 2005, pg. 1080; Post et al. 2003, pg. 31), suggesting additional mortality from the proposed action, even to a small number of fish, may be significant to the affected populations.

The shallow nature of the underwater explosions is unlikely to result in elevated water at the shoreline, a result usually attributable to deep underwater explosions.

<u>Consequences of Exposure</u>

An explosive or pile-driving sound wave is very broad and fast-moving, and produces a supersonic shock wave known to cause barotrauma in animals. The escape of air from an airgun is very slow compared to a pile driving or explosive source, so unlike pile driving or explosives, there is no shock wave from an airgun so no resulting barotraumatic effect that would cause fish mortality (Gisiner 2019, entire). Furthermore, the sound gets less "peaky" as it travels at distance, bounces off the bottom, and is refracted as it travels through water, so the sound tends to spread out resulting in pink noise (not white noise) with a lot of amplitude modulation, and eventually there is no peak with distance (Gisiner 2019, entire). Airguns do not mask signals well so animals can still hear each other between peaks and valleys of sound. The barotraumas injuries associated with exposure to high sound pressure levels include hemorrhage and rupture of internal organs, hemorrhaged eyes, and temporary stunning (Yelverton et al. 1973, p. 37; Yelverton et al. 1975, p. 17; Yelverton and Richmond 1981, p. 6; Turnpenny and Nedwell 1994; Hastings and Popper 2005). Death from barotrauma can be instantaneous, occurring within minutes after exposure, or several days later (Abbott et al. 2002). While underwater airguns are similar to pile-driving in that both exhibit full spectrum sound and both have the potential to cause harmful behavioral or physiological responses by exposed animals, the slow release of compressed air is far less likely to cause injury and mortality in fishes that has been attributed to impact pile driving (Stotz and Colby 2001; John H. Stadler, NMFS, pers. comm. 2002; Fordjour 2003; Abbott et al. 2005; Hastings and Popper 2005).

Several studies have confirmed an effect on fish behavior from sounds from compressed air sources used for seismic exploration. Research has shown catch rates of commercial fish species including cod and haddock declined in areas where airguns were used, and increased 30-50 km away from the sound source, signaling that these fishes avoided the areas where the compressed seismic sources were operating (Slotte et al 2004, entire; Engås et al. 1996, entire). However, other research indicates the reverse response, with more fish being caught in gill nets near areas where compressed air sources were being used for seismic exploration (Løkkeborg et al 2012, entire). In another study, rockfishes exhibited behavioral changes from underwater geophysical surveys at 161 dB and at 180 dB swam in tight circles or moved to the seafloor (Pearson et al 1992, entire).

In other research, no biologically significant effect was found to result from airguns on fish behavior. In one study using coral reef fishes in contained enclosures, swimming speed and increased and swimming direction changed (196 dBpeak at 1 m) but returned to normal soon after (Boeger et al. 2006, entire). Furthermore, repeated exposure to sounds generated by compressed air sources reduced these responses, suggesting habituation to the disturbance may have occurred. In other research, pollack and juvenile saithe in nearshore habitat did not indicate a significant behavioral response to sound from airguns. Fishes were initially startled but remained in position on the reef and their diurnal gatherings on the reef were not affected by sound exposure of 210 dBpeak at 16 m from the source, and 195 dBpeak at109 m (Finneran et al. 2015, entire). However, at 5 m and 218 dBpeak fish did react by moving away.

Given the large amount of uncertainty, however, that lies not only in extrapolating from experimental data to the field, but also between sound sources (compressed air vs. pile driving), and also from one species to another, we believe it is appropriate to utilize the most conservative known level for anticipating behavioral responses. As such, we expect that sound pressure levels in excess of 150 dBrms will cause temporary behavioral changes in bull trout. They are not expected to cause injury. We expect that sound pressure levels above 150 dBrms could result in a temporary alteration of normal foraging and migrating behavior in bull trout. Should sound pressure levels lead to bull trout avoiding an area, or altering their migration timing, it could represent a significant disruption in foraging and migratory behavior. Whether these behavioral effects result in "adverse effects" depend on a number of additional factors such as the duration and timing of exposure, species life histories, and the species' normal use of the area during exposure.

In assessing impacts to marine mammals, NSF determined for the proposed project the distance from the source of ensonification that it takes to attenuate below 160 dBrms is 12.5 km in waters less than 100m and 9.5 km in waters between 100 and 1000m and is 6.7 km in waters greater than 1000m deep. Off the coast of Washington, the tracklines have been pushed offshore (>21 km; 11 nm). Based on this information, we can expect the sound will attenuate to below 150 dBrms (the behavioral response threshold measured at 1 µPa (rms)) somewhere below the 100m depth contour, but still well outside of the likely shallow, nearshore, habitat use area for most bull trout resulting in limited insignificant behavioral responses from the very small number of fish that may be present in deeper water.

For salmon, NMFS is using 186 SEL for TTS (temporary threshold shifts) and 207 SPLpeak for onset of injury for the proposed action. NSF, based on a ship speed of 4.1-4.2 kts and a shot interval of 37.5 m, determined the radius around the vessel at which animals could be exposed to sound levels up to 202 dB SEL was estimated to be 84 m. NMFS calculated a distance to 203 dB SELcum of 4,024.4 m (4 km). This information is based on calculations for SELcum and SELpeak and NMFS chose the greater distance between the two. While it is unclear why there is such a large difference between NMFS and NSF calculations, it is reasonable, due to similar taxonomic and life history characteristics, that we should extrapolate this salmon exposure information for the bull trout. However, given very limited data supporting a likelihood that individual bull trout forage in waters this far offshore, we do not have strong evidence that bull trout are likely to be exposed to injurious effects coincidental with the proposed action at this distance (>17 km, 9 nm). Therefore, is extremely unlikely that individual bull trout will be physically injured as a result of the proposed action.

The proposed use of surface ships, sonar, or other acoustic devices will also result in increased noise levels that could extend into bull trout foraging, migration, and overwintering areas along the outer coast of Washington. This risk is mitigated somewhat by the vessel will be operating in and out of its home port of Newport, Oregon. In addition, these increased sound levels are intermittent or are at frequencies that are not expected to impede bull trout foraging or migratory behavior. Therefore, effects associated with these project elements are considered insignificant.

Effects of the Action on Bull Trout Critical Habitat

As stated in the "Status of the Bull Trout" section above, only PCEs 2, 3, 4, 5, and 8 apply to marine nearshore waters identified as critical habitat. The proposed activities will have no effect on PCEs 4, 5, and 8. The activities will not result in any permanent changes or alterations to marine shoreline habitat, impact water temperatures or water quality in the designated critical habitat area. The activities may affect the following PCEs:

PCE 2 and PCE 3: Activities conducted in waters adjacent to CHU 1 include the use of sonar and airguns that result in increased sound pressure levels that can temporarily act as an impediment within the marine migratory and corridor and primary nearshore foraging areas. However, the area in which potential migratory and foraging bull trout behavioral responses to sound or sound pressure is well away from the source, and therefore the migratory corridor and foraging areas, including bull trout prey species, will not be significantly impeded. Based on the species analysis above, we can expect the sound will attenuate to below 150 dBrms (the behavioral response threshold measured at 1 μPa (rms)) somewhere below the 100m depth contour, but still well outside of the likely shallow, nearshore, migratory and foraging critical habitat use area for bull trout resulting in no significant behavioral responses from fish that may be present. The proposed use of surface ships, sonar, or other acoustic devices will also result in increased noise levels that could extend into designated critical habitat. However, these increased sound levels are intermittent or are at frequencies that are not expected to impede bull trout migration or foraging behavior or success, since we do not expect these impacts to result in a long-term reduction in forage fish abundance. Therefore, the proposed action is not expected to significantly degrade the function of critical habitat.

Conclusion

Based on the NSF BA, the proposed action description, taken together with the above analysis, it is the Service's determination that the proposed action may affect but is not likely to adversely affect the bull trout or its critical habitat.

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APPENDIX G: COASTAL ZONE MANAGEMENT ACT COMPLIANCE

APPENDIX G: COASTAL ZONE MANAGEMENT ACT COMPLIANCE

From: "Caracciolo, Deanna" <deanna.caracciolo@state.or.us>
Date: Wednesday, March 4, 2020 at 4:00 PM
To: "Smith, Holly E." <hesmith@nsf.gov>
Subject: [EXTERNAL] - NSF 2020 Geophysical Survey Action - Federal Consistency Presumed

Greetings Holly,

Today is the decision deadline for the Oregon federal consistency decision pertaining to the proposed Marine Geophysical Survey of the Cascadia Subduction Zone. At this time, please presume state concurrence for the proposed action.

Please don't hesitate to reach out with any questions regarding this presumed concurrence.
Regards,
Deanna

DLCD

Deanna Caracciolo
State-Federal Relations Coordinator | Oregon Coastal Management Program
Oregon Department of Land Conservation and Development
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STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
PO Box 47600 • Olympia, WA 98504-7600 • 360-407-6000
711 for Washington Relay Service • Persons with a speech disability can call 877-833-6341

March 23, 2020

National Science Foundation
Attn: Holly Smith
2415 Eisenhower AVE
Alexandria VA 22314-4684

RE: Coastal Zone Consistency Decision for Activities Undertaken by a Federal Agency
Marine Geophysical Survey of the Cascadia Subduction Zone
Northeastern Pacific Ocean, offshore Washington and Oregon States

Dear Holly Smith:

On January 8, 2020, the National Science Foundation (NSF) submitted a Consistency Determination to the Washington Department of Ecology - manager of the State's Coastal Zone Management Program (CZMP). As described in the Consistency Determination, the NSF proposes to conduct a high-energy marine geophysical survey in late spring/summer 2020 within the Exclusive Economic Zone of the U.S. The NSF is funding the proposal, and it is led by principal investigators from multiple academic institutions and the United States Geological Survey (USGS). The overarching goal of the study is to use modern multi-channel seismic data to characterize subducting plate and accretionary wedge structure, and properties of the megathrust, along nearly the full length of the Cascadia Subduction Zone.

Pursuant to Section 307(c)(3) of the Coastal Zone Management Act of 1972 as amended, Ecology concurs with NSF's determination that the proposed work is consistent with Washington's CZMP. The NSF demonstrated that its proposal is consistent with the CZMP's enforceable policies found in Washington's Ocean Resource's Management Act and the Ocean Management Guidelines, which call for no long-term significant impacts to Washington's coastal zone resources or uses. WAC 173-26-360(7)(j): states *"Ocean uses and their associated coastal or upland facilities should be located, designed and operated* ***to prevent, avoid, and minimize adverse impacts on migration routes and habitat areas of species listed as endangered or threatened****, environmentally critical and sensitive habitats such as breeding, spawning, nursery, foraging areas…".*

NSF Coastal Zone Consistency Decision
Page 2 of 2

While we acknowledge that the NSF proposal meets the above enforceable policies to the maximum extent practicable, we must also recognize that Washington's Southern Resident Killer Whales, which are an endangered species, are under particular threat. Thus, in order to emphasize our concern and need to ensure that the population will not be subjected to additional stress, we are recommending measures that we believe will further ensure protection for these marine mammals. These recommendations are the result of consulting with NMFS as called for by the CZMA, and also with Washington's Department of Fish and Wildlife who has oversight authority for Killer Whale populations that feed and transit through Washington State waters.

We appreciate your willingness to work closely with us and provide information as needed, prior to and after receiving your proposal. We believe that communication between state and federal agencies, when working on projects under the Coastal Zone Management Act, enhances our ability to protect the nation's and state's precious coastal resources.

Should you have questions or concerns, please do not hesitate to contact Therese Swanson at 360 407-6789 or terry.swanson@ecy.wa.gov.

Sincerely,

Brenden McFarland, Section Manager
Environmental Transportation and Review Section
Shorelands and Environmental Assistance Program

Enclosure

E-CC: Jennifer Hennessey, Office of the Governor – Jennifer.Hennessey@gov.wa.gov
Jessica Stocking, WDFW – Jessica.stocking@dfw.gov
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Washington Coastal Zone Management Program Recommendations for Protection of Marine Mammals, particularly Southern Resident Killer Whales during the Marine Geophysical Survey off the Cascadia Subduction Zone
March 23, 2020

Washington is very concerned about its Southern Resident Killer Whale population and is making the following recommendations to consider when conducting the seismic surveys:

The current population estimate for Southern Residents is at 73 individuals. Approximately 59 percent of the total population is predicted to be exposed to effects from the seismic survey activities, which could disrupt the animals' feeding, inhibit the pods' ability to communicate during foraging, and impact prey species. These effects could undermine the animals' health and fitness. Thus, we are recommending mitigation measures aimed at eliminating or reducing the exposure of the Southern Resident Killer Whales. We recommend a closure area within the action area for the survey, and have consulted with NMFS on measures that it is proposing.

The area with the highest likelihood of Southern Resident killer whale occurrence should be closed to surveys, from just south of the Columbia River, north to approximately off Cape Flattery (exclusive of the territorial seas of Canada), and seaward to 200 meters depth. Additionally, we recommend the following Southern Resident Killer Whale specific detection-based mitigation measures:

- The airgun array must be shut down upon visual observation or acoustic detection of a killer whale at ANY distance;
- Tracklines in waters 200 m deep or less must be surveyed in daylight hours only (from 30 minutes before sunrise to 30 minutes after sunset);
- When surveying in waters 200 m deep or less, a second vessel (with two protected-species observers on duty at all times) must travel along the trackline ahead of the Langseth and relay sightings of marine mammals to observers on the Langseth to prepare for shutdowns.

Some general mitigation measures for other marine mammal species include:

- Implementing a 500-m exclusion zone, meaning the airgun array must be shut down when animals come within 500 m of the array. There is an exception to this shutdown requirement for certain genera of dolphins (Tursiops, Delphinus, Stenella, Lagenorhynchus, and Lissodelphis) that are known to approach vessels and are relatively insensitive to sound produced at the predominant frequencies in an airgun pulse while also having a relatively high threshold for the onset of auditory injury (i.e., permanent threshold shift);
- Shutting down the airgun array when groups of six or more large whales (sperm and baleen) are observed together, or a large whale **with a calf** are observed at any distance from the array;
- Using passive acoustic monitoring during **all** survey operations;
- Gradually ramping up the airgun array from a single airgun to the whole active array;
- Implementing vessel strike avoidance measures.

APPENDIX H: OCNMS SRS & PERMIT

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SERVICE
OFFICE OF NATIONAL MARINE SANCTUARIES
Olympic Coast National Marine Sanctuary
115 East Railroad Avenue, Suite 301
Port Angeles, WA 98362-2925

March 12, 2021

Amy Fowler
Incidental Take Program
National Marine Fisheries Service Office of Protected Resources
1315 East-West Highway
Silver Spring, MD 20910

Holly Smith
National Science Foundation
2415 Eisenhower Avenue
Alexandria, Virginia 22314

Dear Ms. Fowler and Ms. Smith:

On May 1, 2020, the National Oceanic and Atmospheric Administration (NOAA) Office of National Marine Sanctuaries (ONMS) received the National Science Foundation (NSF) and NOAA National Marine Fisheries Service (NMFS) initial Sanctuary Resource Statement (SRS) and request to initiate consultation under the National Marine Sanctuaries Act (NMSA; 16 U.S.C. § 1434) for a proposed marine geophysical survey of the Cascadia Subduction Zone in the northeast Pacific Ocean using the R/V *Marcus G. Langseth*. The proposed action includes the issuance of an incidental harassment authorization under the Marine Mammal Protection Act (MMPA) by NMFS to Lamont-Doherty Earth Observatory for takes of marine mammals incidental to the geophysical surveys (April 7, 2020; 85 FR 19580). The SRS references the permit application to Olympic Coast National Marine Sanctuary (OCNMS) initially submitted on December 17, 2019 and a Draft Environmental Assessment prepared by NSF (dated November 21, 2019). After ONMS's request for additional information and clarification, ONMS received a revised permit application on May 15, 2020 and a revised SRS on January 22, 2021. On January 27, 2021, ONMS found the SRS sufficient for the purposes of making an injury determination and developing recommended alternatives as required by the NMSA.

Pursuant to section 304(d) of the NMSA, we hereby provide ONMS's injury determination and recommended alternatives to minimize injury and to protect sanctuary resources. ONMS finds that proposed NSF activities within and outside of the sanctuary will result in injury in the form of harassment of marine mammals in the sanctuary. ONMS provides two recommended alternatives to minimize injury and to protect sanctuary resources:

I. Limit operations in OCNMS to daylight hours only regardless of depth; and
II. Use of the secondary support vessel aiding in marine mammal observations throughout the entire sanctuary.

The enclosed document provides additional information and analysis supporting this injury determination and recommended alternatives.

Consistent with section 304(d)(3) of the NMSA, once NSF and NMFS have had an opportunity to consider our recommended alternatives, please engage ONMS for further consultation on these alternatives. Should NSF and NMFS decide not to follow our alternatives (as provided herein or modified in further consultation), please provide ONMS with a written statement documenting your decision and rationale. Finally, pursuant to section 304(d)(4) of the NMSA, if NSF and NMFS takes an action other than those recommended herein, and such action results in injury to a sanctuary resource, the heads of NSF and NMFS are required to promptly prevent and mitigate further damage, and restore or replace the sanctuary resources in a manner approved by ONMS.

This consultation applies to the proposed action as defined in NSF's draft Environmental Assessment and NMFS's proposed authorization of take. NSF and NMFS must reinitiate consultation with ONMS if either agency determines that they trigger the NMSA's consultation requirements. Specifically:

- If the action is modified such that it is likely to destroy, cause the loss of, or injure a sanctuary resource or quality in a manner different or greater than was considered in a previous consultation under section 304(d) of the NMSA; or
- If the action is likely to destroy, cause the loss of, or injure any sanctuary resource or quality not considered in a previous consultation under 304(d); or
- If new information reveals that the action it is likely to destroy, cause the loss of, or injure a sanctuary resource or quality in a manner different or greater than considered in a previous consultation; or
- If a new action is proposed that is likely to destroy, cause the loss of, or injure a sanctuary resource.

Please contact me at carol.bernthal@noaa.gov, or 360-406-2075, with any questions you may have on these recommended alternatives. We look forward to continuing to work with you and your staff to meet NSF's and NMFS's mission objectives and to protect the Nation's national marine sanctuaries.

Respectfully,

Carol Bernthal

Carol Bernthal, Superintendent
Olympic Coast National Marine Sanctuary

Enclosure:

cc: Timothy J. Greene, Chairman, Makah Tribal Council
JoDean Haupt-Richards, Secretary, Makah Tribe
Russell Svec, Director, Makah Fisheries Management, Makah Tribe
Haley Kennard, Environmental Policy Analyst, Makah Tribe
Ed Johnstone, Fisheries Policy, Quinault Indian Nation
Joe Schumacker, Marine Scientist, Quinault Indian Nation
Frank Geyer, Director, Quileute Natural Resources, Quileute Tribe
Jennifer Hagen, Marine Policy Advisor, Quileute Tribe
Wendy Largent, Natural Resources Director, Hoh Tribe
Julie Ann Koehlinger, Timber, Fish, and Wildlife Biologist, Hoh Tribe

ONMS Injury Determination and Recommended Alternatives for Consultation under the National Marine Sanctuaries Act for the 2021 National Science Foundation Activities

March 12, 2021

I. Background

The proposed federal agency actions subject to consultation consist of the National Science Foundation's (NSF) 2021 high-energy seismic surveys using a 36-airgun array and deployment of Ocean Bottom Seismometers, and NMFS's proposed issuance of an incidental harassment authorization (IHA) for take of marine mammals incidental to these activities. The area of the geophysical survey and proposed impacts overlaps with OCNMS. In the SRS, NMFS and NSF find that the proposed action may incidentally expose marine resources within OCNMS to sound and other environmental stressors associated with seismic surveys. This consultation considers activities occurring both within and outside the sanctuary's boundaries that are likely to injure sanctuary resources.

NSF activities within the scope of this consultation
As described in Section 1 of the SRS and in Section 2.1.2.1 of NSF's draft EA, NSF's proposed action is seismic survey (SRS; dated January 22, 2021). The scope of this consultation is focused on the proposed track lines for seismic airguns (36-airgun array) and temporary deployment of three ocean bottom seismometers (OBSs) within OCNMS. In Section 4 of the 2021 SRS, NSF concludes that activities are only likely to directly injure sanctuary resources through exposure to sound and energy for which an incidental harassment authorization has been requested. See Table 3 of the SRS for further information. The National Marine Fisheries Service proposes to issue a Marine Mammal Protection Act (MMPA) incidental harassment authorization (IHA) to Lamont-Doherty Earth Observatory (L-DEO) for take, by Level A and Level B harassment, of individuals of several species of marine mammals incidental to sounds from the use of seismic airguns associated with the geophysical survey (NMFS Proposed Action).

NSF mitigation measures
NSF's mitigation measures included in the proposed action fall into two categories: procedural mitigation and geographic mitigation measures. Per the SRS, procedural mitigation primarily involves ramp-ups, dedicated observers during daylight operations, passive acoustic monitoring (PAM) during the day and night, and power downs when marine mammals or sea turtles are detected or are about to enter the exclusion zone.

LDEO "would use visual and acoustic monitors to conduct pre-activity monitoring for at least 30 minutes prior to beginning seismic operations. Following the pre-clearance period, the airgun array would be activated with a stepwise increase in the number of active elements (ramp-up) to warn animals of pending operations" (SRS p. 4). Airgun operations would shutdown if a marine mammal enters a designated exclusion zone (500m for all marine mammals, 1,500m for beaked whales and dwarf and pygmy sperm whales, and any distance for all large whales with calves, aggregations of six or more large whales, a North Pacific right whale, or a killer whale observed).

1

Furthermore, airgun operations would also shutdown for killer whale vocalizations detected on the PAM system.

To enhance southern resident killer whale (SRKW) protections, geographic mitigation will be implemented for surveys between Tillamook Head, OR and Barkley Sound, BC within the 200-meter depth contour to be conducted in daylight hours only. Furthermore, a second vessel with additional observers will travel ahead of the survey vessel. The tracklines have also been revised to limit the ensonified area from extending within the 100-meter depth contour in this region due to the high estimated densities of SRKW.

Reduction of vessel speed to 10 knots or less is proposed to prevent ship strikes when mother/calf pairs, pods, or large assemblages of marine mammals are observed. Vessels would maintain a distance of 100 meters from large whales (mysticetes, sperm whales, and killer whales) and 50 meters from all other marine mammals (except those voluntarily approaching the vessel).

NSF monitoring measures

The SRS does not describe any general monitoring provisions specific to NSF activities that would enhance understanding of impacts to marine mammals and other affected species, despite NMFS acknowledgement of monitoring as a key component of adaptive management.

II. *NSF and NMFS Conclusions Regarding the Effects of the Proposed Action on Sanctuary Resources*

NSF and NMFS analyses of potential overlap of activities and sanctuary resources indicate likely injury to sanctuary resources inside the sanctuary due to sound and energy producing activities occurring both inside and outside the sanctuary's boundary. Acoustic impacts from airguns are identified as likely to injure marine mammals, sea turtles, fish, marine invertebrates, and seabirds. However, NMFS and NSF conclude that the proposed activities would not adversely affect or significantly impact marine invertebrates, fish, and fisheries. Furthemore, due to the short-term exposures, the proposed activities would have no significant impact on marine mammals, sea turtles, or seabirds. Specifically, NSF and NMFS find that acoustic exposure resulting from the geophysical survey could result in permanent threshold shifts (hearing damage) to three marine mammal species in the sanctuary: humpback whales, harbor porpoise, and Dall's porpoise. NSF and NMFS further document exposures from the geophysical survey that could result in temporary hearing damage or behavioral responses in 24 marine mammal populations while present in the sanctuary. Predictions for numbers of exposure events per population in the sanctuary range from hundreds of harbor porpoises, Dall's porpoises and Steller sea lions, to dozens of Risso's dolphins and California sea lions to single digits of SRKW, humpback whales, gray whales, fin whales, and blue whales (see Table 3 from SRS).

In total, NSF and NMFS predict that 1,388 instances of marine mammal take per year (21 of which are Level A harassment) will occur in OCNMS as a result of proposed activities for 2021 across 24 species. NMFS and NSF find that levels of impact from the survey within the sanctuary will have only negligible impacts on the affected species or stocks of marine mammals.

It is important to note that OCNMS overlaps several marine mammal biologically important areas (BIAs), as well as proposed critical habitat areas that may provide a greater conservation benefit to the species than other areas within the sanctuary. These areas include:

- Northern Washington humpback feeding BIA (May-Nov);
- Northeast Washington Gray Whale Feeding BIA (May-Nov);
- Gray whale Migration BIA Northbound – Phase A (Jan-Jul);
- Gray whale Migration BIA Northbound – Phase B (Mar-Jul);
- Gray whale Migration BIA Southbound – All (Oct-Mar);
- Gray whale Migration BIA- potential presence (Jan-Jul; Oct-Dec);
- Proposed Southern Resident killer whale critical habitat Area 1 and Area 2; and
- Proposed humpback whale critical habitat.

III. NMSA Injury Determination

Section 304(d) of the NMSA (16 U.S.C. § 1434(d)) requires federal agencies to consult with the Secretary of Commerce regarding any federal action or proposed action, including activities authorized by federal license, lease, or permit, that is likely to destroy, cause the loss of, or injure[1] any sanctuary resource. A portion of the proposed geophysical survey activities will occur within and in close proximity to OCNMS and will result in impacts including Level A and Level B harassment of marine mammals (take[2]), which NMFS is proposing to authorize under the MMPA. ONMS concurs with NMFS and NSF's conclusion that Level A and Level B takes of marine mammals occurring in the sanctuary as a result of survey activities constitute injury as defined under the NMSA.

While NSF and NMFS find that sound and energy produced by the geophysical survey and their direct effects on marine mammals are the focus of this consultation, ONMS remains concerned about impacts to other sanctuary resources such as sea turtles, seabirds, and fish. As such, ONMS is actively engaged in research to better understand fish movement and behavior within sanctuary waters, particularly soniferous species such as rockfishes and endangered and keystone species such as salmon. ONMS is engaged with partners to better understand the acoustic behavior and potential impacts of anthropogenic noise for more acoustically sensitive fish species in the sanctuary. Salmon, however, continue to represent a species of elevated interest for research relative to the impacts of acoustic activities offshore, given their role as key prey for critically endangered SRKW.

[1] The NMSA regulations define "to injure" as "to change adversely, either in the short or long term, a chemical, biological or physical attribute of, or the viability of. This includes, but is not limited to, to cause the loss of or destroy." 15 CFR 922.3. Throughout this letter reference to the word "injury" means "injury" as defined under the NMSA.

[2] Take (as discussed in the SRS and in NMFS' proposed rule) is an estimate of potential impact to marine mammals adjusted to reflect implementation of proposed mitigation. While 'take' does not necessarily account for all injuries to marine mammals, as a basis for initiating NMSA 304(d) consultation, take occurring within the sanctuary has been considered "likely" injury by NMFS and NSF and thus will be considered in our injury analysis.

Based on our evaluation of material provided in the SRS and associated EA, ONMS concurs with NMFS and NSF's conclusion that Level A and Level B takes of marine mammals occurring in the sanctuary as a result of the proposed geophysical survey constitute injury as defined under the NMSA. ONMS is aware that take estimates represent conservative predictions for the maximum number of exposure "events" that could happen during the survey. For each population, the number 25 captures both 25 exposures to one animal in one day in one year and 25 different individuals each exposed once over the course of the survey, and every combination in between. Take is therefore an important quantification and means to explore the possible efficacy of mitigation strategies. However, take is a less useful tool for providing a holistic representation of actualized impacts to OCNMS's resources and qualities.

ONMS is providing NMFS and NSF with the following recommended alternatives to heighten mitigation for SRKW in the sanctuary due to their critically endangered status and use of OCNMS offshore waters.

<u>IV. NMSA Section 304(d) Recommended Alternatives</u>

ONMS recommends that NSF and NMFS implement the following recommended alternatives to protect sanctuary resources during its proposed geophysical survey activities:

1. ***Reduction in take of vulnerable marine mammal stocks within the sanctuary via enhancements of procedural mitigation to daylight hour operations within OCNMS***

ONMS recommends an enhancement of the current procedural mitigation measures to reduce potential injury to marine mammals due to higher density of occurrence within the sanctuary. The sanctuary overlaps humpback and gray whale areas of biological importance, as well as portions of proposed critical habitat for SRKW and humpback whales. National marine sanctuaries are designated due to the special national, and in some cases international, significance of their conservation, recreational, ecological, historical, scientific, cultural, archeological, educational, and/or esthetic qualities. National marine sanctuaries require a higher standard of resource protection than other marine waters. Furthermore, the usual and accustomed fishing grounds of the coastal treaty tribes fully overlap the sanctuary, exemplifying the productivity and uniqueness of this region.

ONMS recommends the augmentation of operations within OCNMS to be restricted to daylight hours only regardless of depth. NSF is currently proposing to limit "survey operations to daylight hours only...in waters 200-m or less between Tillamook Head, OR and Barkley Sound, BC" as this "is expected to increase the ability of PSOs to visually detect Southern Resident killer whales and initiate shutdowns to minimize exposures" (SRS p. 8). NSF is planning to survey 149.7km of OCNMS, of which 47.1km (31.5%) of the tracklines are deeper than 200-m and therefore would not be covered under the existing mitigation measure. There is limited information on the distribution of SRKW on the outer Washington coast. Due to the extreme fragility of this stock we are recommending enhanced precautions to limit exposures of the survey within the full extent of the sanctuary. By restricting activities within the sanctuary to daylight hours, the ability to

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visually detect marine mammals and initiate shutdowns to minimize exposures will be enhanced during survey operations in this highly productive region.

2. ***Reduction in take of vulnerable marine mammal stocks within the sanctuary through utilization of a secondary observer vessel throughout OCNMS***

As mentioned in our previous recommendation, OCNMS is a highly productive region for marine mammals, including listed species under the ESA.

ONMS recommends the augmentation of operations within OCNMS to have continuous utilization of protected species observers (PSOs) on the second vessel operating ahead of the R/V *Marcus G. Langseth* within the sanctuary regardless of depth. NSF currently proposes "survey operations…requiring a second vessel with additional PSOs to travel ahead of the Langseth in waters 200-m or less between Tillamook Head, OR and Barkley Sound, BC" as this "is expected to increase the ability of PSOs to visually detect Southern Resident killer whales and initiate shutdowns to minimize exposures" (SRS p. 8). However, nearly one-third of the tracklines within OCNMS are deeper than 200-m and therefore would not be covered under the existing mitigation. As previously noted, our understanding of SRKW distribution on the outer Washington coast is limited. Due to the extreme fragility of this stock we are recommending enhanced precautions to limit exposures of the survey within the full extent of the sanctuary given the high productivity of this region. By requiring the continuous use of PSOs on the second vessel regardless of depth in OCNMS, the ability to visually detect marine mammals and initiate shutdowns to minimize exposures will be enhanced during survey operations.

<u>V. NMSA Monitoring and Reporting Recommendation</u>

Several programs are being actively developed to better share information regarding the presence of individual SRKW due to their critically endangered status. The Whale Report Alert System, although currently not well populated for offshore waters, is likely to see advancements in the coming years and would provide another resource for mitigation response in OCNMS for this stock. In turn, NSF observations would provide a form of data input in offshore waters that would be of value for the alert system as a whole. We therefore recommend that NSF consider investment in this system as a user when the distribution of information becomes relevant for offshore operations.

<u>VI. Tribal Consultation and Notification</u>

Pursuant to Executive Order 13175 and NOAA Procedures for Government-to-Government Consultation with Federally Recognized Indian Tribes and Alaska Native Corporations, ONMS has developed a 304(d) consultation protocol with the Makah Tribe to ensure timely, meaningful discussion during the 304(d) process. In compliance with ONMS 304(d) consultation protocol with the Makah Tribe, ONMS notified the Makah Tribe of the NSF and NMFS submission of a SRS, as well as provided the completed SRS and initiated formal communication on this proposed federal action on January 27, 2021. On February 22, 2021, ONMS and Makah staff consulted on the completed SRS, ONMS recommendations, tribal interests, and shared priorities. The Makah Tribe submitted a written response supporting ONMS recommendations on March 4,

2021. The Makah Tribe's input has been integrated into ONMS recommendations, where applicable. ONMS also shared the completed SRS with tribal staff at Quinault Indian Nation, Hoh Tribe, and Quileute Tribe on January 28, 2021.

The high productivity of this region has supported tribal subsistence and commerce for thousands of years. The 1855 Treaty of Neah Bay with the Makah Indian Tribe and the 1856 Treaty of Olympia with the Hoh Indian Tribe, Quileute Indian Tribe, and the Quinault Indian Nation reserved the "right of taking fish[3] at all usual and accustomed grounds and stations," into perpetuity. The treaties were a grant of rights from the tribes and a reservation of rights not granted. The Hoh, Makah, and Quileute Tribes and Quinault Indian Nation (hereinafter the coastal treaty tribes) have treaty-reserved rights off reservation, including usual and accustomed fishing grounds (U&As) that extend 30–40 nautical miles offshore in which commercial, subsistence, and ceremonial fisheries occur. The U&As of the coastal treaty tribes fully overlap the sanctuary.

Several of the coastal treaty tribes (Makah, Quileute, and Quinault) have expressed concerns on impacts to treaty-reserved fisheries and have requested coordinated communications from the survey vessel with their respective fisheries departments when approaching their U&As to avoid or minimize impacts. To facilitate this coordination in communications, below are the tribal staff we recommend NSF coordinate with to avoid and minimize adverse impacts.

Hoh Tribe:

- Wendy Largent, Natural Resources Director: wendy.largent@hohtribe-nsn.org, (360) 780-0010
- Julie Ann Koehlinger, Timber, Fish, and Wildlife Biologist: julie.koehlinger@hohtribe-nsn.org, (360) 780-0551
- Brian Hoffman, Fisheries Management Biologist: brian.hoffman@hohtribe-nsn.org, (360) 780-2008

Makah Tribe:

- Ray Colby, Assistant Fisheries Director: ray.colby@makah.com, (360) 640-4262
- Will Jasper, Groundfish Biologist: william.jasper@makah.com, (360) 640-1662
- Tiffany Petersen, Salmon Biologist: tiffany.petersen@makah.com, (360) 640-3047
- Jonathan Scordino, Marine Mammal Biologist: jon.scordino@makah.com, (360) 640-0959

Quileute Tribe:

- Frank Geyer, Natural Resources Director: frank.geyer@quileutetribe.com, (360) 374-2027
- Jennifer Hagen, Marine Policy Advisor: jennifer.hagen@quileutetribe.com, (360)- 640-4430

[3] The Treaty of Neah Bay has unique language reserving Makah's right to "whaling and sealing" in addition to fish.

Quinault Indian Nation:

- Joe Schumacker, Marine Resources Scientist: jschumacker@quinault.org, (360) 590-0162
- Scott Mazzone, Shellfish/Marine Fish Biologist: smazzone@quinault.org, (360) 590-0293
- Alan Sarich, Marine Finfish Biologist: asarich@quinault.org, (360) 591-4946

VII. Next Steps for Consultation

Consistent with section 304(d)(3) of the NMSA, once NSF and NMFS have had an opportunity to consider our recommended alternatives, please engage ONMS for further consultation. Should NSF and NMFS decide not to follow our recommended alternatives (as provided herein or modified in further consultation), please provide ONMS with a written statement documenting your decisions and rationale. Finally, pursuant to section 304(d)(4) of the NMSA, if NSF and NMFS takes an action other than those recommended herein, and such action results in injury to a sanctuary resource, the heads of NSF and NMFS are required to promptly prevent and mitigate further damage, and restore or replace the sanctuary resources in a manner approved by ONMS.

This consultation applies to the proposed action as defined in NSF's draft Environmental Assessment and NMFS's proposed incidental harassment authorization. NSF and NMFS must reinitiate consultation with ONMS if either agency determines that they trigger the NMSA's consultation requirements. Specifically:

- If the action is modified such that it is likely to destroy, cause the loss of, or injure a sanctuary resource or quality in a manner different or greater than was considered in a previous consultation under section 304(d) of the NMSA; or
- If the action is likely to destroy, cause the loss of, or injury a sanctuary resource or quality not considered in a previous consultation under 304(d); or
- If new information reveals that the action it is likely to destroy, cause the loss of, or injure a sanctuary resource or quality in a manner different or greater than considered in a previous consultation; or
- If a new action is proposed that is likely to destroy, cause the loss of, or injure a sanctuary resource.

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UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SERVICE

Olympic Coast National Marine Sanctuary
115 E. Railroad Ave., Suite 301
Port Angeles, Washington 98362

April 1, 2021

Dr. Sean Higgins
Columbia University Lamont-Doherty Earth Observatory
61 Route 9W
Office of Marine Operations
Palisades, NY 10964

Dear Dr. Higgins:

The National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries (ONMS) has approved the issuance of permit number OCNMS-2020-001 to conduct activities within Olympic Coast National Marine Sanctuary (sanctuary) for research purposes. Activities are to be conducted in accordance with the permit application and all supporting materials submitted to the sanctuary, and the terms and conditions of permit number OCNMS-2020-001 (enclosed).

This permit is not valid until signed and returned to the ONMS. Retain one signed copy and carry it with you while conducting the permitted activities. Additional copies must be signed and returned, by either mail or email, to the following individual within 30 days of issuance and before commencing any activity authorized by this permit:

Katie Wrubel
Permit Coordinator
Olympic Coast National Marine Sanctuary
115 E. Railroad Ave., Suite 301
Port Angeles, Washington 98362
Katie.Wrubel@noaa.gov

Your permit contains specific terms, conditions and reporting requirements. Review them closely and fully comply with them while undertaking permitted activities.

If you have any questions, please contact Katie Wrubel at Katie.Wrubel@noaa.gov. Thank you for your continued cooperation with the ONMS.

Sincerely,

Carol Bernthal

Carol Bernthal
Superintendent

Enclosure

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SERVICE

Olympic Coast National Marine Sanctuary
115 E. Railroad Ave., Suite 301
Port Angeles, Washington 98362

OLYMPIC COAST NATIONAL MARINE SANCTUARY RESEARCH PERMIT

Permittee:
Dr. Sean Higgins
Columbia University Lamont-Doherty Earth Observatory
61 Route 9W
Office of Marine Operations
Palisades, NY 10964

Permit Number: OCNMS-2020-001
Effective Date: May 1, 2021
Expiration Date: August 31, 2021

Project Title: Collaborative Research: Illuminating the Cascadia plate boundary zone and accretionary wedge with a regional-scale ultra-long offset multi-channel seismic study

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This permit is issued for activities in accordance with the National Marine Sanctuaries Act (NMSA), 16 USC §§ 1431 *et seq.*, and regulations thereunder (15 CFR Part 922). All activities must be conducted in accordance with those regulations and law. No activity prohibited in 15 CFR Part 922 is allowed except as specified in the activity description below.

Subject to the terms and conditions of this permit, the National Oceanic and Atmospheric Administration (NOAA), Office of National Marine Sanctuaries (ONMS) hereby authorizes the permittee listed above to conduct research activities within Olympic Coast National Marine Sanctuary (OCNMS or sanctuary). All activities are to be conducted in accordance with this permit and the permit application received December 17, 2019. The permit application is incorporated into this permit and made a part hereof; provided, however, that if there are any conflicts between the permit application and the terms and conditions of this permit, the terms and conditions of this permit shall be controlling.

Permitted Activity Description:
The following activities are authorized by this permit:

Deployment of 3 ocean bottom seismometers and abandonment of concrete anchors.

No further activities prohibited by sanctuary regulations are allowed.

Permitted Activity Location:
The permitted activity is allowed only in the following location(s):

Approximate coordinates for the OBS deployments within the Olympic Coast National Marine Sanctuary (OCNMS) would be as follows:

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Line	OBS	Lon	Lat	Depth (m)
22	113	-124.92642	47.22340	586.2
22	114	-124.80873	47.24203	149.3
22	115	-124.69096	47.26055	105.1

Special Terms and Conditions:

1. This permit is effective from either May 1, 2021 or the day it is signed by the permittee and delivered to the OCNMS Permit Coordinator (see General Terms and Condition #1), whichever is later. The executed permit will be valid through August 31, 2021. The permittee may request an amendment from the OCNMS Superintendent a minimum of 60 days in advance of this expiration date, to extend the effective date of this permit. Amendments to this permit cannot be made after expiration.

2. This permit does not relieve the permittee of responsibility to comply with all other federal, state and local laws and regulations.

3. While in, or adjacent to, the sanctuary strict compliance to mitigations outlined in the Marine Mammal Protection Act (MMPA) incidental harassment authorization (IHA) are required as well as the recommended alternatives agreed upon under National Marine Sanctuaries Act (NMSA) 304(d) consultation and requirements under Endangered Species Act consultations. In addition to IHA mitigations, daily contact between NMFS Protected Resources Division and the protected species observers shall be established.

4. As agreed under NMSA 304(d) consultation, while within OCNMS survey activities will be restricted to daylight hours only with sufficient visibility to enhance efficacy of protected species observers. Furthermore, while in OCNMS, regardless of depth, a secondary support vessel aiding in protected species observations will be utilized.

5. The OCNMS Permit Coordinator (see General Terms and Condition #1) shall be notified at least 72-hours in advance, and at the conclusion, of any field operations conducted under this permit. Notification shall include a brief description of the planned operations and schedule.

6. The Permittee will provide ship-based and shore side contacts to the OCNMS Permit Coordinator. The Permittee will provide notice when the R/V *Oceanus* will be deploying the ocean bottom seismometers as well as when the R/V *Marcus G. Langseth* is underway. This notice should include the anticipated schedule for approaching the sanctuary. The permittee will also provide notice a minimum of 72-hours prior to entering OCNMS boundaries to the OCNMS Permit Coordinator.

7. When approaching tribal usual and accustomed fishing grounds (U&As), the survey vessel should communicate directly with their respective fisheries departments a minimum of 72-hours in advance to avoid or minimize impacts. To facilitate this coordination in communications below are the tribal staff we recommend NSF coordinate with to avoid and minimize adverse impacts:

- Quinault Indian Nation:
  - Joe Schumacker, Marine Resources Scientist: jschumacker@quinault.org, (360) 590-0162
  - Scott Mazzone, Shellfish/Marine Fish Biologist: smazzone@quinault.org, (360) 590-0293
  - Alan Sarich, Marine Finfish Biologist: asarich@quinault.org, (360) 591-4946

- Hoh Tribe:
  - Wendy Largent, Natural Resources Director: wendy.largent@hohtribe-nsn.org, (360) 780-0010
  - Julie Ann Koehlinger, Timber, Fish, and Wildlife Biologist: julie.koehlinger@hohtribe-nsn.org, (360) 780-0551
  - Brian Hoffman, Fisheries Management Biologist: brian.hoffman@hohtribe-nsn.org, (360) 780-2008

- Quileute Tribe:
  - Frank Geyer, Natural Resources Director: frank.geyer@quileutetribe.com, (360) 374-2027
  - Jennifer Hagen, Marine Policy Advisor: jennifer.hagen@quileutetribe.com, (360)-640-4430

- Makah Tribe:
  - Ray Colby, Assistant Fisheries Director: ray.colby@makah.com, (360) 640-4262
  - Will Jasper, Groundfish Biologist: william.jasper@makah.com, (360) 640-1662
  - Tiffany Petersen, Salmon Biologist: tiffany.petersen@makah.com, (360) 640-3047
  - Jonathan Scordino, Marine Mammal Biologist: jon.scordino@makah.com, (360) 640-0959

8. The permit holder will contact the U.S. Naval Air Station Whidbey Island Community Planning & Liaison Officer for the Northwest Training Range Complex (NWTRC) a minimum of 48 hours prior to the planned arrival on the first air gun array survey line. The permit holder is required to work with the U.S. Navy to avoid conflicts with naval operations. The current contact is Ms. Kimberly Peacher, who can be reached at (360) 930-4085 (work cell) or kimberly.peacher@navy.mil. The OCNMS permit coordinator should be informed of any communication and agreements between the U.S. Navy and the permit holder.

9. The permittee shall maintain contact with the U.S. Coast Guard D13 Waterways Management Branch regarding the location of the ocean bottom seismometers, to ensure that they are properly identified on the nautical charts and/or noticed in the "Local Notice to Mariners", as appropriate. Copies of any correspondence, example "Local Notice to Mariners" notice, or other permit or authorization shall be provided to the OCNMS Permit Coordinator (see General Terms and Condition #1).

10. Operations within the International Maritime Organization (IMO) Area to be Avoided (ATBA) or within the traffic lanes are to be conducted in coordination with the United States

Coast Guard Seattle Traffic or Canadian Coast Guard Prince Rupert Traffic, as appropriate.

11. During activities authorized by this permit, the permittee shall display, when appropriate, international signals for conducting special operations, monitor VHF radio and attempt to establish bridge-to-bridge communications with all approaching commercial shipping traffic to advise them of restricted maneuverability and to arrange passing and/or closest point of approach.

12. Within 30 days of completion of each installation, servicing or retrieval event, the permittee shall submit a brief, written report on the permitted activities within OCNMS, including revised coordinates (if the instrument location is not consistent with its proposed coordinates) and a description of materials abandoned on the seafloor. Please send this report to Katie Wrubel, OCNMS Permit Coordinator, via email (katie.wrubel@noaa.gov).

13. The permittee is required to recover all equipment, with the exception of three concrete anchors. If equipment is not recovered a report describing the failed attempted recovery, detailed description of the abandoned equipment, its location, and plans for future recovery attempts shall be provided to the OCNMS Permit Coordinator within 2 weeks of the incident. At no time may hazardous materials, including batteries, be discarded within the sanctuary.

14. No activity authorized by this permit shall disturb or impact any historical or marine archaeological resources of the sanctuary. If historical or marine archaeological resources are encountered at any time, the permittee shall cease all further activities under this permit and immediately contact the OCNMS Permit Coordinator (see General Terms and Condition #1).

15. Data and results from the survey should be made available within a reasonable timeframe. The permittee should present the results of the survey to the Olympic Coast communities and can work with OCNMS on identifying avenues for outreach (i.e., Sanctuary webinar series, Sanctuary Advisory Council meeting, or other venues).

16. The permittee shall submit final report of all activities conducted under this permit to the OCNMS Permit Coordinator (see General Terms and Condition #1) no later than December 31 of 2021. The report should include information regarding permitted activities such as servicing dates, problems encountered, lost equipment, and disturbance of historical artifacts. There should be a section that documents lost equipment that has not been recovered to date, this should include equipment that was lost under previous permits related to the same project, if applicable.

17. The permittee shall submit a report of the survey findings within a reasonable amount of time following completion of the survey. This report should be provided to the OCNMS Permit Coordinator and the coastal treaty tribes (see Special Condition #7 for contacts).

Higgins
Permit # OCNMS-2020-001
Page 5 of 6

General Terms and Conditions:

1. Within 30 (thirty) days of the date of issuance, the permittee must sign and date this permit for it to be considered valid. Once signed, the permittee must send copies, via mail or email, to the following individual:

   Katie Wrubel
   Permit Coordinator
   Olympic Coast National Marine Sanctuary
   115 E. Railroad Ave , Suite 301
   Port Angeles, Washington 98362
   Katie.Wrubel@noaa.gov

2. It is a violation of this permit to conduct any activity authorized by this permit prior to the ONMS having received a copy signed by the permittee.

3. This permit may only be amended by the ONMS. The permittee may not change or amend any part of this permit at any time. The terms of the permit must be accepted in full, without revision; otherwise, the permittee must return the permit to the sanctuary office unsigned with a written explanation for its rejection. Amendments to this permit must be requested in the same manner the original request was made.

4. All persons participating in the permitted activity must be under the supervision of the permittee, and the permittee is responsible for any violation of this permit, the NMSA, and sanctuary regulations for activities conducted under, or in conjunction with, this permit. The permittee must assure that all persons performing activities under this permit are fully aware of the conditions herein.

5. This permit is non-transferable and must be carried by the permittee at all times while engaging in any activity authorized by this permit.

6. This permit may be suspended, revoked, or modified for violation of the terms and conditions of this permit, the regulations at 15 CFR Part 922, the NMSA, or for other good cause. Such action will be communicated in writing to the applicant or permittee, and will set forth the reason(s) for the action taken.

7. This permit may be suspended, revoked or modified if requirements from previous ONMS permits or authorizations issued to the permittee are not fulfilled by their due date.

8. Permit applications for any future activities in the sanctuary or any other sanctuary in the system by the permittee might not be considered until all requirements from this permit are fulfilled.

9. This permit does not authorize the conduct of any activity prohibited by 15 CFR Part 922, other than those specifically described in the "Permitted Activity Description" section of this permit. If the permittee or any person acting under the permittee's supervision

conducts, or causes to be conducted, any activity in the sanctuary not in accordance with the terms and conditions set forth in this permit, or who otherwise violates such terms and conditions, the permittee may be subject to civil penalties, forfeiture, costs, and all other remedies under the NMSA and its implementing regulations at 15 CFR Part 922.

10. Any publications and/or reports resulting from activities conducted under the authority of this permit must include the notation that the activity was conducted under National Marine Sanctuary Permit OCNMS-2020-001 and be sent to the ONMS official listed in general condition number 1.

11. This permit does not relieve the permittee of responsibility to comply with all other federal, state and local laws and regulations, and this permit is not valid until all other necessary permits, authorizations, and approvals are obtained. Particularly, this permit does not allow disturbance of marine mammals or seabirds protected under provisions of the Endangered Species Act, Marine Mammal Protection Act, or Migratory Bird Treaty Act. Authorization for incidental or direct harassment of species protected by these acts must be secured from the U.S. Fish and Wildlife Service and/or NOAA Fisheries, depending upon the species affected.

12. The permittee shall indemnify and hold harmless the Office of National Marine Sanctuaries, NOAA, the Department of Commerce and the United States for and against any claims arising from the conduct of any permitted activities.

13. Any question of interpretation of any term or condition of this permit will be resolved by NOAA.

Your signature below, as permittee, indicates that you accept and agree to comply with all terms and conditions of this permit. This permit becomes valid when you, the permittee, countersign and date below. Please note that the expiration date on this permit is already set and will not be extended by a delay in your signing.

Sean Higgins — 4/12/21

Dr. Sean Higgins — Date
Columbia University Lamont-Doherty Earth Observatory

Carol Bernthal — 04/01/2021

Carol Bernthal — Date
Superintendent
Olympic Coast National Marine Sanctuary

0 document(s) attached.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SERVICE
OFFICE OF NATIONAL MARINE SANCTUARIES
Olympic Coast National Marine Sanctuary
115 East Railroad Avenue, Suite 301
Port Angeles, WA 98362-2925

January 27, 2021

Amy Fowler
Incidental Take Program
National Marine Fisheries Service Office of Protected Resources
1315 East-West Highway
Silver Spring, MD 20910

Holly Smith
National Science Foundation
2415 Eisenhower Avenue
Alexandria, Virginia 22314

Dear Ms. Fowler, Ms. Smith:

On May 1, 2020, the National Oceanic and Atmospheric Administration (NOAA) Office of National Marine Sanctuaries (ONMS) received the National Science Foundation (NSF) and NOAA National Marine Fisheries Service (NMFS) initial Sanctuary Resource Statement (SRS) and request to initiate consultation under the National Marine Sanctuaries Act (NMSA; 16 U.S.C. 1434) for a proposed marine geophysical survey of the Cascadia Subduction Zone in the northeast Pacific Ocean using the R/V *Marcus G. Langseth*. The proposed action includes the associated notice of proposed rulemaking by NMFS to issue incidental take authorizations under the Marine Mammal Protection Act (MMPA) to Lamont-Doherty Earth Observatory for takes of marine mammals incidental to the geophysical surveys (April 7, 2020; 85 FR 19580). The SRS references the permit application to Olympic Coast National Marine Sanctuary (OCNMS) initially submitted on December 17, 2019 and a Draft Environmental Assessment prepared by NSF (dated November 21, 2019). After ONMS's request for additional information and clarification, ONMS received a final revised permit application on May 15, 2020 and a final revised SRS on January 22, 2021.

Pursuant to section 304(d) of the NMSA, ONMS conducted a review of the revised SRS and referenced documents and finds that it is sufficient for the purposes of making an injury determination and developing recommended alternatives. The next step in the consultation process is for ONMS to evaluate whether OCNMS resources are likely to be injured by the proposed action, and if so to develop any necessary reasonable and prudent alternatives to protect sanctuary resources. Consistent with NOAA's government-to-government consultation responsibilities with the Makah Tribe, ONMS will share a copy of the SRS with the Makah Tribe and initiate discussions regarding technical/policy input on any potential recommended alternatives. ONMS will complete this work within 45 days of the date of this letter, no later than March 12, 2021.

If you have any questions, please contact Katie Wrubel at katie.wrubel@noaa.gov.

Sincerely,

Carol Bernthal

Carol Bernthal
Sanctuary Superintendent
Olympic Coast National Marine Sanctuary

cc: Vicki Wedell, NOAA Office of National Marine Sanctuaries
Sophie Godfrey-McKee, NOAA Office of National Marine Sanctuaries
Leila Hatch, NOAA Office of National Marine Sanctuaries
George Galasso, NOAA Olympic Coast National Marine Sanctuary
Katie Wrubel, NOAA Olympic Coast National Marine Sanctuary

APPENDIX I: CANADIAN FISHERIES ACT - DFO LETTER OF ADVICE

Fisheries and Oceans Canada
Pacific Region
Ecosystem Management Branch
3190 Hammond Bay Road
Nanaimo, BC
V9T 6N7

Pêches et Océans Canada
Région du Pacifique
Gestion des ecosystems
3190, rue Hammond Bay
Nanaimo, (C.-B.)
V9T 6N7

April 6, 2021

Your file *Votre référence*
NSF Cascadia Subduction Zone Seismic Survey

Our file *Notre référence*
20-HPAC-01328

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 Cascadia Subduction Zone, May 01 – July 10, 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) at the Cascadia Subduction Zone in the Northeast Pacific Ocean off the west coast of Vancouver Island during late spring/summer 2021. In particular:

- The proposed two-dimensional (2-D) seismic surveys will occur over an estimated 16 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: 37.5 m shot interval) with a total discharge volume of ~6600 in^3 in water depths ranging from 60–4400 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.

Canada

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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 species include the endangered Southern Resident Killer Whale.

Our review considered the following information:

- DFO Request for Review form dated December 18, 2020; and
- Draft *Environmental Assessment/Analysis (EA/A) of a Marine Geophysical Survey by R/V Marcus G Langseth of the Cascadia Subduction Zone in the Northeast Pacific Ocean, Late Spring/Summer 2020* dated November 21, 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 sections 32, 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 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 physical limitations of observing animals during certain conditions, such as late spring/summer 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 Southern Resident Killer Whales, in particular, are currently facing imminent 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 are already low, as in the case of the Southern Resident Killer Whales. In addition, the activities will occur adjacent to designated critical habitat of Southern and Northern Resident Killer Whales as well as in areas under consideration for critical habitat orders for Transient Killer Whales. The generation of noise is intrinsic to the survey methodology and will cause short term disturbance of marine mammals including temporary threshold shift (hearing) and masking (communication). Physical injury or harm/harassment is not anticipated, as generated noise will continue 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 to the potential for short term disturbance to the SARA-listed species as indicated above, 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 four 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 designated 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 Cascadia Subduction Zone 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 document and the submitted EA/A document be implemented along with the following mitigation and avoidance measures.

The most stringent measure should be implemented where appropriate:

- Conduct seismic survey activities outside of designated 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.
- 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* 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 Southern Resident 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 Southern Resident Killer Whales 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 Southern Resident 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 Cascadia Subduction Zone 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 July 31, 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*