Draft Environmental Assessment of Marine Geophysical Surveys by R/V *Marcus G. Langseth* of the Cascadia Subduction Zone in the Northeast Pacific Ocean, 2022

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ABSTRACT

Researchers from New Mexico Institute of Mining and Technology (NMT) and Oregon State University (OSU), with funding from the U.S. National Science Foundation (NSF), propose to conduct seismic surveys from the Research Vessel (R/V) *Marcus G. Langseth* (*Langseth*), which is owned and operated by Lamont-Doherty Earth Observatory (L-DEO) of Columbia University, at the Cascadia Subduction Zone and Juan de Fuca Plate in the Northeast Pacific Ocean during summer 2022. The proposed two-dimensional (2-D) seismic surveys would occur within the Exclusive Economic Zones (EEZ) of the U.S., in water >1600 m deep (Proposed Action [PA]). The proposed seismic surveys would collect data to understand the thermal structure of the Juan de Fuca plate as it enters the Cascadia subduction zone. 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…".

In May 2021, NSF funded a more extensive high-energy survey off the coast of Oregon, Washington, and British Columbia. This Draft Environmental Assessment (EA) tiers to the EA and issued Finding of No Significant Impact (FONSI) for the 2021 action, with updates to the project information and data as appropriate. All federal authorizations were issued for the 2021 activity, including incidental harassment authorizations (IHAs) and Biological Opinions (BOs). This EA also tiers to the EA of Marine Geophysical Surveys by the R/V *Marcus G. Langseth* in the Northeastern Pacific Ocean, June–July 2012 and issued FONSI for similar seismic surveys conducted in 2012 in, or near, the proposed survey area; and, it 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 Draft EA addresses NSF's requirements under the National Environmental Policy Act (NEPA) for the proposed NSF federal action within the U.S. EEZ. As operator of R/V *Langseth*, L-DEO, on behalf of itself, NSF, NMT, and OSU, will request an Incidental Harassment Authorization (IHA) from the U.S. National Marine Fisheries Service (NMFS) 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 will be used to support an ESA Section 7 consultation with NMFS. 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.

Numerous species of marine mammals occur within the northeastern Pacific Ocean. Under the U.S. ESA, several of these species are listed as ***endangered***, including the North Pacific right, gray whale (Western North Pacific Distinct Population Segment or DPS), humpback (Central America DPS), sei, fin, blue, sperm, and Southern Resident DPS of killer whales. However, it is unlikely that Western North Pacific gray whales or Southern Resident killer whales would occur in the proposed offshore project area. In addition, the ***threatened*** Mexico DPS of the humpback whale and the ***threatened*** Guadalupe fur seal could occur in the proposed project area. The ***threatened*** northern sea otter is not expected to occur in the offshore project area.

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. ESA-listed seabirds that could be encountered in the area include the ***endangered*** short-tailed albatross and Hawaiian petrel. The ***threatened*** marbled murrelet is unlikely to occur in the offshore survey areas.

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. Although the ***threatened*** bull trout could occur in shallow water along the coast, it is not expected to occur in the offshore survey area.

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; two 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 monitored; shut downs when marine mammals are detected in or about to enter the designated EZ. The acoustic source would also be 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 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. Level A takes would not be anticipated and therefore were not requested.

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
ODFW	Oregon Department of Fish and Wildlife
OEIS	Overseas Environmental Impact Statement
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
SBP	Sub-bottom Profiler
SEL	Sound Exposure Level (a measure of acoustic energy)
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
µPa	microPascal
vs.	versus
WCMC	World Conservation Monitoring Centre
WHOI	Woods Hole Oceanographic Institution
y	year

I Purpose and Need

This Draft Environmental Assessment (EA) addresses NSF's requirements under the National Environmental Policy Act (NEPA) and tiers to the following documents, including for similar seismic surveys: 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; Final Environmental Assessment/Analysis of Marine Geophysical Surveys by R/V *Marcus G. Langseth* in the Cascadia Subduction Zone in the Northeast Pacific Ocean, 2021; and Final Environmental Assessment/Analysis of Marine Geophysical Surveys by R/V *Marcus G. Langseth* Northeastern Pacific Ocean, June–July 2012, and Finding of No Significant Impacts (FONSIs).[1] The purpose of this Draft 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.

The Draft 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 will be used in support of other regulatory processes, including an application for an Incidental Harassment Authorization (IHA) and Section 7 consultation under the *Endangered Species Act* (ESA) with the National Marine Fisheries Service (NMFS). Information from the IHA application prepared by LGL Ltd., environmental research associates, was incorporated into the Draft EA. 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 summer 2022. 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 and were not requested or anticipated to be issued.

1.1 Mission of NSF

The National Science Foundation (NSF) was established by Congress with the National Science Foundation Act of 1950 (Public Law 810507, as amended) and is the only federal agency dedicated to the support of fundamental research and education in all scientific and engineering disciplines. Further details on the mission of NSF are described in § 1.2 of the PEIS.

1.2 Purpose of and Need for the Proposed Action

As noted in the PEIS, § 1.3, NSF has a continuing need to fund seismic surveys that enable scientists to collect data essential to understanding the complex Earth processes beneath the ocean floor. The purpose of the proposed study is to improve understanding of the thermal structure of the Juan de Fuca plate as it enters the Cascadia subduction zone. The proposed study would acquire heat flow and seismic data across

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[1] PEIS, EAs and FONSIs 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.

several distinct structures that have not been previously studied, including a pseudofault, complex buried seamounts, and small outcrops that represent the summit of much larger buried seamounts. Although existing seismic and bathymetric data are adequate for identifying targets for heat flow measurements, they are not adequate for determining basement and sediment structure in order to interpret heat flow observations.

The proposed activities would collect data in support of a research proposal that was reviewed through the NSF merit review process and identified as an NSF program priority 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

- 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, 2005, and 2020)); 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.*);
- Coastal Zone Management Act (CZMA) of 1972 (16 USC §§1451 *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 Draft 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.

2.1 Proposed Action

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

2.1.1 Project Objectives and Context

The primary objective of this proposal is to understand the thermal structure of the Juan de Fuca plate as it enters the Cascadia subduction zone. Prior heat flow measurements across the flank of a buried seamount near the subduction zone offshore Washington suggest that the basement surface is isothermal, which implies high permeability and fluid flow within the oceanic crust and an impermeable seal at the seafloor. Prior work on young crust near the Juan de Fuca Ridge indicate that the crustal flow paths are connected over large distances when basement outcrops are present. Recent seismic data indicate that buried seamounts are more widely distributed than previously thought, and some of these seamounts show seismic evidence for fluid flow into the overlying sediments, which is inconsistent with the idea that sediment cover is impermeable. The proposed study would acquire heat flow and seismic data across several distinct structures that have not been previously studied, including a pseudofault, complex buried seamounts, and small outcrops that represent the summit of much larger buried seamounts. Although existing seismic and bathymetric data are adequate for identifying targets for heat flow measurements, they are not adequate for determining basement and sediment structure in order to interpret heat flow observations.

To achieve the project goals, the Principal Investigators (PI) Drs. G. Spinelli (NMT), R. Harris (OSU) and A. Tréhu (OSU) propose to utilize 2-D seismic reflection capabilities of R/V *Langseth*. The 2-D seismic reflection data are required to constrain basement depth and other structural features that affect the heat flow measured near the seafloor and are critical for accurately modeling the heat flow observations.

2.1.2 Proposed Activities

2.1.2.1 Location of the Survey Activities

The proposed surveys would occur within ~42–47°N, ~125–127°W. Four proposed survey regions are indicated in Figure 1 along with the proposed number of line km to be acquired; the tracklines could occur anywhere within the coordinates noted above. The surveys are proposed to occur within the EEZ of the U.S. in water >1600 m deep. R/V *Langseth* would likely leave out of and return to port in Newport, OR, during summer 2022. The ensuing analysis (including take estimates) focuses on the time of the survey (summer). For cetaceans, the best available densities available were for summer/fall; for pinnipeds, the highest densities for either spring, summer or fall were used.

2.1.2.2 Description of Activities

The Proposed Action would acquire high-resolution 2-D seismic reflection data in conjunction with densely-spaced heat flow measurements off the coasts of Oregon and Washington in the Northeast Pacific Ocean within the EEZ of the U.S. Four regions where the surveys are proposed to occur within ~42–47°N, ~125–127°W are depicted in Figure 1; the tracklines could occur anywhere within the boxes shown in Figure 1. No representative survey tracklines are shown, as actual track lines and order of survey operations would be dependent on data collected in situ and weather.

The procedures to be used for the proposed surveys would be similar to those used during previous seismic surveys by L-DEO and would use conventional seismic methodology. The surveys would involve one source vessel, R/V *Langseth*, which is owned and operated by L-DEO. R/V *Langseth* would deploy two 45/105 in^3 GI airguns as an energy source with a total volume of ~90 in^3. The receiving system would consist of one 800–1400 m long hydrophone streamer. As the airguns are towed along the survey lines, the hydrophone streamer would transfer the data to the on-board processing system. Approximately 1135 km of transect lines would be surveyed in four survey regions in the Northeast Pacific Ocean: 200 km, 95, 440 km, and 400 km in the Coast, Nubbin, Pseudofault, and Oregon survey regions, respectively. All survey effort would occur in deep water >1600 m. In addition to the operations of the airgun array, the ocean floor would be mapped with the Kongsberg EM 122 MBES and a Knudsen Chirp 3260 SBP. A Teledyne RDI 75 kHz Ocean Surveyor ADCP would be used to measure water current velocities. These sources are described in § 2.2.3.1 of the PEIS.

As the airguns are towed along the survey lines, the towed hydrophone array in the streamer would receive the reflected signals and transfer the data to the on-board processing system. The turning rate of the vessel with gear deployed would be limited; thus, the maneuverability of the vessel would be limited during operations. Approximately 1135 km of transect lines would be surveyed in the Northeast Pacific Ocean. All survey effort would occur in deep water >1600 m.

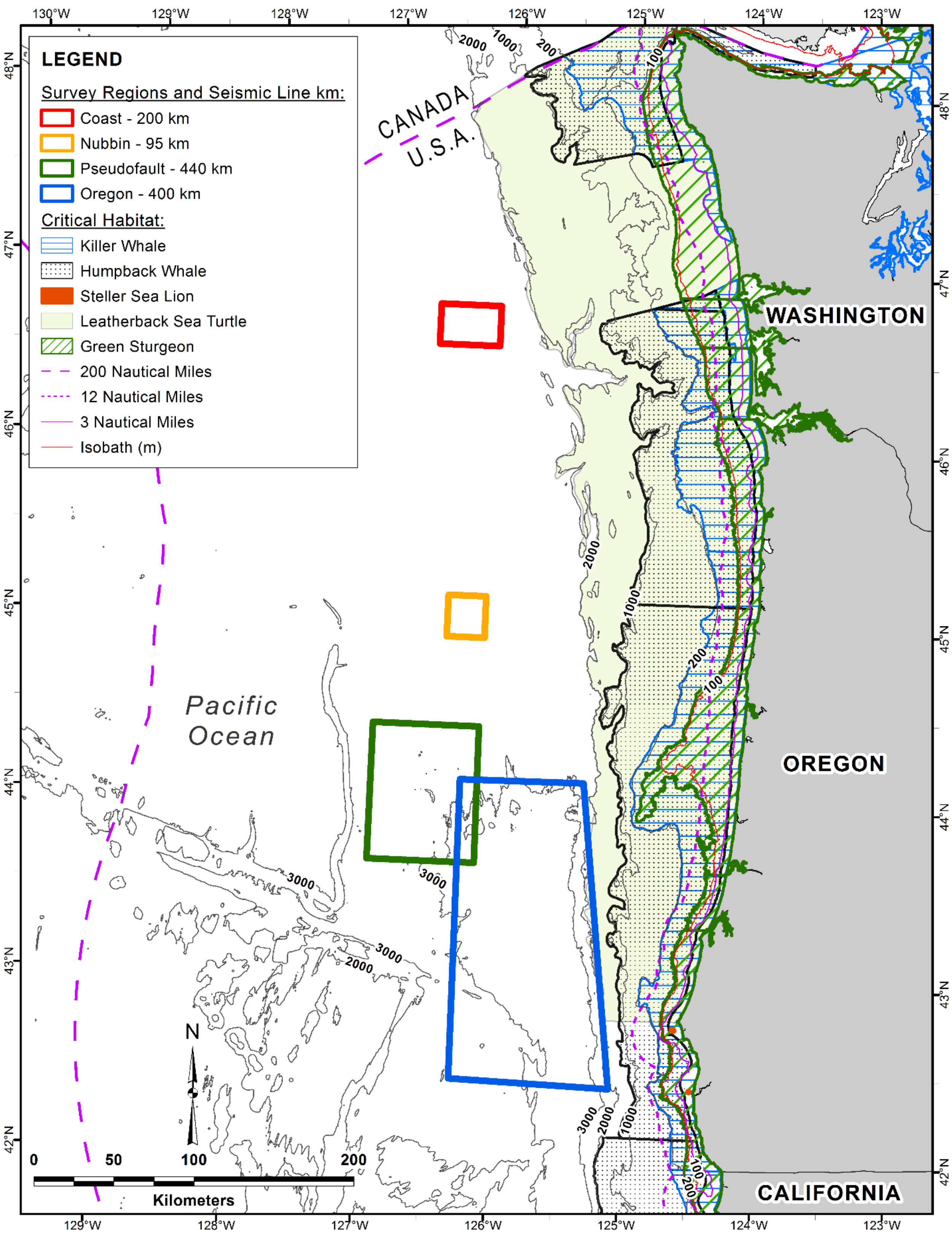

FIGURE 1. Location of the proposed seismic surveys in the Northeast Pacific Ocean and U.S. critical habitat.

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. 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 are scheduled for summer 2022 and would be expected to last for ~23 days, including ~6 days of seismic operations, 3 days of transit, and 14 days of heat flow measurements.

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).

2.1.2.5 Airgun Description

During the surveys, R/V *Langseth* would tow a 2 GI-airgun cluster in true GI (45/105) mode as the seismic source, with a total discharge volume of 90 in^3. The two inline GI airgun would be spaced 2.46 m apart. The array would be towed at a depth of 2–4 m, and the shot interval would be 12.5–25 m.

GI Airgun Specifications

Energy Source:	Two GI guns of 45 in^3 each
Gun positions used:	Two inline airguns 2.46 m apart
Towing depth of energy source:	2–4 m
Source output (2.46-m gun separation)*:	0-peak is 3.6 bar-m (231.1 dB re 1 µPa·m); peak-peak 7.2 bar-m (237.1 dB re 1 µPa·m)
Air discharge volume:	Approx. 90 in^3
Dominant frequency components:	0–188 Hz
Gun volumes at each position (in^3):	45, 45

*Source output downward based on a conservative tow depth of 4 m.

2.1.2.6 Heat Flow Measurement Description

Heat flow data would be acquired with a new heat flow probe. The probe is lowered into the seafloor sediment, penetrating up to 6 m into the sediment. The heat flow measurements along a transect would be acquired in "pogo" mode, in which the probe is left in the water between sites on a particular transect as the ship slowly moves from site to site along the transect. Heat flow transects would be along new or existing seismic lines with additional seismic data acquired to determine the basement structure perpendicular to the heat flow transects, allowing for incorporation of 3-D effects in the modeling of heat and fluid transport. The heat probe is a passive system that takes the temperature of the sediments like a thermometer.

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. 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.

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 surveys was to evaluate what source level was necessary to meet the research objectives. It was decided that the scientific objectives could be met using a low-energy source consisting of two 45/105 in^3 GI guns (total volume of 90 in^3) at a tow depth of ~2–4 m.

***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), 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, summer is the most practical season for the proposed surveys based on operational requirements and data quality concerns.

***Mitigation Zones*.—**During the planning phase, mitigation zones for the proposed seismic surveys were not derived from the farfield signature but calculated based on modeling by L-DEO for the Level B (160 dB re 1µPa_{rms}) threshold. The background information and methodology for this are provided in Appendix A. The proposed surveys would acquire data with the 2-GI airgun array at a tow depth of ~2–4 m. L-DEO model results are used to determine the 160-dB_{rms} radius for the 2-GI airgun array in deep water (>1000 m) down to a maximum water depth of 2000 m, as animals are generally not anticipated to dive below 2000 m (Costa and Williams 1999).

The NSF and USGS PEIS defined a low-energy source as any towed acoustic source whose received level is ≤180 dB re 1 µPa_{rms} (the Level A threshold under the former NMFS acoustic guidance) at 100 m, including any single or any two GI airguns and a single pair of clustered airguns with individual volumes of ≤250 in^3. In § 2.4.2 of the PEIS, Alternative B (the Preferred Alternative) conservatively applied a 100-EZ for all low-energy acoustic sources in water depths >100 m. Consistent with the PEIS, that approach is used here for the pair of 45/105 in^3 GI airguns in all water depths. If marine mammals are detected in or about to enter the appropriate EZ, the airguns would be shut down immediately. Enforcement of mitigation zones via shut downs would be implemented in the Operational Phase, as noted below. A fixed 160-dB "Safety Zone" was not defined for the same suite of low-energy sources in the NSF and USGS PEIS. Table 1 shows the distances at which the 160-dB and 175-dB re 1µPa_{rms} sound levels are expected to be received for the 2-GI airgun array at a 4-m tow depth. The 160-dB level is the behavioral disturbance criterion (Level B) that is used by NMFS to estimate anticipated takes for marine mammals.

This document has been prepared in accordance with the current National Oceanic and Atmospheric Administration (NOAA) acoustic practices, and the monitoring and mitigation procedures are based on best practices (e.g., Pierson et al. 1998; Weir and Dolman 2007; Nowacek et al. 2013a; Wright 2014; Wright and Cosentino 2015; Acosta et al. 2017; Chou et al. 2021). Although Level A takes would not be

TABLE 1. Level B. Predicted distances to the 160 dB re 1 μPa$_{rms}$ sound level that could be received from two 45/105 in^3 GI guns (at a tow depth of 4 m) that would be used during the seismic surveys in the Northeast Pacific Ocean during summer 2022.

Airgun Configuration	Water Depth (m)	Predicted Distances (m) to a Received Sound Level of 160 dB re 1 μPa$_{rms}$
Two 45-in^3 GI guns	>1000	553

anticipated, for other recent low-energy seismic surveys, NMFS required protected species observers (PSOs) to establish and monitor a 100-m exclusion zone (EZ) and a 200-m buffer zone beyond the EZ. Shut downs would be implemented for marine mammals within the designated EZ. A shut down would also be implemented for sea turtles or diving ESA-listed seabirds. A 100-m EZ would be used for shut downs of the single airgun during for sea turtles and seabirds. Enforcement of mitigation zones via 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/foraging near the vessel, and observing for potential impacts of acoustic sources on fish;
2. PSO data and documentation; and
3. 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).

Three 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. The proposed operational mitigation measures are standard for all low-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). The vessel would maintain a separation distance of 500 m from any right whale, 100 m from large whales (mysticetes and sperm whales), and 50 m from all other marine mammals, 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 shutdown would be implemented at any distance. In addition, a shut down at any distance would be implemented for a large whale with calf and North Pacific Right Whale. We anticipate NMFS will require an EZ of 1500 m for pygmy sperm, dwarf sperm, and beaked whales and an EZ of 500 m for other marine mammals (with the exception of bow-riding dolphins).

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 2). 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 § 4.2.

2.3 Alternatives Considered but Eliminated from Further Analysis

Table 2 provides a summary of the Proposed Action, alternative, and alternatives eliminated from further analysis.,

2.3.1 Alternative E1: Alternative Location

These survey locations were chosen to provide a variety of fluid flow environments of the subducting tectonic plate along the Cascadia margin. 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 the heavily populated region of the Pacific Northwest which motivates significant scientific interest and public safety concerns. .

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).

TABLE 2. 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 ~6 days of seismic operations. Additional operational days would be expected for heat flow measurements, equipment deployment, maintenance, and retrieval; weather; marine mammal activity; and other contingencies. The affected environment, environmental consequences, and cumulative impacts of the proposed activities are described in § III and IV. The standard monitoring and mitigation measures identified in the PEIS would apply, along with any additional requirements identified by regulating agencies in the U.S. All necessary permits and authorizations, including an IHA, would be requested from regulatory bodies.

Alternatives	Description
Alternative 1: No Action	Under this Alternative, no proposed activities would be conducted, and seismic data would not be collected. While this alternative would avoid impacts to marine resources, it would not meet the purpose and need for the Proposed Action. Geological data of scientific value and relevance increasing our understanding of Cascadia Subduction Zone, geohazards, and heat flow processes 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	Research activities are proposed to study geologic processes at the Cascadia Subduction Zone where 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 this heavily populated region of the Pacific Northwest. The acquired data would improve understanding 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.

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, temporary disturbances to seafloor sediments from the heat probe during the surveys. 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 operation 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. Human activities in the area around the survey vessel would be limited to fishing, research (including any NMFS trawl surveys), naval activities, and other vessel traffic. However, no significant impacts on these activities would be anticipated particularly because of the short duration of the proposed activities and small energy source proposed. Whale watching, tourism, and subsistence hunting/fishing would not be anticipated to occur in the survey area due to distance from the coast. 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 and 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).

More detailed information about the oceanographic attributes of the proposed survey area off Washington and Oregon was included in the 2021 EA (See Section 3.1) and is incorporated by reference as if fully set forth herein.

3.2 Protected Areas

3.2.1 Critical Habitat

A small portion of the survey overlaps critical habitat for leatherback sea turtles, east of the 2000-m isobath off Oregon (Fig. 1). In addition, critical habitat has been designated near the proposed survey areas for marine mammals and fish. No marine mammal or fish critical habitat occurs within the proposed survey area. Critical habitat for Steller sea lion is located at Rogue Reef (Pyramid Rock) and Orford Reef (Long Brown Rock and Seal Rock) along the coast of Oregon, more than 40 km from the survey area (see Fig. 1). More detailed information about marine mammal and fish critical habitat was included in the 2021 EA and is incorporated by reference as if fully set forth herein. Critical habitat for the ***threatened*** Pacific Coast population of western snowy plover and the ***threatened*** marbled murrelet is strictly terrestrial and would not be affected by the proposed activities.

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).

3.2.2 Other Conservation Areas

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). In addition, there are numerous conservation areas along the coasts of Washington or Oregon: Washington Islands National Wildlife Refuges, Olympic Coast National Marine Sanctuary, Lewis and Clark National Wildlife Refuge, Willapa National Wildlife Refuge, Oregon Islands National Wildlife Refuge, Three Arch Rocks National Wildlife Reserve, Washington State Seashore Conservation Area, Cape Falcon Marine Reserve, Cascade Head Marine Reserve, Otter Rock Marine Reserve, Cape Perpetua Marine Reserve, and Redfish Rock Marine Reserve and Marine Protected Area. The survey activities and ensonified areas would be well outside (>140 km off Washington; >40 km off Oregon) of any of these areas. More detailed information about these conservation areas was included in the 2021 EA (See Section 3.2.2) and is incorporated by reference as if fully set forth herein.

3.3 Marine Mammals

Thirty marine mammal species could occur in or near the proposed survey regions, including 7 mysticetes (baleen whales), 18 odontocetes (toothed whales), and 5 pinnipeds (seals and sea lions) (Table 3). Six of the species/populations are listed under the U.S. ESA as ***endangered***, including the sperm, humpback (Central America DPS), sei, fin, blue, and North Pacific right 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 unlikely that gray whales from the ***endangered*** Western North Pacific DPS or Southern Resident killer whales would occur in the proposed survey area. Although there is critical habitat in the coastal waters for Southern Resident killer whales, humpback whales (Central America and Mexico DPS), and the Steller sea lion, none of the proposed survey transects enter or ensonify marine mammal critical habitat to sound levels >160 dB re 1 μPa_{rms}.

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 British Columbia (B.C.) waters from 1993–2003; all records occurred in inshore waters. No other sightings have been made since 2003 (Ford 2014). In addition, harbor porpoise, harbor seal, and sea otters are not included here, as they typically occur closer to shore.

TABLE 3. 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	Abundance[2]	U.S. *ESA*[3]	IUCN[6]	CITES[7]
Mysticetes						
North Pacific right whale	Rare	Coastal, shelf,	400-500[8]	EN	CR[9]	I
Gray whale	Rare	Coastal, shelf	243[10]; 26,960	DL[11]	LC[13]	I
Humpback whale	Uncommon	Mainly nearshore	2,900; 10,103[14]	EN/T[15]	LC	I
Common minke whale	Uncommon	Nearshore, offshore	636; 20,000[16]	NL	LC	I
Sei whale	Rare	Mostly pelagic	519; 27,197[17]	EN	EN	I
Fin whale	Common	Slope, pelagic	9,029; 13,620-18,680[18]	EN	VU	I
Blue whale	Rare	Pelagic and coastal	1,496	EN	EN	I
Odontocetes						
Sperm whale	Common	Pelagic, steep	1,997; 26,300[20]	EN	VU	I
Pygmy sperm whale	Rare	Deep, off	4,111	NL	LC	II
Dwarf sperm whale	Rare	Deep, shelf, slope	N.A.	NL	LC	II
Cuvier's beaked whale	Uncommon	Pelagic	3,274	NL	LC	II
Baird's beaked whale	Uncommon	Pelagic	2,697	NL	LC	I
Blainville's beaked whale	Rare	Pelagic	3,044[21]	NL	LC	II
Hubbs' beaked whale	Rare	Slope,	3,044[21]	NL	DD	II
Stejneger's beaked whale	Uncommon	Slope,	3,044[21]	NL	NT	II
Common bottlenose dolphin	Rare	Coastal, shelf, deep	1,924[22]	NL	LC	II
Striped dolphin	Rare	Off continental	29,211	NL	LC	II
Short-beaked common dolphin	Uncommon	Shelf, pelagic,	969,861	NL	LC	II
Pacific white-sided dolphin	Common	Offshore, slope	26,814	NL	LC	II
Northern right whale dolphin	Common	Slope, offshore	26,556	NL	LC	II
Risso's dolphin	Uncommon	Shelf, slope, seamounts	6,336	NL	LC	II
False killer whale	Rare	Pelagic	N.A.	NL	NT	II
Killer whale	Common	Widely distributed	73[23] 349[24] 300[25]	EN[26]	DD	II
Short-finned pilot whale	Rare	Pelagic, high-relief	836	NL	LC	II
Dall's porpoise	Common	Shelf, slope, offshore	25,750	NL	LC	II
Pinnipeds						
Guadalupe fur seal	Rare	Mainly coastal,	34,187	T	LC	I
Northern fur seal	Uncommon	Pelagic, offshore	14,050[27] 608,143[28]	NL	VU	N.A.
Northern elephant seal	Uncommon	Coastal, pelagic in	179,000[29]	NL	LC	II

Species	Occurrence in Area[1]	Habitat	Abundance[2]	U.S. *ESA*[3]	IUCN[6]	CITES[7]
Steller sea lion	Rare	Coastal, offshore	43,201[30]	DL[31]	NT[32]	N.A.
California sea lion	Rare	Coastal	257,606[33]	NL	LC	N.A.

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. (2021), unless otherwise stated.
3 U.S. *Endangered Species Act* (ESA; NOAA 2021a): EN = Endangered, T = Threatened, NL = Not listed.
6 Classification from the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species (IUCN 2021); 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 2021): 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 (Carretta et al. 2021).
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. 2021).
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 2021).
17 Central and Eastern North Pacific (Hakamada and Matsuoka 2015a).
18 North Pacific (Ohsumi and Wada 1974).
20 Eastern Temperate Pacific; estimate based on visual sightings (Barlow and Taylor 2005).
21 All mesoplodont whales (Moore and Barlow 2017; Carretta et al. 2021).
22 California/Oregon//Washington offshore stock (Carretta et al. 2021).
23 Eastern North Pacific Southern Resident stock (Carretta et al. 2021).
24 West Coast Transient stock; minimum estimate (Muto et al. 2021).
25 North Pacific Offshore stock (Carretta et al. 2021).
26 The Southern Resident DPS is listed as endangered; no other stocks are listed.
27 California stock (Carretta et al. 2021).
28 Eastern Pacific stock (Muto et al. 2021).
29 California breeding stock (Carretta et al. 2021).
30 Eastern U.S. stock (Muto et al. 2021).
31 The Eastern DPS was delisted in 2013 (78 FR 66139, 4 November 2013); the Western DPS is listed as endangered.
32 Globally considered as near threatened; western population listed as endangered, and eastern population is considered least concern.
33 U.S. stock (Carretta et al. 2021).

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 to the north of the proposed survey area. The general distribution of mysticetes, odontocetes, and pinnipeds 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, and is located to the south of the proposed survey area. The general distribution of mysticetes, odontocetes, and pinnipeds 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. Detailed information specifically about species distribution in the proposed survey area off Washington and Oregon was included in the 2021 EA (See Section 3.3), and in the associated IHA application for this survey, and is incorporated by reference as if fully set forth herein.

3.4 Sea Turtles

Four species of sea turtles have been reported in the waters of 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 region; occurrences of loggerhead and olive ridley turtles are rare. The loggerhead and olive ridley turtles are generally warm-water species and are considered extralimital occurrences in these areas (Buchanan et al. 2001). Thus, only leatherback turtles are likely to occur in the survey areas, 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***. 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. Detailed information specifically about species distribution in the proposed survey area off Washington and Oregon was included in the 2021 EA (See Section 3.4) and is incorporated by reference as if fully set forth herein.

3.5 Seabirds

Two seabird species that are listed as endangered under the ESA could occur in or near the proposed survey area — the short-tailed albatross (*Phoebastria albatrus*) and the Hawaiian petrel (*Phoebastria albatrus*). The ***threatened*** marbled murrelet (*Brachyramphus marmoratus*) and the ***threatened*** Pacific Coast population of western snowy plover (*Charadrius nivosus nivosus*) are unlikely to occur in the offshore survey areas. Detailed information specifically about species distribution in the proposed survey area off Washington and Oregon was included in the 2021 EA (See Section 3.5) and is incorporated by reference as if fully set forth herein.

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), bocaccio (*Sebastes paucispinis*), yellow-eye rockfish (*S. ruberrimus*), Pacific eulachon (*Thaleichthys pacificus*), and green sturgeon (*Acipenser medirostris*) (Table 4). Detailed information specifically about species distribution in the proposed survey area off Washington and Oregon was included in the 2021 EA (See Section 3.6.1) and is incorporated by reference as if fully set forth herein.

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.

TABLE 4. 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

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, including groundfish, coastal pelagic fishes, Pacific coast salmon, and highly migratory species (See 2021 EA, Fig. 3).

Detailed information specifically about EFH in the proposed survey area off Washington and Oregon was included in the 2021 EA (See Section 3.6.2) and is incorporated by reference as if fully set forth herein.

3.6.3 Habitat Areas of Particular Concern

Habitat Areas of Particular Concern (HAPC) are a subset of EFH that provide important ecological functions, are especially vulnerable to degradation, or include habitat that is rare (NOAA 2019h). Rocky Reefs HAPC for groundfish is located within the eastern-most survey area off Oregon. Several other HAPC occur in Washington or Oregon waters, including several areas of interest (Daisy Bank/Nelson Island, Washington State Waters, Thompson and President Jackson Seamounts), as well as seagrass, canopy kelp, and estuaries. There are no HAPCs designated at this time for highly migratory species (PFMC 2016d). Detailed information about HAPC in the proposed survey area off Washington and Oregon was included in the 2021 EA (See Section 3.6.3 and Fig. 4) and is incorporated by reference as if fully set forth herein.

3.7 Commercial, Recreational, Tribal Fisheries & Aquaculture

The survey activities would not occur near any aquaculture activities, which generally occur close to the coast. 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). Most marine recreational fisheries activity on the U.S. west coast occurs March-October 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).

The coast and nearshore areas are of cultural and economic importance to indigenous people of the Pacific Northwest. Tribes in Washington State have treaties with the federal government that include fishing rights within “Usual and Accustomed Fishing and Hunting Areas” (U&A). The proposed surveys off the Washington and Oregon coasts would avoid the U&A areas of the Hoh Tribe, Makah Tribe, Quileute Tribe, and Quinault Nation.

More details about commercial, recreational, Tribal fisheries and aquaculture in the survey regional were included in the 2021 EA and are incorporated by reference as if fully set forth herein.

3.8 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. The survey area is located >140 km from the mouth of the Columbia River and would occur in water depths >1600 m, outside the range for recreational SCUBA diving.

IV ENVIRONMENTAL CONSEQUENCES

4.1 Proposed Action

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

The potential effects (or lack thereof) of airgun sounds on marine mammals and sea turtles were described in detail in the PEIS, including information on the hearing abilities of marine mammals and sea turtles, and a comprehensive review of relevant background information in § 3.4.4.3, § 3.6.4.3, § 3.7.4.3, § 3.8.4.3, and Appendix E of the PEIS and Section 4.1.1 of the 2021 EA. Recent literature that has become available since the PEIS was released in 2011 were referenced in Section 4.1.1 of the 2021 EA and is incorporated by reference as if fully set forth herein.

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

Marine Mammals

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.

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.

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.

As noted above, more details about potential effects can be found in the 2021 EA and the PEIS.

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.

As noted above, more details about potential effects can be found in the 2021 EA and the PEIS.

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. The 2021 EA included a summary of recent literature that had become available since the PEIS was released in 2011 and is incorporated by reference as if fully set forth herein.

There is little 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.

Recent publications referenced in the 2021 EA remained in general 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 was not likely to impact marine mammals and was 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 would be 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. Information about these possible effects were included in the 2021 EA and is incorporated by reference as if fully set forth herein. 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.

Information on vessel strikes was reviewed in § 3.4.4.4, § 3.6.4.4, and § 3.8.4.4 of the PEIS and Section 4.1.1.3. 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.

As noted above, more details about potential effects can be found in the 2021 EA and the PEIS.

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; two dedicated PSOs maintaining a visual watch during all daytime airgun operations; two PSOs for 30 min before and during ramp ups in U.S. waters; shut downs when marine mammals are detected in or about to enter designated EZ; and 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. No injurious takes (Level A) would be expected. In the sections below, we describe methods to estimate the number of potential exposures to 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 or disturbed appreciably by Level B sound levels by the seismic surveys in the Northeast Pacific Ocean. The main sources of distributional and numerical data used in deriving the estimates are summarized below.

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 area in the absence of seismic surveys. 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.

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.

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 proposed survey areas; if no density spatial modeling was available, other data sources were used (USN 2019). 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 densities 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). Spatially-explicit density data from the NOAA CetSound website (NOAA 2021f) 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).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.

CetMap (https://cetsound.noaa.gov/cda) provides output from habitat-based density models for cetaceans in the CCE (Becker et al. 2020) in the form of GIS layers; these were used to calculate takes in the survey regions. The methods used to determine densities are detailed in 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 5 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). When seasonal densities were available, the calculated exposures were based on summer densities (Appendix B), 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 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). The context of an exposure of a marine mammal to sound can affect the animal's initial response to the sound (e.g., Ellison et al. 2012; NMFS 2013b; Hastie et al. 2020; Hückstädt et al. 2020; Southall et al. 2021). Southall et al. (2021) provide a detailed framework for assessing marine mammal behavioral responses to anthropogenic noise and note that use of a single threshold can lead to large errors in prediction impacts due to variability in responses between and within species.

The numbers of marine mammals that could be exposed to airgun sounds with received levels ≥160 dB re 1 μPa_{rms} (Level B) on one or more occasions have been estimated using a method recommended by NMFS for calculating the marine area that would be within the Level B threshold around the operating seismic source, along with the expected density of animals in the area. This method was developed to account in some way for the number of exposures as well as the number of individuals exposed. It involves selecting a seismic trackline(s) that could be surveyed on one day (~200 km) that is roughly similar to that of the entire survey. The area expected to be ensonified on that day was determined by entering the planned survey lines into a MapInfo GIS, using GIS to identify the relevant areas by "drawing" the applicable Level B (Table 1) buffers around that line. The ensonified areas, increased by 25%, were then multiplied by the

TABLE 5. Densities and estimates of the possible numbers of individual marine mammals that could be exposed to the Level B thresholds for various hearing groups during the proposed seismic surveys in the Northeast Pacific Ocean during summer 2022. Species in italics are listed under the ESA as *endangered* or *threatened*.

Species	Density (#/km^2)	Level B Calculated Take	Regional Population Size	Requested Take as % of Pop.[1]	Requested Take Authorization[2]
LF Cetaceans					
North Pacific right whale	0	0	400	0	0
Humpback whale	0.0005	1	2,900	0.1	**2**
Blue whale	0.0002	0	1,496	0.1	**2**
Fin whale	0.0024	4	9,029	<0.1	4
Sei whale	0.0004	1	519	0.4	**2**
Minke whale	0.0013	2	636	0.3	2
Gray whale	0.0010	1	26,960	<0.1	1
MF Cetaceans					
Sperm whale	0.0029	5	1,997	0.4	**7**
Baird's beaked whale	0.0004	1	2,697	0.3	**9**
Small beaked whale[3]	0.0024	4	3,044	0.1	4
Bottlenose dolphin	0.0000	0	1,924	1	**13**
Striped dolphin	0.0021	3	29,211	<0.2	**46**
Short-beaked common dolphin	0.0048	8	969,861	<0.1	**179**
Pacific white-sided dolphin	0.0599	99	26,814	0.4	99
Northern right-whale dolphin	0.0495	82	26,556	0.3	82
Risso's dolphin	0.0099	16	6,336	0.3	**22**
False killer whale	N.A.	N.A.	N.A.	N.A.	**5**
Killer whale	0.0009	2	649	1.1	**7**
Short-finned pilot whale	0.0003	0	836	3.5	**29**
HF Cetaceans					
Pygmy/dwarf sperm whale	0.0016	3	4,111	0.1	3
Dall's porpoise	0.0936	155	25,750	0.6	155
Otariid Seals					
Northern fur seal	0.0361/0.0330*	56	608,143	<0.1	56
Guadalupe fur seal	0.0294	49	34,187	0.1	49
California sea lion	1.2951/0.0714*	794	257,606	0.3	794
Steller sea lion	0.0026	4	43,201	<0.1	4
Phocid Seal					
Northern elephant seal	0.0433	72	179,000	<0.1	72

N.A. means not applicable or not available. * Different densities based on distance from shore (see Appendix B).

1 Requested take authorization expressed as % of population off California/Oregon/Washington, Eastern North Pacific, or U.S. stock (see Table 3).

2 Requested take authorization is Level B calculated takes, used by NMFS as proxy for number of individuals exposed. Numbers in bold are based on mean group size from Mobley et al. (2000) for false killer whale and Barlow (2016) for other species.

35 Requested take includes one each of Blainville's beaked whale, Stejneger's beaked whale, Cuvier's beaked whale, and Hubbs' beaked whale (see Appendix B for more information).

number of survey days (6 days). This is equivalent to adding an additional 25% to the proposed line km (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.

4.1.1.6 Conclusions for Marine Mammals and Sea Turtles

The proposed seismic surveys would involve towing a small 2-GI airgun cluster, 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, and 3.8.7, the PEIS concluded that outside the Gulf of Alaska, airgun operations with implementation of the proposed monitoring and mitigation measures could result in a small number of Level B behavioral effects in some cetaceans and pinnipeds, that Level A effects were unlikely, and that operations were unlikely to adversely affect ESA-listed species. Level A takes are considered highly unlikely. The brief duration of exposure of any given animal, the large proportion of survey effort in deeper water, 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.

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 B harassment are low percentages of the regional population sizes. The proposed activities are likely to adversely affect ESA-listed species for which takes are being requested (Table 6). However, the relatively short-term exposures are unlikely to result in any long-term negative consequences for the individuals or their populations. Therefore, no significant impacts on marine mammals would be anticipated from the proposed activities.

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. 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 2014). 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 turtles (Table 7).

TABLE 6. ESA determination for marine mammal species expected to be encountered during the proposed surveys in the Northeast Pacific Ocean during summer 2022.

	ESA Determination		
Species	**No Effect**	**May Affect – Not Likely to Adversely Affect**	**May Affect – Likely to Adversely Affect**
North Pacific Right Whale		√	
Humpback Whale (Central America DPS)			√
Humpback Whale (Mexico DPS)			√
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			√

TABLE 7. ESA determination for sea turtle species expected to be encountered during the proposed surveys in the Northeast Pacific Ocean during summer 2022.

	ESA Determination		
Species	**No Effect**	**May Affect – Not Likely to Adversely Affect**	**May Affect – Likely to Adversely Affect**
Leatherback Turtle		√	
Green Turtle (East Pacific DPS)		√	
Hawksbill Turtle	√		
Loggerhead Turtle (North Pacific Ocean DPS)	√		
Olive Ridley Turtle (Mexico's Pacific Coast Breeding Colonies)	√		

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 were summarized in the 2021 EA and are incorporated by reference as if fully set forth herein. Although research on the effects of exposure to airgun sound on marine invertebrates and fishes is increasing, many data gaps remain (Hawkins et al. 2015; Carroll et al. 2017), including how particle motion rather than sound pressure levels affect invertebrates and fishes that are exposed to sound (Hawkins and Popper 2017; Popper and Hawkins 2018). It is important to note that while all invertebrates and fishes are likely sensitive to particle motion, no invertebrates and not all fishes (e.g., sharks) are sensitive to the sound pressure component.

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

The newly available information presented in the 2021 EA did 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 8), and their fisheries, including commercial, recreational, and subsistence fisheries. Additionally, no mortality of fish or marine invertebrates would be expected in marine reserves along the coast of Oregon, as the injury threshold distances would not enter the reserves that would be at least 40 km away off Oregon and more than 140 km away off Washington. 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 2021 and 2012, there were no observed significant impacts. In addition, no adverse effects on EFH or HAPC are expected given the small energy source, short-term nature of the seismic survey (~6 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. In addition, the acoustic source would be shut down in the event an ESA-listed seabird was observed diving or foraging within the EZ. Given that the proposed activities would use a small source, that there is limited occurrence of diving birds in the proposed project area, and there would be shutdown mitigation, the proposed activities would not be anticipated affect seabird species in the region, including short-tailed albatross, Hawaiian petrel, and marbled murrelet (Table 9). 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.

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.

TABLE 8. ESA determination for DPSs or ESUs of fish species expected to be encountered during the proposed surveys in the Northeast Pacific Ocean during summer 2022.

	ESA Determination		
Species	**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)	√		

TABLE 9. ESA determination for seabird species expected to be encountered during the proposed surveys in the Northeast Pacific Ocean during summer 2022.

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

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 & 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, however, no survey operations are planned within or near Tribal U&A fisheries. Therefore, no adverse impacts to tribal U&A fisheries and 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." The 2021 EA identified and considered research, vessel traffic, naval and fisheries activities that have or could occur and impact the environment within the proposed survey area. Therefore, the information from Section 4.1.6 of the 2021 EA is incorporated by reference as if fully set forth herein. Similar types of activities (e.g., research, vessel traffic, naval, and fisheries) experienced in 2021 would be anticipated again in 2022. 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, especially given the very short duration of the proposed activities.

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; Level A takes would not be anticipated. Effects on recruitment or survival would be expected to be (at most) negligible.

4.1.8 Coordination with Other Agencies and Processes

This Draft EA has been prepared by LGL on behalf of L-DEO and NSF pursuant to NEPA and tiers to the 2021 EA, 2012 EA, and PEIS. Potential impacts to marine mammals, endangered species, and critical habitat have also been assessed in the document. The Draft EA will be used to support other regulatory processes, such as the ESA and MMPA. NSF will coordinate with other entities, such as the Navy to avoid space-use conflicts and/or security matters, as appropriate.

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. New data providing important information about thermal and structural features of the subducting plate that would be taken into account when developing models to evaluate geohazards related to the Cascadia Subduction Zone would not be collected. Data that would be of interest for improving the general understanding of subduction zone dynamics would also be foregone, including the detailed understanding of the thermal effects of the structures targeted by this project that could be extrapolated to other similar structures for which heat flow data are not available. The No Action Alternative would not meet the purpose and need for the proposed activity.

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VI LITERATURE CITED

The 2021 EA, upon which this Draft EA tiers, included literature cited. To avoid redundancy and duplication, the relevant literature cited in the 2021 EA is incorporated by reference as if set forth fully herein.

List of Appendices

Appendix A: Determination of Mitigation Zones

Appendix B: Methods for Marine Mammal Densities and Take Estimates

APPENDIX A: DETERMINATION OF MITIGATION ZONES

During the planning phase, mitigation zones for the proposed marine seismic surveys were calculated based on modeling by L-DEO for the Level B (160 dB re 1µPa_{rms}) threshold. 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 airguns, for the two 45-in^3 GI airguns. 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 GoM in 2007–2008 (Tolstoy et al. 2009; Diebold et al. 2010).

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 (~2000 m) for marine mammals (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 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) for the 36-airgun array at a tow depth of 6 m can be used to derive mitigation radii.

The proposed surveys would acquire data with two 45-in^3 GI guns at a tow depth of 2–4 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).

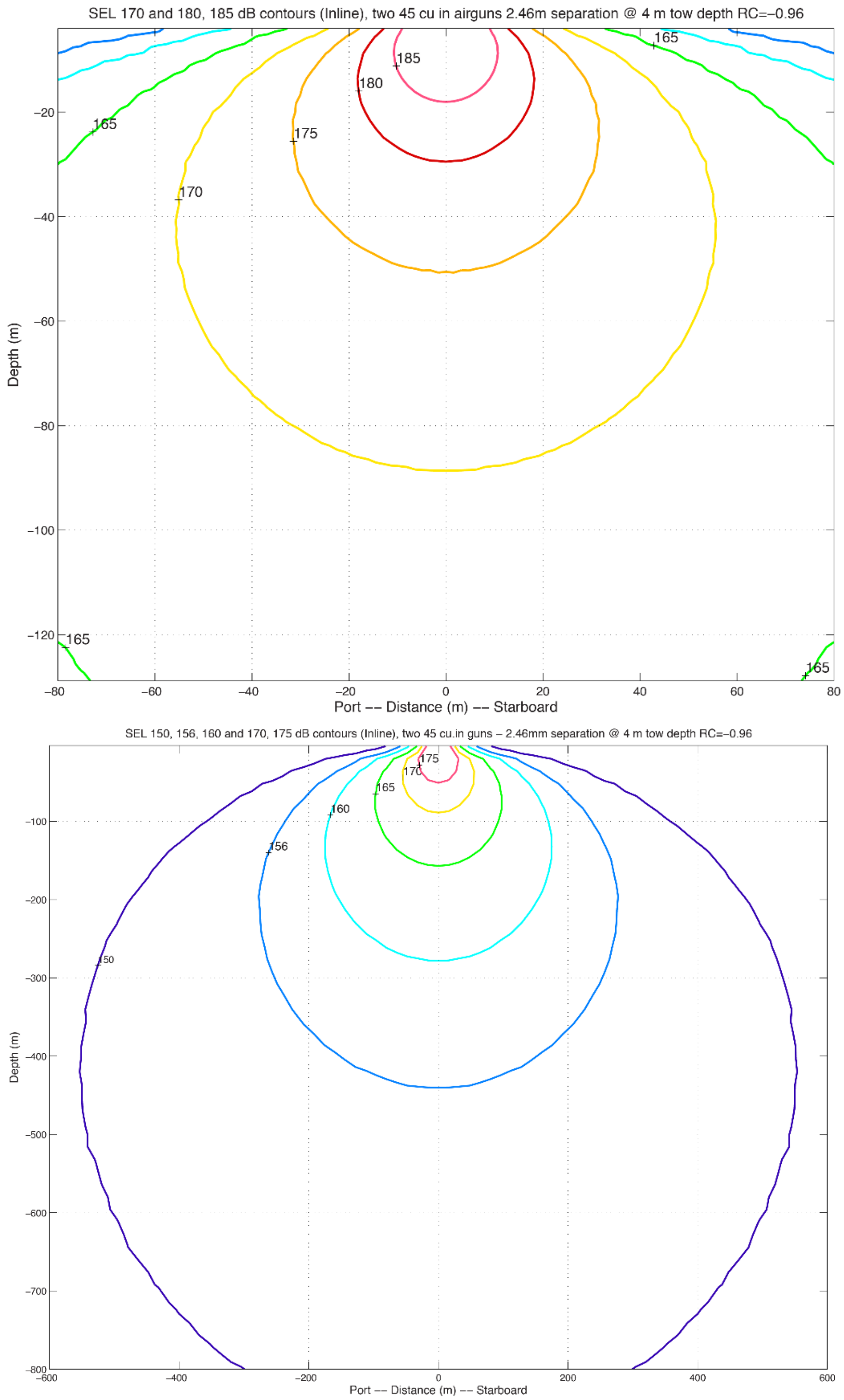

FIGURE A-1. Modeled deep-water received sound exposure levels (SELs) from the two 45-in^3 GI guns, with a 2.46 m gun separation, planned for use during the proposed surveys in the Northeast Pacific Ocean at a 4-m tow depth. Received rms levels (SPLs) are expected to be ~10 dB higher. The radius to the 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- and 175-dB re 1µPa$_{rms}$ sound exposure levels (SEL)[3] are expected to be received for the 2-GI airgun array at the maximum 4-m tow depth in deep water. The 160-dB level is the behavioral disturbance criterion that is used to estimate anticipated Level B takes for marine mammals; a 175-dB level is used by NMFS, as well as the U.S. Navy (USN 2017), to determine behavioral disturbance for sea turtles. A recent retrospective analysis of acoustic propagation of R/V *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 R/V *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 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 level[4] have confirmed that the L-DEO model generated conservative mitigation zones, resulting in significantly larger zones than required by 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, but did not establish new thresholds for Level B Harassment. The 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). 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. However, many data gaps remain where exposure criteria are concerned (Southall 2021). This document has been prepared in accordance with the current NOAA acoustic practices, and the procedures are based on best practices noted by Pierson et al. (1998), Weir and Dolman (2007), Nowacek et al. (2013a), Wright (2014), and Wright and Cosentino (2015).

TABLE A-1. Level B. Predicted distances to the 160 dB re 1 µPa$_{rms}$ sound levels that could be received from two 45/105 in^3 GI guns (at a tow depth of 4 m) that would be used during the seismic surveys in the Northeast Pacific Ocean during summer 2022.

Airgun Configuration	Water Depth (m)	Predicted Distances (m) to a Received Sound Level of 160 dB re 1 µPa$_{rms}$
Two 45-in^3 GI guns	>1000	553

[3] SEL (measured in dB re 1 µPa^2 · s) is a measure of the received energy in the pulse and represents the SPL that would be measured if the pulse energy were spread evenly across a 1-s period. Because actual seismic pulses are less than 1 s in duration in most situations, this means that the SEL value for a given pulse is usually lower than the SPL calculated for the actual duration of the pulse. In this EA, we assume that rms pressure levels of received seismic pulses would be 10 dB higher than the SEL values predicted by L-DEO's model.

[4] 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).

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APPENDIX B: METHODS FOR MARINE MAMMAL DENSITIES AND TAKE CALCULATIONS

The U.S. Navy (USN) primarily used SWFSC spatial models to develop a marine species density database for the Northwest Training and Testing Study Area, which encompasses the proposed survey area; if no density spatial modeling was available, other data sources were used (USN 2019). 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 (i.e., for minke, sei, gray, killer, and short-finned pilot whales, *Kogia* spp., pinnipeds, and leatherback sea turtle). The densities (Table B-1) were then multiplied by the daily ensonified area and the number of survey days (6) to determine Level B takes (Table B-2).

For most pinnipeds, we used the the highest densities for spring, summer, or fall from USN (2019), but corrected the estimates by projecting the most recent population growth/updated population estimates to 2022, when available. This same approach was used by NMFS for a previous L-DEO survey (i.e., CASCADIA) in the region in 2021. For Californa sea lions, spring densities from USN (2019) were used directly; the density for the '40–70 km from shore' distance band was used for the Oregon survey region, and the density for the '70–450 km from shore' distance band was used for the other survey regions. For the northern fur seal, the density for spring for the 'up to 70 km from shore' distance band was used for the Oregon survey region, and the spring density for the '>130 km from shore' distance band was used for the other survey regions. For the Guadalupe fur seal and Steller sea lion, summer densities for the '200-m isobath to 300 km from shore' were used. For the gray whale, the summer/fall density for the '10–47 km from shore' distance band (USN 2019) was used for the Oregon survey region; a density of zero was used for all other survey regions. For killer whales, the annual density for all stocks occurring offshore was used from USN (2019).

As recommended by NMFS, spatially-explicit density data from summer/fall from the NOAA CetSound website (NOAA 2021) 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 of summer/fall habitat-based density models for cetaceans in the CCE (Becker et al. 2020) 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 area expected to be ensonified to >160 dB SPL (i.e., the survey area). North, west, and south boundaries are based on overlap/intersection with geographic extents of all four combined survey regions; eastern grid coverage limit was defined by inclusion of cells that contained >25% overlap with the angled boundary of the survey area polygon. The densities from all grid cells overlapping the ensonified areas were averaged to calculate an average species-specific density for each species (Table B-1). These densities were then multiplied by the daily area expected to be ensonified and by the number of survey days (6) to estimate Level B takes (Table B-2).

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 or Washington. Requested takes for some other species (indicated in bold in Table 5) were also increased to mean group size (Barlow 2016).

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

Species	Distance Band	Estimated Density (#/km^2)	Source	Comments
LF Cetaceans				
North Pacific right whale		*0*	-	Near zero
Humpback whale		0.000464	Becker et al. (2020)	Summer/fall
Blue whale		0.000226	Becker et al. (2020)	Summer/fall
Fin whale		0.002410	Becker et al. (2020)	Summer/fall
Sei whale		*0.000400*	USN (2019)	Summer/fall
Minke whale		*0.001300*	USN (2019)	Summer/fall
Gray whale				
	10-47 km from shore	0.001000	USN (2019)	Highest density applied for summer/fall; applied to Oregon survey region
MF Cetaceans				
Sperm whale		0.002859	Becker et al. (2020)	Summer/fall
Baird's beaked whale		0.000407	Becker et al. (2020)	Summer/fall
Small beaked whale		0.002446	Becker et al. (2020)	Summer/fall
Bottlenose dolphin		0.000038	Becker et al. (2020)	Summer/fall
Striped dolphin		0.002095	Becker et al. (2020)	Summer/fall
Short-beaked common dolphin		0.004845	Becker et al. (2020)	Summer/fall
Pacific white-sided dolphin		0.059902	Becker et al. (2020)	Summer/fall
Northern right-whale dolphin		0.049535	Becker et al. (2020)	Summer/fall
Risso's dolphin		0.009917	Becker et al. (2020)	Summer/fall
False killer whale				
Killer whale (Offshore waters)		0.000920	USN (2019)	Annual densities
Short-finned pilot whale		0.000250	USN (2019)	Annual densities
HF Cetaceans				
Pygmy/dwarf sperm whale		0.001630	USN (2019)	Annual densities
Dall's porpoise		0.093613	Becker et al. (2020)	Summer/fall
Otariid Seals				
Northern fur seal*				
	up to 70 km from shore	0.036115	USN (2019)	Density for February-May (higher than June-September, but lower than in January)
	>130 km from shore	0.032983	USN (2019)	Density for February-May (higher than June-September, but lower than in January)
*Guadalupe fur seal**				
	200-m isobath to 300 km	*0.029450*	USN (2019)	Summer/fall density
California sea lion				
	40-70 km from shore	1.295100	USN (2019)	Spring density (highest)
	70-450 km from shore	0.071400	USN (2019)	Spring density (highest)
Steller sea lion*				
	200-m isobath to 300 km	0.002573	USN (2019)	Used highest density for OR/WA for summer
Phocid Seals				
Northern elephant seal*		0.043301	USN (2019)	Fall density (highest)

*densities adjusted for most recent population size

TABLE B-2. Take estimates for the proposed survey area in the Northeast Pacific Ocean.

Species	Density (#/km^2)	Regional Population Size	Daily Ensonified Area (km^2)	Number of Seismic Days	25% Increase	Estimated Level B Takes	% of Pop. (Requested Takes)	Requested Level B Take Authorization^
LF Cetaceans								
North Pacific right whale	*0*	400	221	6	1.25	0	0.00	0
Humpback whale	*0.000464*	2,900	221	6	1.25	1	0.07	**2**
Blue whale	*0.000226*	1,496	221	6	1.25	0	0.13	**2**
Fin whale	*0.002410*	9,029	221	6	1.25	4	0.04	4
Sei whale	*0.000400*	519	221	6	1.25	1	0.39	**2**
Minke whale	*0.001300*	636	221	6	1.25	2	0.34	2
Gray whale	*0.001000*	26,960	221	2	1.25	1	0.00	1
MF Cetaceans								
Sperm whale	*0.002859*	1,997	221	6	1.25	5	0.35	**7**
Baird's beaked whale	*0.000407*	2,697	221	6	1.25	1	0.33	**9**
Small beaked whale	*0.002446*	3,044	221	6	1.25	4	0.13	4
Bottlenose dolphin	*0.000038*	1,924	221	6	1.25	0	0.68	**13**
Striped dolphin	*0.002095*	29,211	221	6	1.25	3	0.16	**46**
Short-beaked common dolphin	*0.004845*	969,861	221	6	1.25	8	0.02	**179**
Pacific white-sided dolphin	*0.059902*	26,814	221	6	1.25	99	0.37	99
Northern right-whale dolphin	*0.049535*	26,556	221	6	1.25	82	0.31	82
Risso's dolphin	*0.009917*	6,336	221	6	1.25	16	0.35	**22**
False killer whale	N.A.	N.A.	221	6	1.25	N.A.	N.A.	**5**
Killer whale	*0.000920*	649	221	6	1.25	2	1.08	**7**
Short-finned pilot whale	*0.000250*	836	221	6	1.25	0	3.47	**29**
HF Cetaceans								
Pygmy/dwarf sperm whale	*0.001630*	4,111	221	6	1.25	3	0.07	3
Dall's porpoise	*0.093613*	25,750	221	6	1.25	155	0.60	155
Otariid Seals								
Northern fur seal	0.01103/0.01007*	608,143	221	6	1.25	17	0.00	17
Guadalupe fur seal	0.029450	34,187	221	6	1.25	49	0.14	49
California sea lion	0.0037/0.0065*	257,606	221	6	1.25	9	0.00	9
Steller sea lion	0.002573	43,201	221	6	1.25	4	0.01	4
Phocid Seal								
Northern elephant seal	0.037279	179,000	221	6	1.25	62	0.03	62

N.A. = not available. Highlighted cells indicate species for which densities were based on Becker et al. (2020); non-highlighted cells indicate species with densities from USN (2019), except for the right whale, for which densities were assumed to be zero. ^Requested take for false killer whale is based on mean group size from Mobley et al. (2000); all other requested takes in bold are mean group sizes from Barlow (2106). *Two different densities were used depending on water depth/distance from shore (see Table B-1 for densities).