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

Prepared for

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ABSTRACT

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

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

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

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

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

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

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

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

LIST OF ACRONYMS

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

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

I PURPOSE AND NEED

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

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

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

1.1 Mission of NSF

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

1.2 Purpose of and Need for the Proposed Action

As noted in the PEIS, § 1.3, NSF has a continuing need to fund seismic surveys that enable scientists to collect data essential to understanding the complex Earth processes beneath the ocean floor. The purpose of the proposed study is to use two-dimensional (2-D) seismic surveying in order to characterize crustal

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

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

1.3 Background of NSF-funded Marine Seismic Research

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

1.4 Regulatory Setting

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

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

II ALTERNATIVES INCLUDING PROPOSED ACTION

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

2.1 Proposed Action

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

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

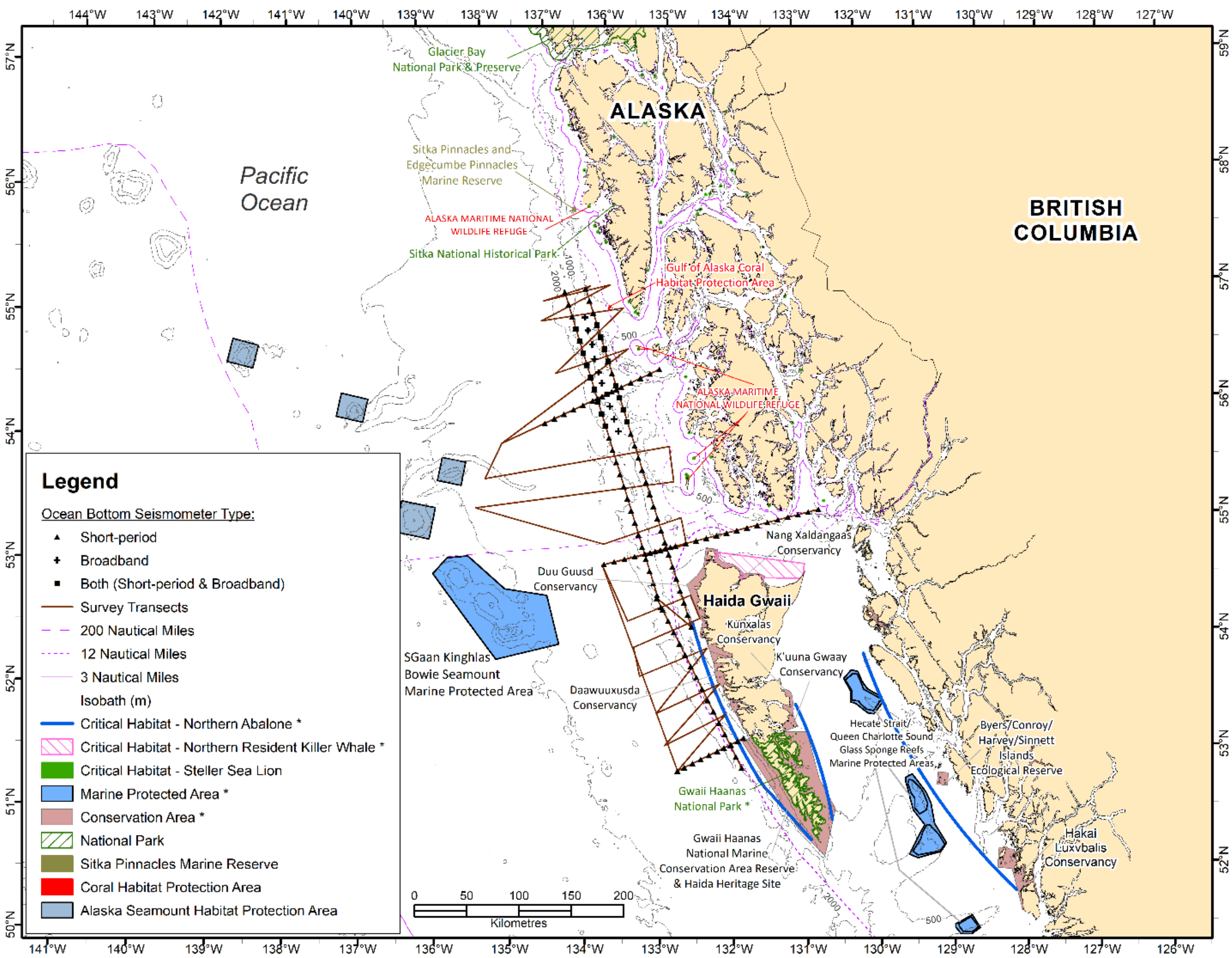

FIGURE 1. Location of the proposed seismic surveys and OBS deployments in the Northeast Pacific Ocean off the coasts of Southeast Alaska and northern British Columbia. Canadian conservation areas and critical habitat are denoted by *.

2.1.1 Project Objectives and Context

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

The QCF system is a ~1200-km-long onshore-offshore transform system connecting the Cascadia and Alaska-Aleutian subduction zones. The QCF is the ~900 km-long offshore component of the transform system, and the fault accommodates >50 mm/yr of dextral strike-slip motion between the Pacific and North American tectonic plates. This project would characterize ~450-km segment of the fault that encompasses systematic variations in key parameters in space and time: 1) changes in fault obliquity relative to Pacific-North American plate motion leading to increased convergence from north to south; 2) Pacific plate age and theoretical mechanical thickness decrease from north to south; and 3) a shift in Pacific plate motion at ~12-6 Ma that may have increased convergence along the entire length of the fault, possibly initiating underthrusting in the southern portion of the study area. Current understanding of how these variations are expressed through seismicity, crustal-scale deformation, and lithospheric structure and dynamics is limited due to lack of instrumentation and modern seismic imaging.

The main goal of the seismic program proposed by University of New Mexico and Western Washington University is to characterize crustal and uppermost mantle velocity structure, fault zone architecture and rheology, and seismicity of the QCF. To achieve the project goals, the Principal Investigators (PI) Drs. L. Worthington (University of New Mexico) and E. Roland (Western Washington University) propose to utilize long-offset 2-D seismic reflection and wide-angle reflection-refraction capabilities of R/V *Langseth* and a combined U.S.-Canadian broadband OBS array.

2.1.2 Proposed Activities

2.1.2.1 Location of the Survey Activities

The proposed survey would occur within ~52–57°N, ~131–137°W. Representative survey tracklines are shown in Figure 1. As described further in this document, however, some deviation in actual tracklines, including the order of survey operations, could be necessary for reasons such as science drivers, poor data quality, inclement weather, or mechanical issues with the research vessel and/or equipment. Thus, for the surveys, the tracklines could occur anywhere within the coordinates noted above. The surveys are proposed to occur within Exclusive Economic Zones (EEZ) of the U.S. and Canada, including within Canadian Territorial Waters ranging in depth from 50 to 2800 m.

2.1.2.2 Description of Activities

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

Short-period OBSs would be deployed along five OBS refraction lines by CCGS *Tully*. Two OBS lines run parallel to the coast, and three are perpendicular to the coast; one perpendicular line is located off Southeast Alaska, one is off Haida Gwaii, and another is located in Dixon Entrance (Fig. 1). Following refraction shooting of a single line, short-period instruments on that line would be recovered, serviced, and redeployed on a subsequent refraction line while MCS data would be acquired by the *Langseth.* MCS lines would be acquired off Southeast Alaska, Haida Gwaii, and Dixon Entrance (Fig. 1). The coast-parallel OBS refraction transect nearest to shore (Fig. 1) would only be surveyed once at OBS shot spacing. The other coast-parallel OBS refraction transect (on the ocean side; Fig. 1) would be acquired twice, once during refraction and once during reflection surveys. In addition, portions of the three coast-perpendicular OBS refraction lines would also be surveyed twice, once for OBS shot spacing and once for MCS shot spacing. The coincident reflection/refraction profiles that run parallel to the coast would be acquired in multiple segments to ensure straight-line geometry. Sawtooth transits during which seismic data would be acquired would take place between transect lines when possible; otherwise boxcar turns would be performed to save time. Both reflection and refraction surveys would use the same airgun array with the same discharge volume. As previously noted, the location of the survey lines could shift from what is currently depicted in Figure 1 depending on factors such as science drivers, poor data quality, weather, etc.

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

In addition to the operations of the airgun array, a multibeam echosounder (MBES), sub-bottom profiler (SBP), and Acoustic Doppler Current Profiler (ADCP) would be operated from R/V *Langseth* continuously during the seismic surveys, but not during transit to and from the survey area. All planned geophysical data acquisition activities would be conducted by L-DEO with on-board assistance by the scientists who have proposed the studies. The vessel would be self-contained, and the crew would live aboard the vessel.

2.1.2.3 Schedule

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

2.1.2.4 Vessel Specifications

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

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

Other details of CCGS *Tully* include the following:

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

2.1.2.5 Airgun Description

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

2.1.2.6 OBS Description

The seismometers would consist of up to 60 short-period OBSs and 28 broadband instruments that would be deployed prior to or during the survey. Along OBS refraction lines, short-period OBSs would be deployed by CCGS *Tully* at ~10 km intervals, with a spacing of ~5 km over the central ~40 km of the fault zone for fault-normal crossings. Following refraction shooting of a single line, short-period instruments on that line would be recovered, serviced, and redeployed on a subsequent refraction line while MCS data are acquired. The OBSs have a height and diameter of ~1 m and an anchor weighing ~80 kg. OBS sample rates would be set at 100 Hz and 200 Hz for the broadband and short-period OBSs, respectively, so that all instruments can be used for refraction imaging and earthquake analysis. The lower sample rate for the broadband OBSs is desirable, as the instruments would be deployed for an extended period of time. All OBSs would be recovered upon conclusion of the survey; however, the broadband OBSs would be deployed for ~12 months before recovery.

2.1.2.7 Additional Acoustical Data Acquisition Systems

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

2.1.3 Monitoring and Mitigation Measures

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

2.1.3.1 Planning Phase

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

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

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

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

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

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

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

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

2.1.3.2 Operational Phase

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

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

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

*An EZ of 100 m would be used as the shut-down distance for sea turtles in all water depths.
[1] Distance is based on L-DEO model results.
[2] Distance is based on L-DEO model results with a 1.5 × correction factor between deep and intermediate water depths.
[3] Distance is based on empirically derived measurements in the GOM with scaling applied to account for differences in tow depth.
[4] Based on empirical data from Crone et al. (2014); see Appendix A for details.

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

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

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

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

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

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

2.2 Alternative 1: No Action Alternative

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

2.3 Alternatives Considered but Eliminated from Further Analysis

2.3.1 Alternative E1: Alternative Location

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

2.3.2 Alternative E2: Use of Alternative Technologies

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

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

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

III AFFECTED ENVIRONMENT

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

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

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

3.1 Oceanography

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

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

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

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

3.2 Protected Areas

3.2.1 Critical Habitat in Alaska, U.S.

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

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

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

3.2.2 Critical Habitat in Canada

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

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

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

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

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

3.2.3 Other Conservation Areas in U.S. Waters

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

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

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

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

3.2.4 Other Conservation Areas in Canada

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

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

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

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

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

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

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

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

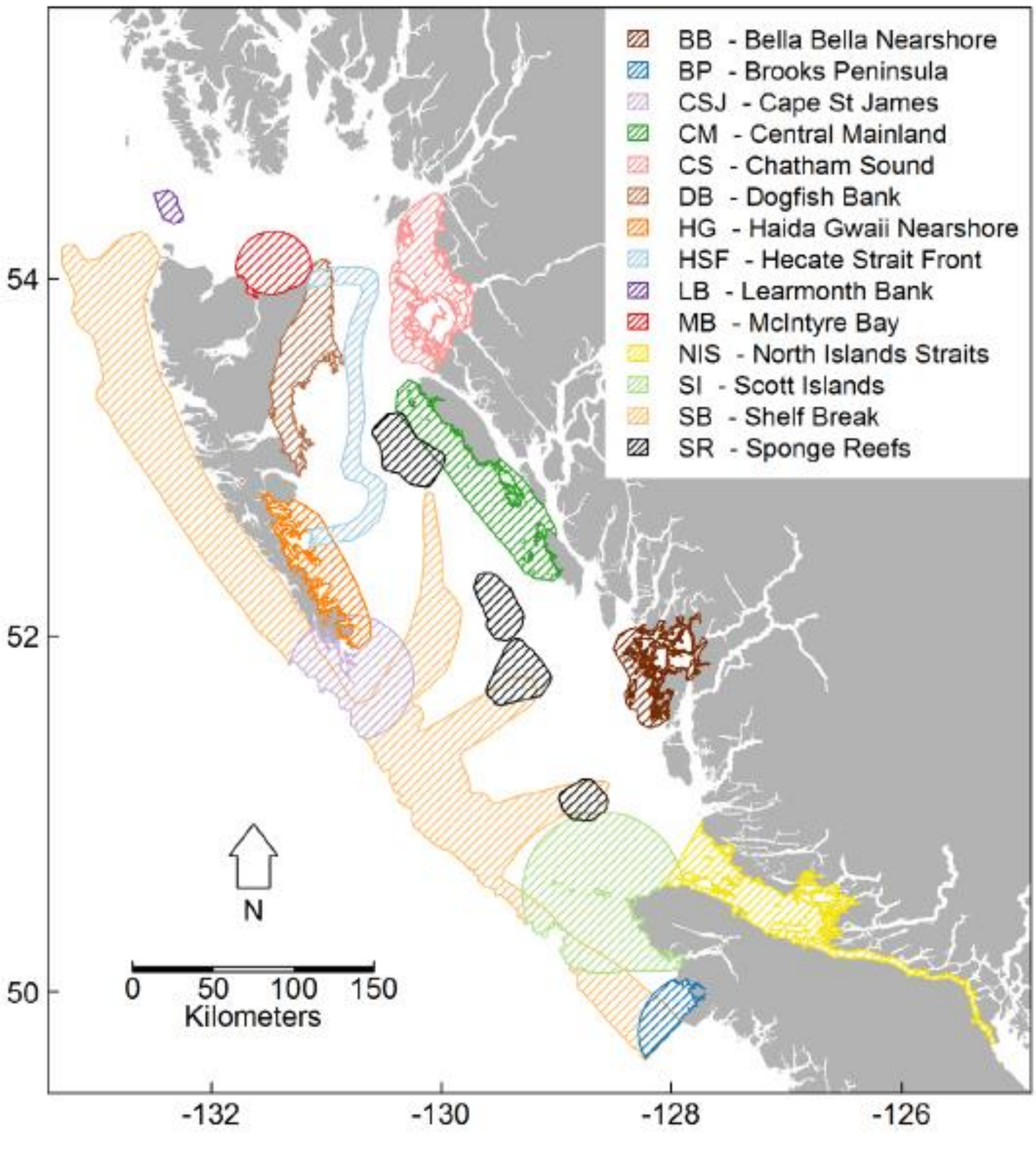

FIGURE 2. EBSAs off the B.C. Coast in the Pacific Northern Shelf Bioregion (Source: Rubidge et al. 2018).

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

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

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

3.3 Marine Mammals

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

[47] Southwest Alaska DPS is listed as threatened.

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

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

3.3.1 Mysticetes

3.3.1.1 North Pacific Right Whale *(Eubalaena japonica)*

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

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

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

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

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

Right whales have been scarce in B.C. since 1900 (Ford 2014). In the 1900s, there were only six records of right whales for B.C., all of which were catches by whalers (Ford et al. 2016); five occurred to the west of Haida Gwaii (Ford 2014). Since 1951, there have only been four confirmed records. A sighting of one individual 15 km off the west coast of Haida Gwaii was made on 9 June 2013 and another sighting occurred on 25 October 2013 on Swiftsure Bank near the entrance to the Strait of Juan de Fuca (Ford 2014; Ford et al. 2016; DFO 2017a). Another sighting was made off Haida Gwaii in June 2018 (CBC 2018a), and the most recent sighting was made during DFO surveys off Haida Gwaii during June 2021 (Kloster 2021). There have been two additional unconfirmed records for B.C., including one off Haida Gwaii in 1970 and another for the Strait of Juan de Fuca in 1983 (Brownell et al. 2001; DFO 2011a; Ford 2014).

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

3.3.1.2 Gray Whale (*Eschrichtius robustus*)

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

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

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

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

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

Gray whales are common off Haida Gwaii and western Vancouver Island (Williams and Thomas 2007), in particular during the migration. Whales travel southbound along the coast of B.C. during their migration to Baja California between November and January, with a peak off Vancouver Island during late December; during the northbound migration, whales start appearing off Vancouver Island during late February, with a peak in late March, with fewer whales occurring during April and May (Ford 2014). Northbound migrants typically travel within ~5 km from shore (Ford 2014), although some individuals have been sighted more than 10 km from shore (Ford et al. 2010a, 2013). Based on acoustic detections described by Meyer (2017 *in* COSEWIC 2017), the southward migration also takes place in shallow shelf waters. During surveys in B.C. waters during summer, most sightings were made within 10 km from the coast in water shallower than 100 m (Ford et al. 2010a).

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

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

3.3.1.3 Humpback Whale (*Megaptera novaeangliae*)

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

North Pacific humpback whales summer in feeding grounds along the Pacific Rim and in the Bering and Okhotsk seas (Pike and MacAskie 1969; Rice 1978; Winn and Reichley 1985; Calambokidis et al. 2000, 2001, 2008; Bettridge et al. 2015). Humpbacks winter in four different breeding areas: (1) the coast of Mexico; (2) the coast of Central America; (3) around the main Hawaiian Islands; and (4) in the western Pacific, particularly around the Ogasawara and Ryukyu islands in southern Japan and the northern Philippines (Calambokidis et al. 2008; Bettridge et al. 2015). These breeding areas are recognized as the Mexico, Central America, Hawaii, and Western Pacific DPSs, but feeding areas have no DPS status (Bettridge et al. 2015; NMFS 2016b). There is potential for mixing of the western and eastern North Pacific humpback populations on their summer feeding grounds, but several sources suggest that this occurs to a limited extent (Muto et al. 2020). NMFS is currently reviewing the global humpback whale stock structure in light of the revisions to their ESA listing and identification of 14 DPSs (NMFS 2016b). Individuals encountered in the proposed survey area would likely be from the Hawaii DPS, followed by the Mexico DPS; individuals from the Central America DPS are unlikely to feed in northern B.C. and Southeast Alaska (Calambokidis et al. 2008; Ford 2014). According to Wade (2017), ~3.8% of humpbacks occurring in Southeast Alaska and northern B.C. are likely to be from the Mexico DPS; the rest would be from the Hawaii DPS.

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

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

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

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

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

3.3.1.4 Common Minke Whale (*Balaenoptera acutorostrata scammoni*)

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

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

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

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

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

3.3.1.5 Sei Whale (*Balaenoptera borealis*)

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

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

Sei whales are now considered rare in Pacific waters of the U.S. and Canada; in B.C., there were no sightings in the late 1900s after whaling ceased (Gregr et al. 2006). A single sei whale was seen off southeastern Moresby Island in Hecate Strait coastal surveys in the summers of 2004/2005 (Williams and Thomas 2007). Ford (2014) only reported two sightings for B.C., both of those far offshore from Haida Gwaii. Possible sei whale vocalizations were detected off the west coast of Vancouver Island during spring and summer 2006 and 2007 (Ford et al. 2010b). Gregr and Trites (2001) proposed that the area off northwestern Vancouver Island and the continental slope may be critical habitat for sei whales because of favorable feeding conditions; however, no critical habitat has been designated (Parks Canada 2016). The waters off western Haida Gwaii were identified as sei whale important areas by PNCIMAI (2011). Sei whales could be encountered during the proposed survey, although this species is considered rare in these waters.

3.3.1.6 Fin Whale (*Balaenoptera physalus*)

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

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

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

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

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

Acoustic detections have been made throughout the year in pelagic waters west of Vancouver Island (Edwards et al. 2015). Calls were detected from February through July 2006 at Union Seamount off northwestern Vancouver island, and from May through September at La Pérouse Bank (Ford et al. 2010b). Gregr and Trites (2001) proposed that the area off northwestern Vancouver Island and the continental slope may be critical habitat for fin whales because of favorable feeding conditions; however, no critical habitat has been designated (Parks Canada 2016). The waters off western Haida Gwaii and Dixon Entrance were also identified as fin whale important areas by PNCIMAI (2011). Fin whales are likely to be encountered in the proposed survey area.

3.3.1.7 Blue Whale (*Balaenoptera musculus*)

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

In the North Pacific, blue whale calls are detected year-round (Stafford et al. 2001, 2009; Moore et al. 2002b, 2006; Monnahan et al. 2014), and Stafford et al. (2009) reported that sea-surface temperature is a good predictor variable for blue whale call detections. However, no detections of blue whales had been made in the GOA since the late 1960s (NOAA 2004a; Calambokidis et al. 2009) until blue whale calls were recorded in the area during 1999–2002 (Stafford 2003; Stafford and Moore 2005; Moore et al. 2006; Stafford et al. 2007). Call types from both northeastern and northwestern Pacific blue whales were recorded from July through December in the GOA, suggesting that two stocks used the area at that time (Stafford 2003; Stafford et al. 2007). Call rates peaked from August through November (Moore et al. 2006). More recent acoustic studies using fixed PAM have confirmed the presence of blue whales from both the Central and Eastern North Pacific stocks in the GOA concurrently (Baumann-Pickering et al. 2012; Debich et al. 2013; Rice et al. 2015). Blue whale calls were recorded in all months, at all shelf, slope, and seamount sites; and during all years (2011–2015) of those studies.

Before 2004, sightings of blue whales had not been documented in Alaska for at least 30 years. In July 2004, three blue whales were sighted in the GOA. The first blue whale was seen on 14 July ~185 km southeast of Prince William Sound; two more blue whales were seen ~275 km southeast of Prince William Sound (NOAA 2004a; Calambokidis et al. 2009). These whales were thought to be part of the California feeding population (Calambokidis et al. 2009). In August 2004, 19 sightings of more than 40 blue whales were seen during an L-DEO survey off southern Prince of Wales Island, Southeast Alaska, in Dixon Entrance and Cordova Bay (Maclean and Koski 2005). Rone et al. (2017) reported five blue whale sightings (seven animals) in 2013, and 13 blue whale sightings (13 animals) in 2015 in the U.S. Navy training area east of Kodiak.

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

3.3.2 Odontocetes

3.3.2.1 Sperm Whale (*Physeter macrocephalus*)

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

Sperm whales are distributed widely across the North Pacific (Rice 1989). Males can migrate north in the summer to feed in the GOA, Bering Sea, and waters around the Aleutian Islands (Kasuya and Miyashita 1988). Most of the information regarding sperm whale distribution in the GOA (especially the eastern GOA) and Southeast Alaska has come from anecdotal observations from fishermen and reports from fisheries observers aboard commercial fishing vessels (e.g., Dahlheim 1988). Fishery observers have identified interactions (e.g., depredation) between longline vessels and sperm whales in the GOA and Southeast Alaska since at least the mid-1970s (e.g., Hill et al. 1999; Straley et al. 2005; Sigler et al. 2008), with most interactions occurring in the West Yakutat and East Yakutat/Southeast regions (Perez 2006;

Hanselman et al. 2008). Sigler et al. (2008) noted high depredation rates in West Yakutat, East Yakutat/ Southeast region, as well as the central GOA. Sperm whales are commonly sighted during surveys in the Aleutians and the central and western GOA (e.g., Forney and Brownell 1996; Moore 2001; Waite 2003; Wade et al. 2003; Zerbini et al. 2004; Barlow and Henry 2005; Ireland et al. 2005; Straley et al. 2005; Rone et al. 2017). In contrast, there are fewer reports on the occurrence of sperm whales in the eastern GOA (e.g., Rice and Wolman 1982; Mellinger et al. 2004a; MacLean and Koski 2005; Rone et al. 2010).

From 1908–1967, 6158 sperm whales were caught off the west coast of B.C. They were taken in large numbers in April, with a peak in May. Analysis of data on catch locations, sex of the catch, and fetus lengths indicated that males and females were both 50–80 km from shore while mating in April and May, and that by July and August, adult females had moved to waters >100 km offshore to calve), and adult males had moved to within ~25 km of shore (Gregr et al. 2000). At least in the whaling era, females did not travel north of Vancouver Island whereas males were observed in deep water off Haida Gwaii (Gregr et al. 2000). After the whaling era, sperm whales have been sighted and detected acoustically in B.C. waters throughout the year, with a peak during summer (Ford 2014). Acoustic detections at La Pérouse Bank off southwestern Vancouver Island have been recorded during spring and summer (Ford et al. 2010b). Sightings west of Vancouver Island and Haida Gwaii indicate that this species still occurs in B.C. in small numbers (Ford 2014). Based on whaling data, Gregr and Trites (2001) proposed that the area off northwestern Vancouver Island and the continental slope may be critical habitat for male sperm whales because of favorable feeding conditions; however, no critical habitat has been designated (Parks Canada 2016). The waters off western Haida Gwaii were also identified as sperm whale important areas by PNCIMAI (2011). Sperm whales are likely to be encountered in the proposed survey area.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

3.3.2.6 Northern Right Whale Dolphin (*Lissodelphis borealis*)

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

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

3.3.2.7 Risso's Dolphin (*Grampus griseus*)

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

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

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

3.3.2.8 Killer Whale (*Orcinus orca*)

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

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

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

Southern Resident killer whales primarily occur in the southern Strait of Georgia, Strait of Juan de Fuca, Puget Sound, and the southern half of the west coast of Vancouver Island (Ford et al. 1994; Baird 2001; Carretta et al. 2020); however, their range may extend into Southeast Alaska (Carretta et al. 2020). These aforementioned areas in B.C. and Washington have been designated as critical habitat either by the U.S. or Canada. In the fall, this population is known to occur in Puget Sound, and during the winter, they occur along the outer coast and do not spend a lot of time in critical habitat areas (Ford 2014). Southern resident killer whales mainly feed on salmon, in particular Chinook, and their movements coincide with those of their prey (Ford 2014).

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

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

3.3.2.9 Harbor Porpoise (*Phocoena phocoena*)

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

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

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

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

3.3.2.10 Dall's Porpoise (*Phocoenoides dalli*)

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

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

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

3.3.3 Pinnipeds

3.3.3.1 Northern Fur Seal (*Callorhinus ursinus*)

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

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

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

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

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

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

3.3.3.2 California Sea Lion (*Zalophus californianus*)

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

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

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

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

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

3.3.3.3 Steller Sea Lion (*Eumetopias jubatus*)

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

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

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

Steller sea lions are present in Alaska year-round, with centers of abundance in the GOA and Aleutian Islands. There are several rookeries in Southeast Alaska, including Hazy Island, White Sisters Island, Forrester Island near Dixon Entrance, Graves Rock along the outer coast of Glacier Bay National Park & Reserve (GBNPP), and Biali Rock (Calkins et al. 1999; Raum-Suryan and Pitcher 2000; Raum-Suryan 2001; Gelatt et al. 2007; Hastings et al. 2017; Sweeney et al. 2017). The rookeries at Hazy Island, White Sisters Island, and Forrester Island as well as several major haulouts are designated as critical habitat (Fig. 1). Numerous other haulouts occur through Southeast Alaska (Sweeney et al. 2017). During an L-DEO seismic survey off Southeast Alaska, numerous sightings were made north of the survey area during September 2004 (MacLean and Koski 2005). Juvenile sea lions branded as pups on Forrester Island have been observed at South Marble Island in GBNPP (Mathews 1996), and some juveniles from the Western stock have been observed at South Marble Island and Graves Rocks in GBNPP (Raum-Suryan 2001).

In B.C., there are six main rookeries, which are situated at the Scott Islands off northwestern Vancouver Island, the Kerouard Islands near Cape St. James at the southern end of Haida Gwaii, North Danger Rocks in eastern Hecate Strait, Virgin Rocks in eastern Queen Charlotte Sound, Garcin Rocks off southeastern Moresby Island in Haida Gwaii, and Gosling Rocks on the central mainland coast (Ford 2014). The Scott Islands and Cape St. James rookeries are the two largest breeding sites with 4000 and 850 pups born in 2010, respectively (Ford 2014). Some adults and juveniles are also found on sites known as year-round haulouts during the breeding season. Haul outs are located along the coasts of Haida Gwaii, the central and northern mainland coast, the west coast of Vancouver Island, and the Strait of Georgia; some are year-round sites whereas others are only winter haul outs (Ford 2014). Pitcher et al. (2007) reported 24 major haulout sites (>50 sea lions) in B.C., but there are currently around 30 (Ford 2014). The total pup and non-pup count of Steller sea lions in B.C. in 2002 was 15,438; this represents a minimum population estimate (Pitcher et al. 2007). The highest pup counts in B.C. occur in July (Bigg 1988). Steller sea lions could be encountered in the proposed project areas, especially in the waters closer to shore.

3.3.3.4 Northern Elephant Seal (*Mirounga angustirostris*)

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

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

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

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

3.3.3.5 Harbor Seal (*Phoca vitulina*)

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

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

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

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

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

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

3.3.4 Fissiped

3.3.4.1 Northern Sea Otter (*Enhydra lutris kenyoni*)

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

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

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

3.4 Sea Turtles

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

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

3.4.1 Leatherback Turtle (*Dermochelys coriacea*)

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

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

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

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

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

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

3.4.2 Green Turtle (*Chelonia mydas*)

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

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

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

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

3.5 Seabirds

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

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

3.5.1 Short-tailed Albatross

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

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

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

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

3.5.2 Hawaiian Petrel

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

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

3.5.3 Marbled Murrelet

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

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

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

3.5.4 Pink-footed Shearwater

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

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

3.6 Corals

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

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

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

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

3.7.1 ESA-Listed Fish Species

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

3.7.1.1 Salmonids

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

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

3.7.1.2 Green Sturgeon

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

3.7.2 Essential Fish Habitat

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

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

3.7.3 Habitat Areas of Particular Concern

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

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

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

3.7.4 SARA-Listed Fish and Marine Invertebrate Species

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

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

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

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

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

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

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

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

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

3.7.5 Rockfish Conservation Areas

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

3.8 Fisheries

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

3.8.1 Biologically and Economically Important Species

3.8.1.1 Groundfish

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

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

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

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

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

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

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

3.8.1.2 Forage Fish

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

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

3.8.1.3 Rockfish

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

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

3.8.1.4 Shellfish

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

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

3.8.2 Commercial Fisheries

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

3.8.3 Indigenous Fisheries

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

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

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

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

3.8.4 Recreational Fisheries

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

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

3.8.5 Aquaculture

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

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

3.9 Cultural Resources

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

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

IV Environmental Consequences

4.1 Proposed Action

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

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

4.1.1.1 Summary of Potential Effects of Airgun Sounds

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

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

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

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

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

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

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

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

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

Baleen Whales

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Toothed Whales

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

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

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

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

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

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

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

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

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

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

Pinnipeds

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

Sea Turtles

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Sea Turtles

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

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

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

4.1.1.2 Possible Effects of Other Acoustic Sources

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

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

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

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

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

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

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

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

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

4.1.1.3 Other Possible Effects of Seismic Surveys

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

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

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

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

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

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

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

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

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

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

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

4.1.1.4 Mitigation Measures

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

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

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

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

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

For the majority of species, we used a combination of habitat-based stratified marine mammal densities developed by the U.S. Navy for assessing potential impacts of training activities in the GOA (DoN 2014) and densities for Behm Canal in Southeast Alaska (DoN 2019). Based on recommendations by NMFS, the GOA densities were used for offshore areas, and the Behm Canal densities were used for coastal waters. Consistent with Rone et al. (2014), four strata were defined by DoN (2014) for the GOA including (1) Inshore: all waters <1000 m deep; (2) Slope: from 1000 m water depth to the Aleutian trench/subduction zone; (3) Offshore: waters offshore of the Aleutian trench/subduction zone; and (4) Seamount: waters within defined seamount areas. For cetaceans, the preferred densities for coastal waters (shallow and intermediate depths) were from Behm Canal; 'Offshore' densities from the GOA were used for offshore waters. If no densities were available for Behm Canal, then 'Inshore' densities were used for coastal waters (shallow and intermediate depths); 'Offshore' densities were used for offshore waters.

For pinnipeds, we used densities from Behm Canal, when available, for shallow water (<100 m), 'Inshore' densities for intermediate-depth water (100–1000 m), and 'Offshore' densities for offshore waters. As densities for Behm Canal are for inland waters and are therefore expected to be much greater than densities off the coast, we did not use the Behm Canal densities for intermediate-depth waters. All marine mammal densities corresponding to the various strata in the GOA and single density values for Behm Canal were based on data from several different sources, including Navy funded line-transect surveys in the GOA, as described in Appendix B. Densities for harbor porpoise, northern right whale dolphin, California sea lion, northern sea otter, and leatherback turtle were determined using alternate density sources (see Appendix B for details).

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

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

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

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

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

N.A. means not available/not applicable.

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

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

N.A. means not applicable or not available.
[1] Level B takes, based on the 160-dB criterion, excluding exposures to sound levels equivalent to PTS thresholds.
[2] Level A takes if there were no mitigation measures.
[3] Requested take authorization (Level A + Level B) expressed as % of population (see Table 5).
[4] Requested take authorization is Level A plus Level B calculated takes, except as indicated otherwise.
[5] Fifteen takes from Mexico DPS; remainder from Hawaii DPS (assumes 3.8% of humpbacks that occur in southeast Alaska and northern B.C. are from the Mexico DPS (Wade 2017).
[6] Two Level B takes and zero Level A takes from western DPS; remainder from Eastern North Pacific DPS (assumes 0.1% of gray whales could be from the Western North Pacific DPS (NMSF pers. comm. based on Carretta et al. 2019, 2020).
[7] All takes expected to occur in Canadian waters (takes in territorial waters not included here).
[8] Requested take increased to mean group size (Barlow 2016).
[9] Takes include individuals from all stocks that could occur in survey area; no takes expected for Southern Resident DPS.
[10] Fifty-four Level B takes and zero Level A takes would be from the Western DPS; remainder of takes from Eastern DPS (based on Hastings et al. (2019), it is expected that 2.2% of Steller sea lions in the central outer coast region of southeast Alaska would be from the endangered Western DPS.
[11] Takes calculated by USFWS and detailed in Appendix C.

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

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

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

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

4.1.1.6 Conclusions for Marine Mammals and Sea Turtles

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

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

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

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

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

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

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

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

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

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

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

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

4.1.2.1 Effects of Sound on Marine Invertebrates

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

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

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

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

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

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

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

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

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

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

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

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

4.1.2.2 Effects of Sound on Fish

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

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

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

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

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

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

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

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

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

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

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

4.1.2.3 Effects of Sound on Fisheries

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

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

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

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

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

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

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

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

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

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

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

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

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

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

4.1.3 Direct Effects on Seabirds and Their Significance

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

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

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

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

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

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

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

4.1.5 Direct Effects on Cultural Resources and Their Significance

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

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

4.1.6 Cumulative Effects

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

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

4.1.6.1 Past and Future Research Activities

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

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

4.1.6.2 Naval Activities

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

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

4.1.6.3 Vessel Traffic

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

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

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

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

4.1.6.4 Fisheries Interactions

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

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

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

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

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

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

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

4.1.6.5 Whaling and Sealing

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

4.1.6.6 Tourism

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

4.1.7 Unavoidable Impacts

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

4.1.8 Coordination with Other Agencies and Processes

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

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

(a) Endangered Species Act (ESA)

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

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

(b) Marine Mammal Protection Act (MMPA)

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

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

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

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

(f) Canadian Department of Fisheries and Oceans

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

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

4.2 No Action Alternative

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

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APPENDIX A: DETERMINATION OF MITIGATION ZONES

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

Typically, for deep and intermediate-water cases, the field measurements cannot be used readily to derive mitigation radii, as at those GoM sites the calibration hydrophone was located at a roughly constant depth of 350–500 m, which may not intersect all the sound pressure level (SPL) isopleths at their widest point from the sea surface down to the maximum relevant water depth for marine mammals of ~2000 m (Costa and Williams 1999). Figures 2 and 3 in Appendix H of the PEIS show how the values along the maximum SPL line that connects the points where the isopleths attain their maximum width (providing the maximum distance associated with each sound level) may differ from values obtained along a constant depth line. At short ranges, where the direct arrivals dominate and the effects of seafloor interactions are minimal, the data recorded at the deep and slope sites are suitable for comparison with modeled levels at the depth of the calibration hydrophone. At longer ranges, the comparison with the mitigation model—constructed from the maximum SPL through the entire water column at varying distances from the airgun array—is the most relevant. The L-DEO modeling results are summarized below.

In deep and intermediate-water depths, comparisons at short ranges between sound levels for direct arrivals recorded by the calibration hydrophone and model results for the same array tow depth are in good agreement (Fig. 12 and 14 in Appendix H of the PEIS). Consequently, isopleths falling within this domain can be predicted reliably by the L-DEO model, although they may be imperfectly sampled by measurements recorded at a single depth. At greater distances, the calibration data show that seafloor-reflected and sub-seafloor-refracted arrivals dominate, whereas the direct arrivals become weak and/or incoherent (Fig. 11, 12, and 16 in Appendix H of the PEIS). Aside from local topography effects, the region around the critical distance (~5 km in Fig. 11 and 12, and ~4 km in Fig. 16 in Appendix H of the PEIS) is where the observed levels rise closest to the mitigation model curve. However, the observed sound levels are found to fall almost entirely below the mitigation model curve (Fig. 11, 12, and 16 in Appendix H of the PEIS). Thus, analysis of the GoM calibration measurements demonstrates that although simple, the L-DEO model is a robust tool for conservatively estimating mitigation radii. In shallow water (<100 m), the depth of the calibration hydrophone (18 m) used during the GoM calibration survey was appropriate to sample the maximum sound level in the water column, and the field measurements reported in Table 1 of Tolstoy et al. (2009) can be scaled for the single airgun at a tow depth of 6 m to derive mitigation radii.

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

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

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

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

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

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

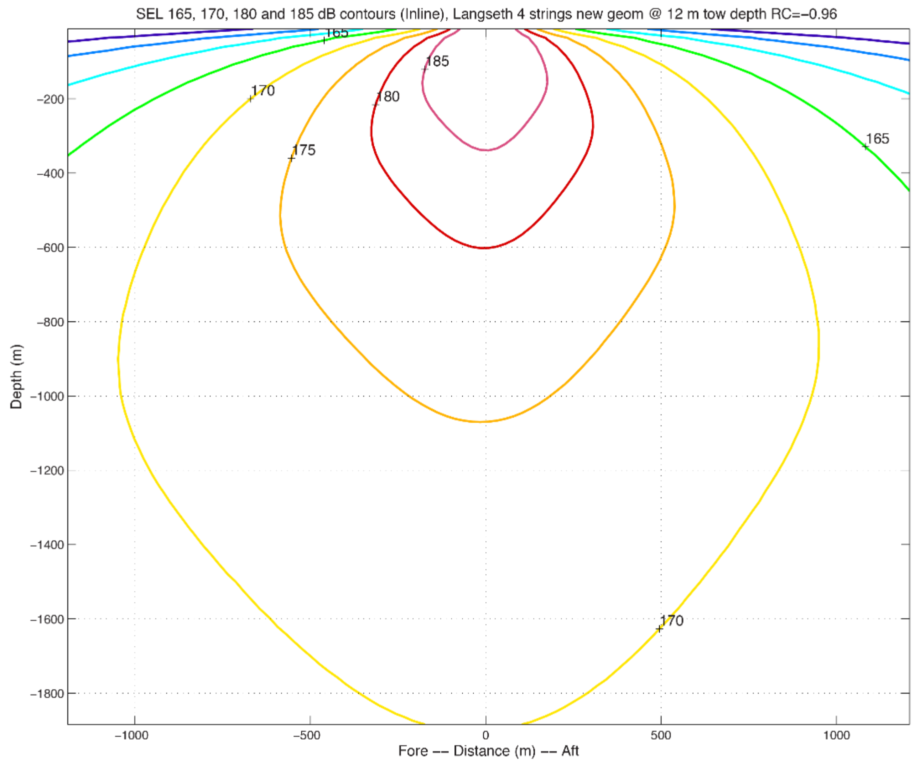
TABLE A-3. Level B. Predicted distances to which sound levels ≥160-dB and ≥175-dB re 1 μPa_{rms} could be received during the proposed surveys in the Northeast Pacific Ocean. The 160-dB criterion applies to all hearing groups of marine mammals and the 175-dB criterion applies to sea turtles.

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

[1] Distance is based on L-DEO model results.
[2] Distance is based on L-DEO model results with a 1.5 × correction factor between deep and intermediate water depths.
[3] Distance is based on empirically derived measurements in the GOM with scaling applied to account for differences in tow depth.
[4] Based on empirical data from Crone et al. (2014).
* An EZ of 100 m would be used as the shut-down distance for sea turtles in all water depths.

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

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



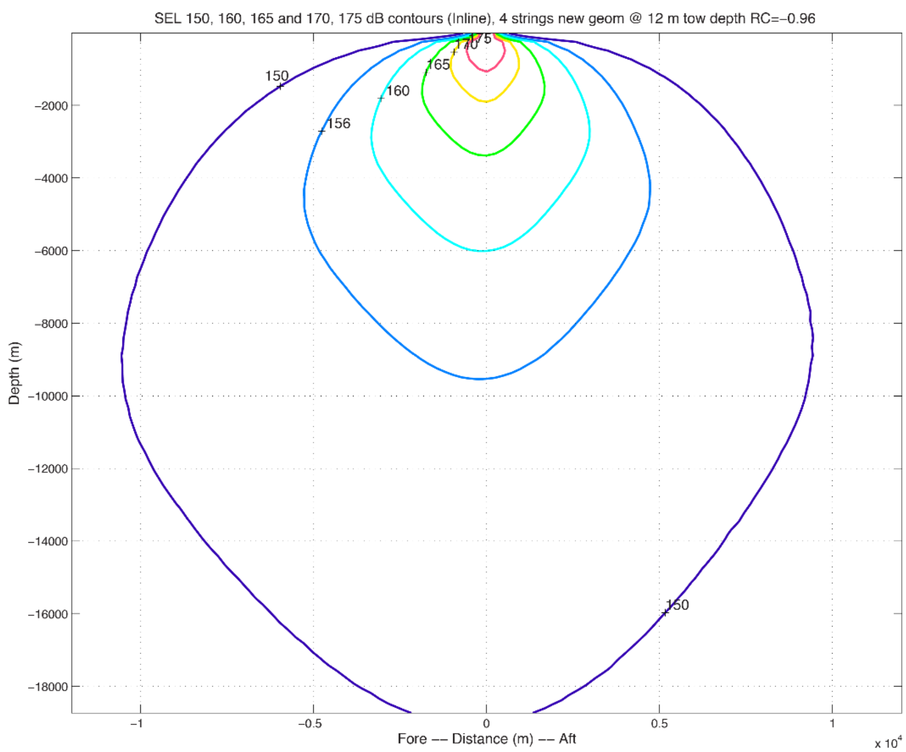


FIGURE A-1. Modeled deep-water received sound exposure levels (SELs) from the 36-airgun array at a 12-m tow depth planned for use during the proposed surveys in the Northeast Pacific Ocean. Received rms levels (SPLs) are expected to be ~10 dB higher. For example, the radius to the 150-dB SEL isopleth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

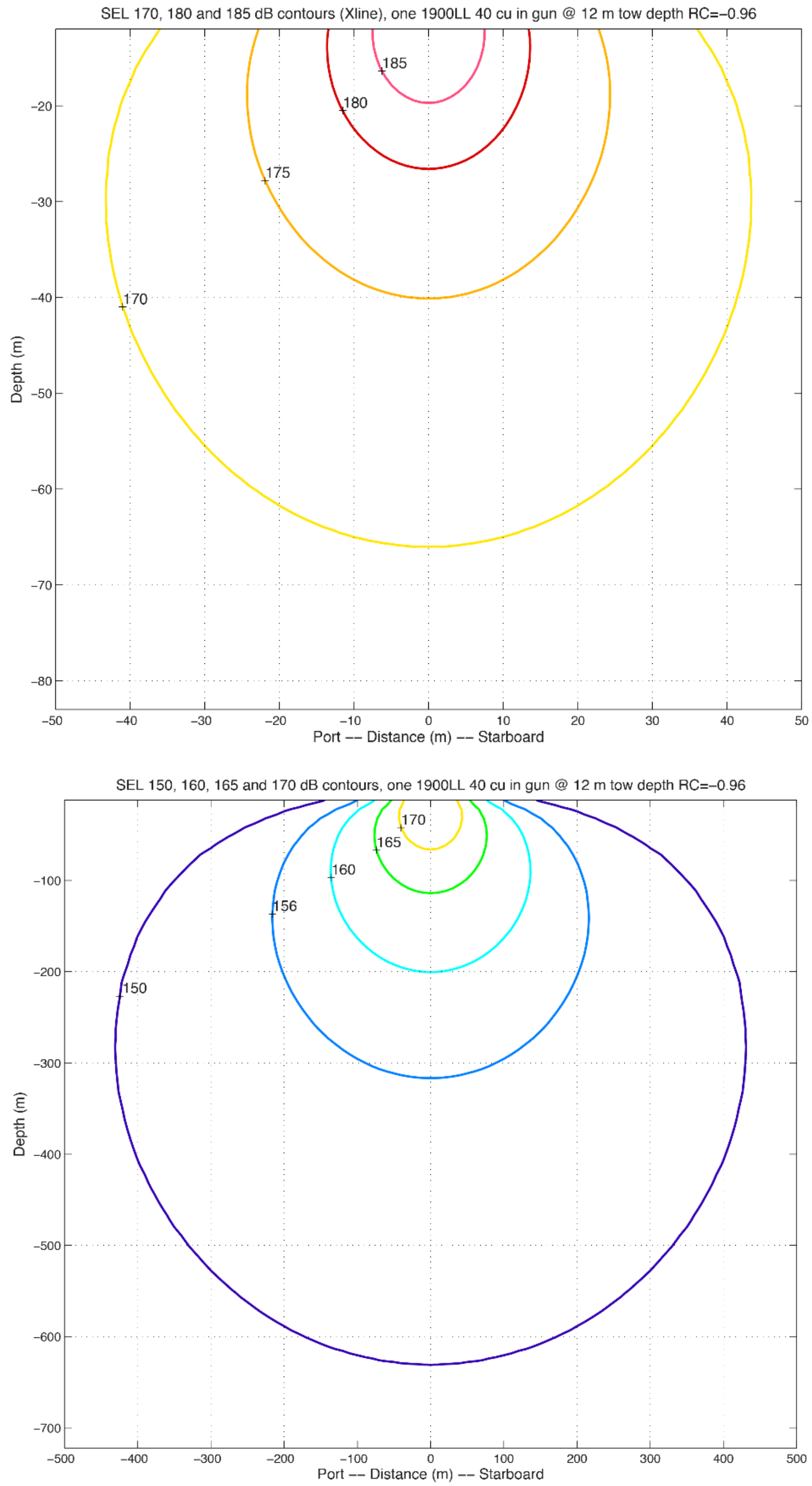
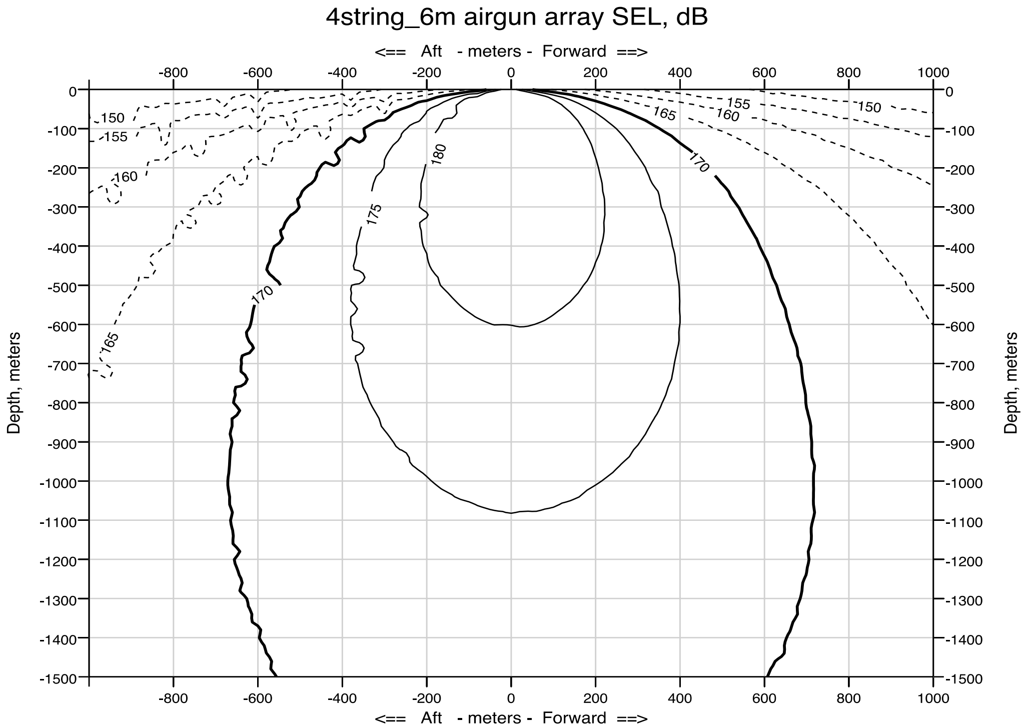


FIGURE A-2. Modeled deep-water received SELs from a single 40-in^3 airgun towed at a 12-m depth, which is planned for use as a mitigation airgun during the proposed surveys in the Northeast Pacific Ocean. Received rms levels (SPLs) are expected to be ~10 dB higher. For example, the radius to the 150-dB SEL isopleth is a proxy for the 160-dB rms isopleth. The upper plot is a zoomed-in version of the lower plot.



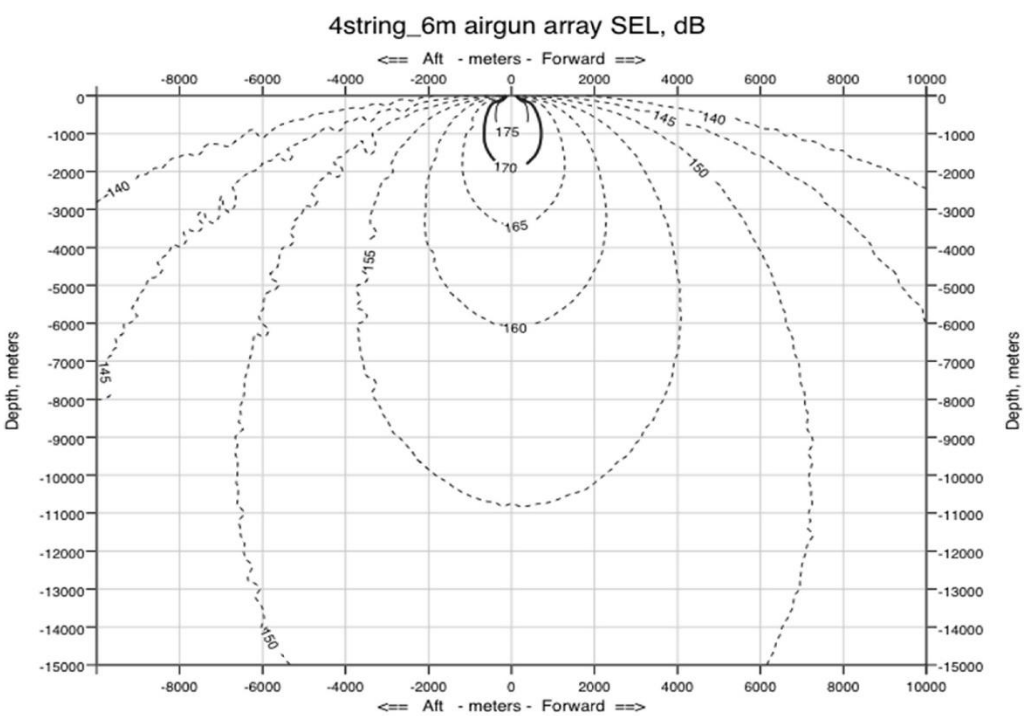


Figure A-3. Modeled deep-water received sound exposure levels (SELs) from the 36-airgun array at a 6-m tow depth used during the GoM calibration survey. Received rms levels (SPLs) are expected to be ~10 dB higher. For example, the radius to the 150 dB SEL isopleth is a proxy for the 160-dB rms isopleth.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

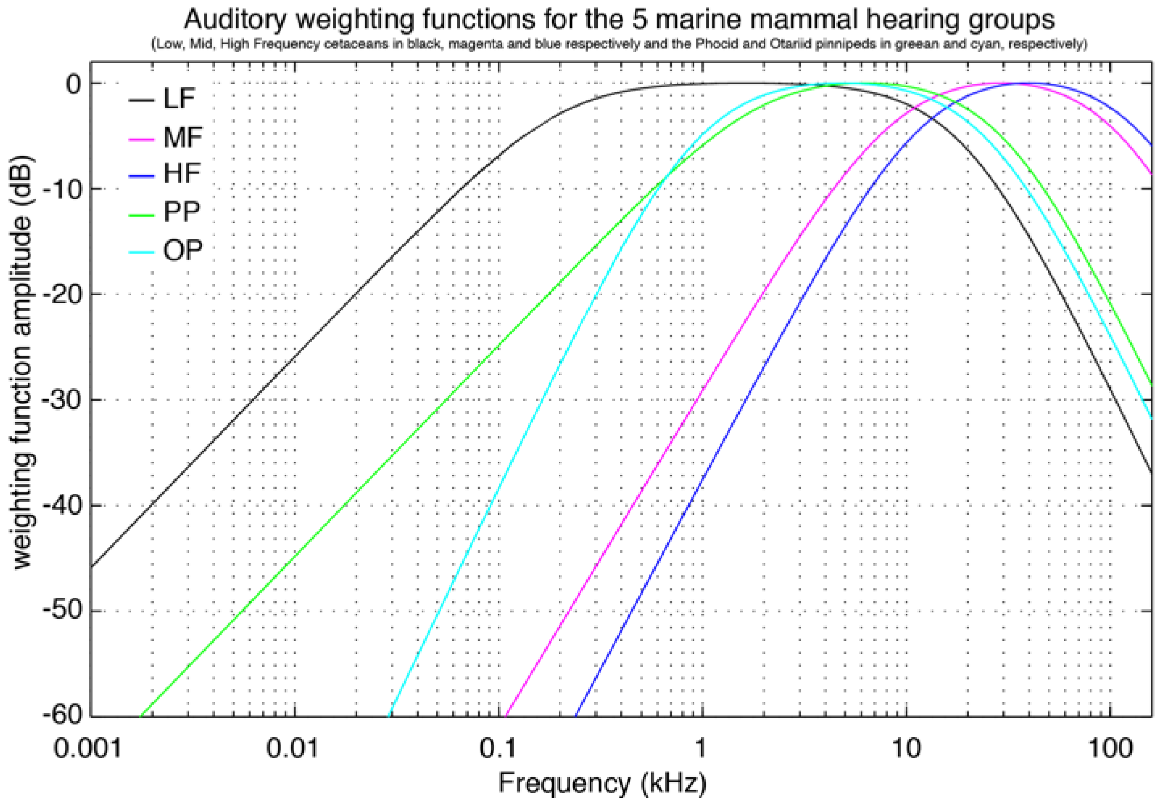


FIGURE A-4. Auditory weighting functions for five marine mammal hearing groups from the NMFS Technical Guidance.

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

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

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

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

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

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

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

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

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

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

STEP 1: GENERAL PROJECT INFORMATION

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

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

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

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

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

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

STEP 3: SOURCE-SPECIFIC INFORMATION

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

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

SEL_{cum}

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

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

^Time between onset of successive pulses.

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

RESULTANT ISOPLETHS*

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

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

WEIGHTING FUNCTION CALCULATIONS

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

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

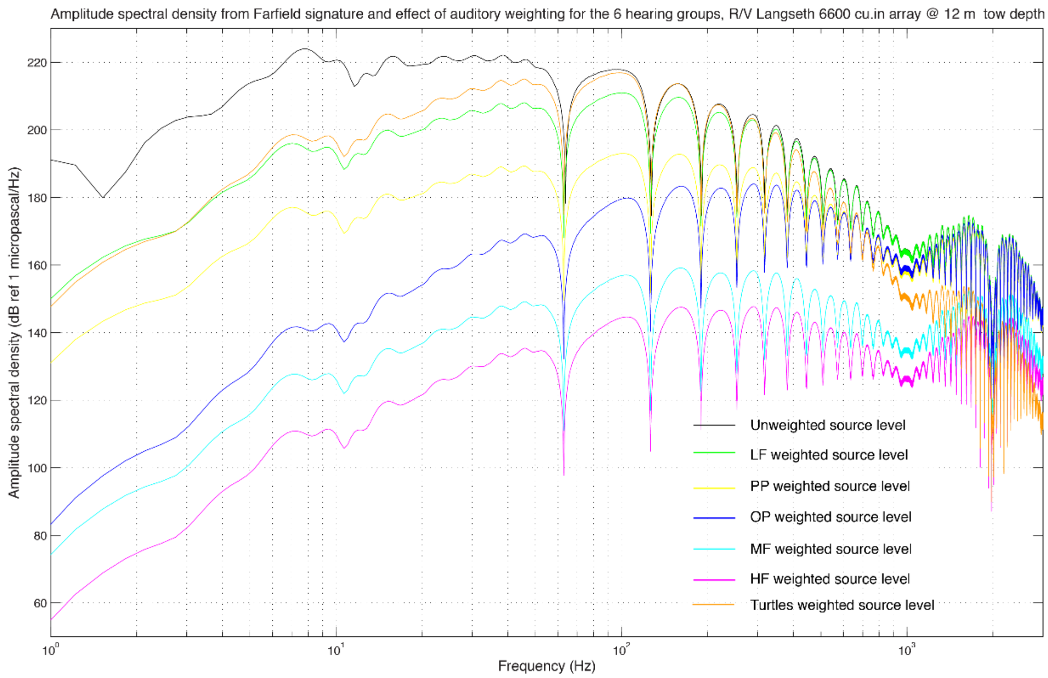


FIGURE A-5. Modeled amplitude spectral density of the 36-airgun array farfield signature. Amplitude spectral density before (black) and after (colors) applying the auditory weighting functions for LF, MF, and HF cetaceans, Phocid Pinnipeds (PP), Otariid Pinnipeds (OP), and Sea Turtles. Modeled spectral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

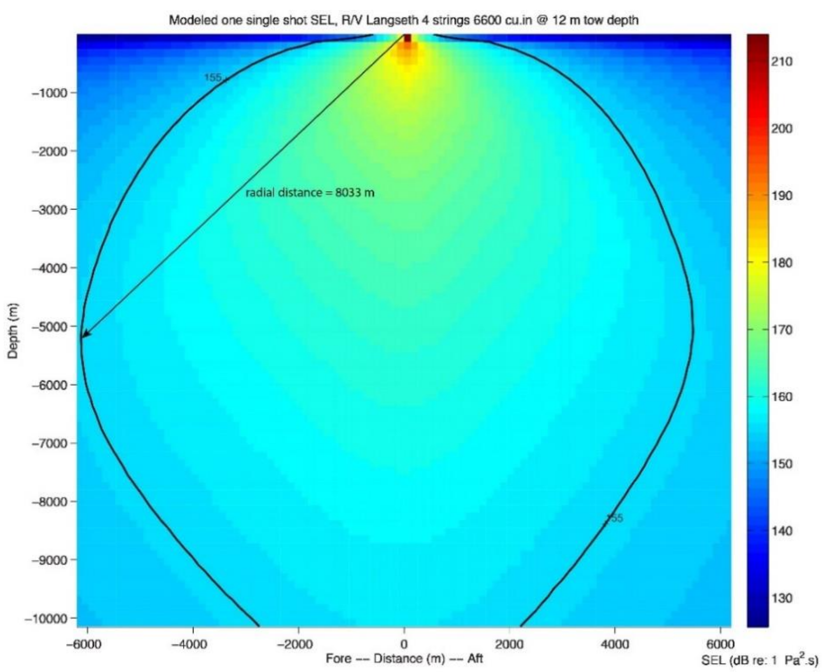


FIGURE A-6. Modeled received sound levels (SELs) in deep water from the 36-airgun array. The plot provides the radial distance from the geometrical center of the source array to the 155-dB SEL isopleth (8033 m). Radial distance allows us to determine the modified farfield SEL using a propagation of $20\log_{10}$(radial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

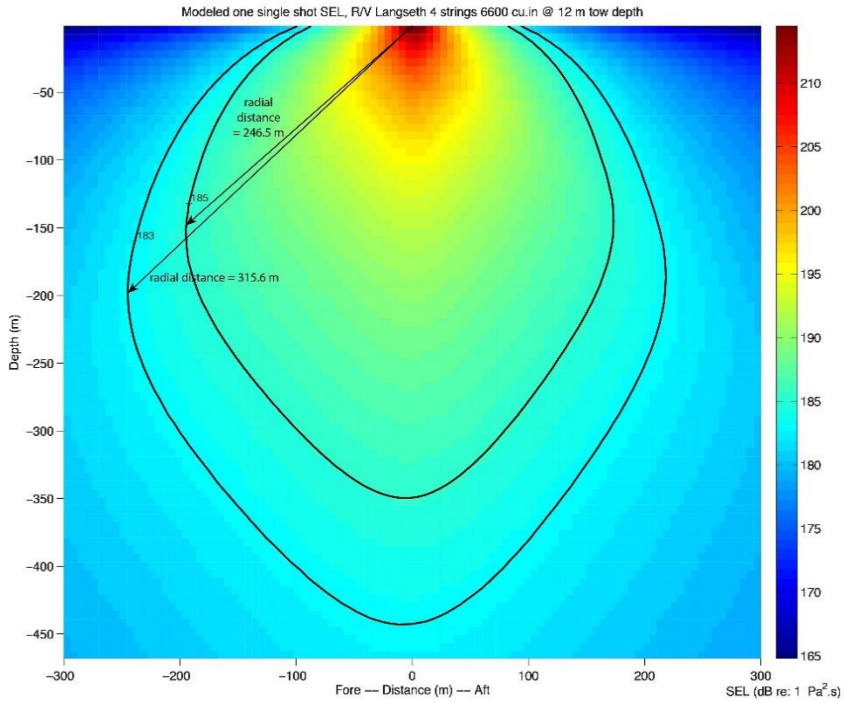


FIGURE A-7. Modeled received sound levels (SELs) in deep water from the 36-airgun array. The plot provides the radial distance from the geometrical center of the source array to the 183–185-dB SEL isopleths (315.6 and 246.5 m, respectively).

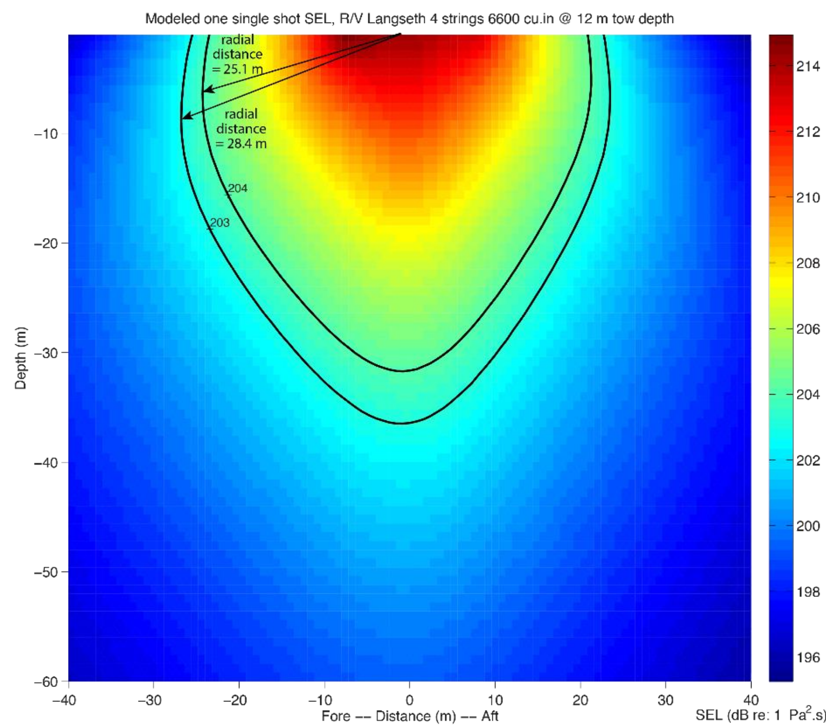


FIGURE A-8. Modeled received sound levels (SELs) in deep water from the 36-airgun array. The plot provides the radial distance from the geometrical center of the source array to the 203-dB and 204-dB SEL isopleth (28.4 m and 25.1 m, respectively).

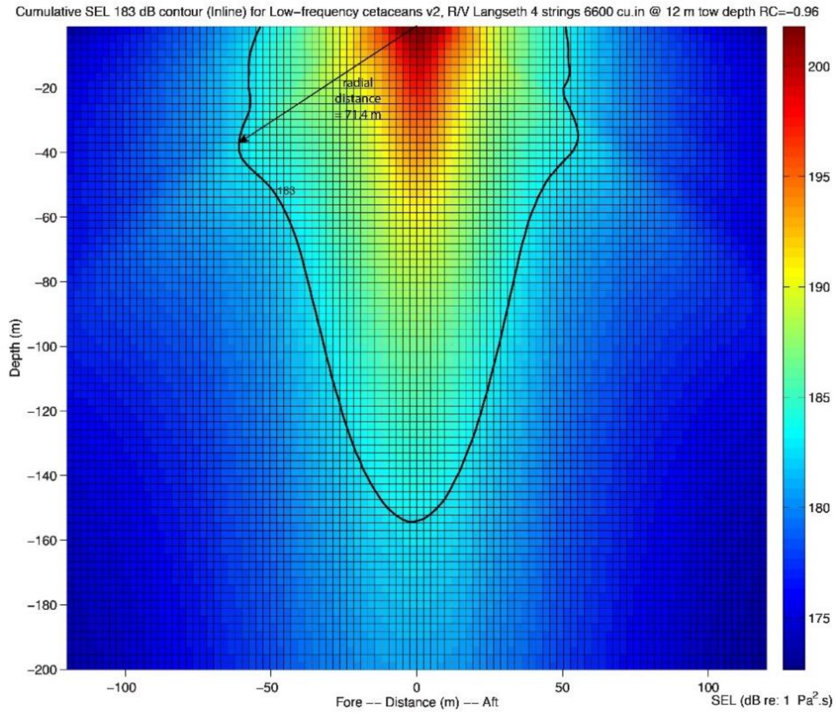


FIGURE A-9. Modeled received sound exposure levels (SELs) from the 36-airgun array at a 12-m tow depth, after applying the auditory weighting function for the LF cetaceans hearing group following the NMFS Technical Guidance. The plot provides the radial distance to the 183-dB SEL_{cum} isopleth for one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

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

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

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

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

N.A. means not applicable or not available.

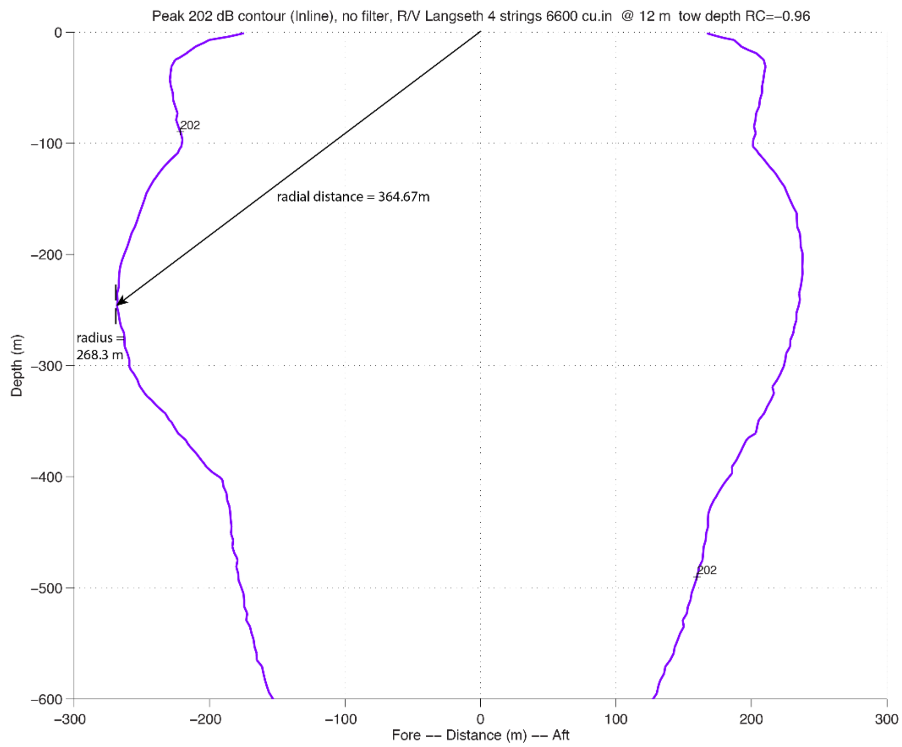


FIGURE A-10. Modeled deep-water received Peak SPL from the 36-airgun array at a 12-m tow depth. The plot provides the distance to the 202-dB Peak isopleth.

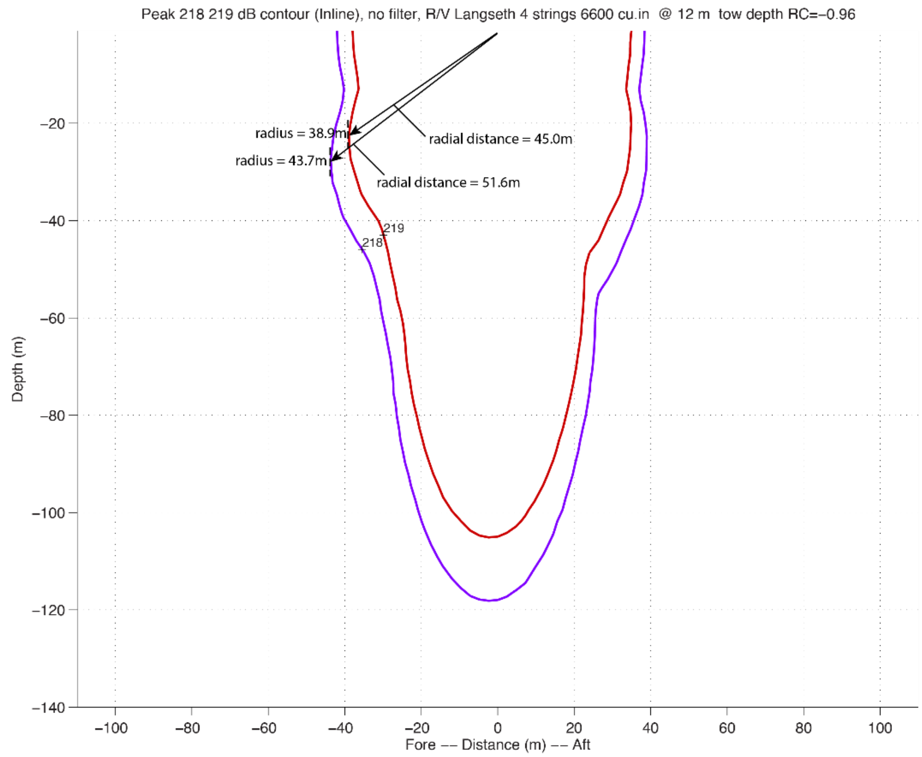


FIGURE A-11. Modeled deep-water received Peak SPL from the 36-airgun array at a 12-m tow depth. The plot provides the distances to the 218- and 219-dB Peak isopleths.

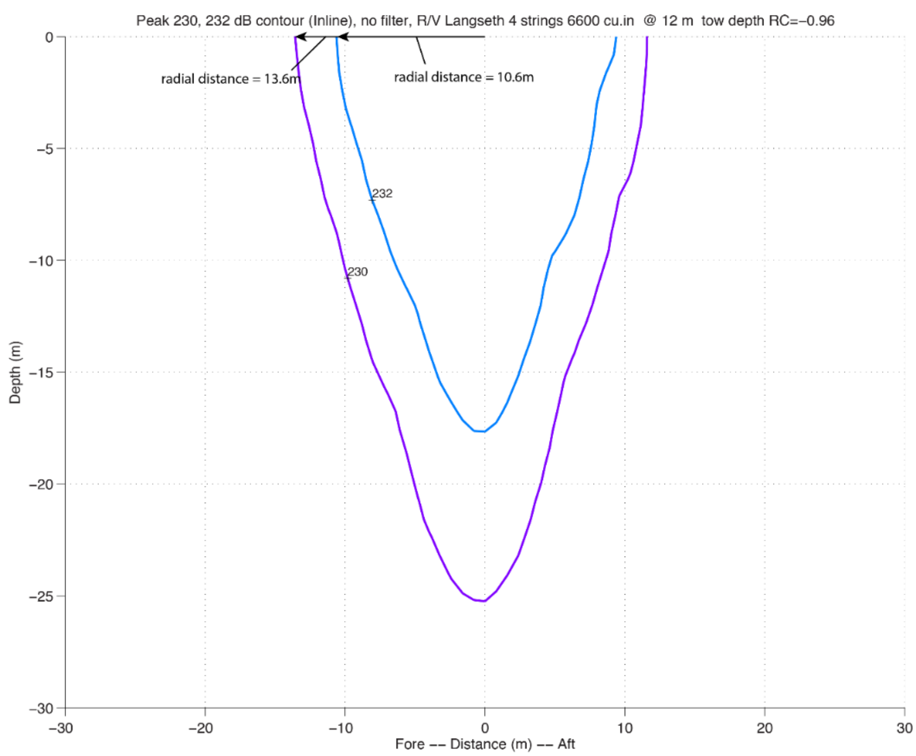


FIGURE A-12. Modeled deep-water received Peak SPL from the 36-airgun array at a 12-m tow depth. The plot provides the distances to the 230- and 232-dB Peak isopleths.

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

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

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

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

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

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

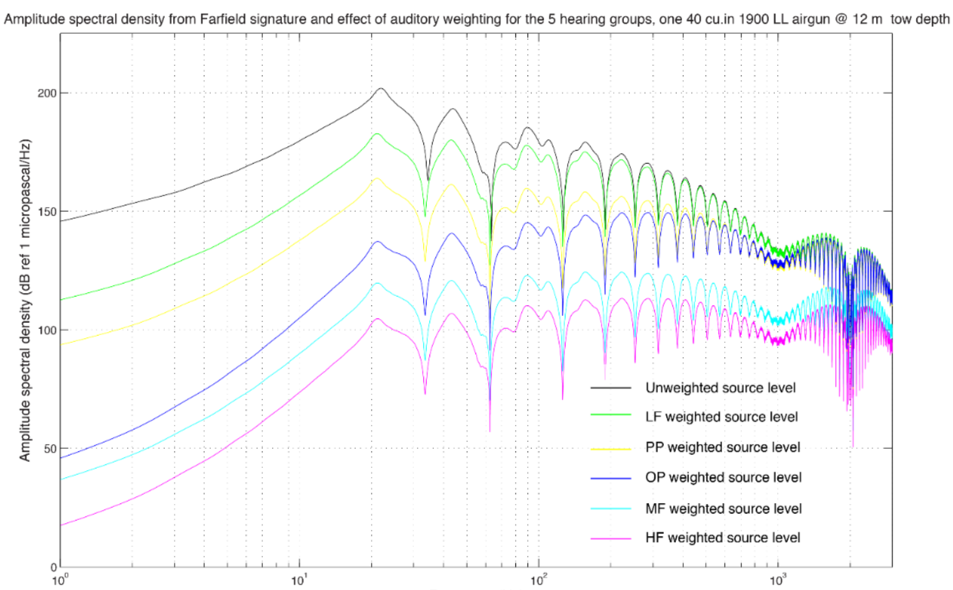


FIGURE A-13. Modeled amplitude spectral density of the 40-in³ airgun farfield signature. Amplitude spectral density before (black) and after (colors) applying the auditory weighting functions for LF, MF, and HF cetaceans, Phocid Pinnipeds (PP), and Otariid Pinnipeds (OP). Modeled spectral levels are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

TABLE A-7. Results for modified farfield SEL source level modeling for the single 40-in³ mitigation airgun with weighting function calculations for the SEL_{cum} criteria, as well as resulting isopleths to thresholds for various marine mammal hearing groups.

STEP 1: GENERAL PROJECT INFORMATION	
PROJECT TITLE	R/V Langseth mitigation gun
PROJECT/SOURCE INFORMATION	one 40 cu.in 1900LL airgun @ a 12 m tow depth - speed of 4.2 knots and shot interval of 37.5 m
Please include any assumptions	
PROJECT CONTACT	

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

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

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

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

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

STEP 3: SOURCE-SPECIFIC INFORMATION

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

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

SEL_{cum}

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

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

^Time between onset of successive pulses.

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

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

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

WEIGHTING FUNCTION CALCULATIONS

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

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

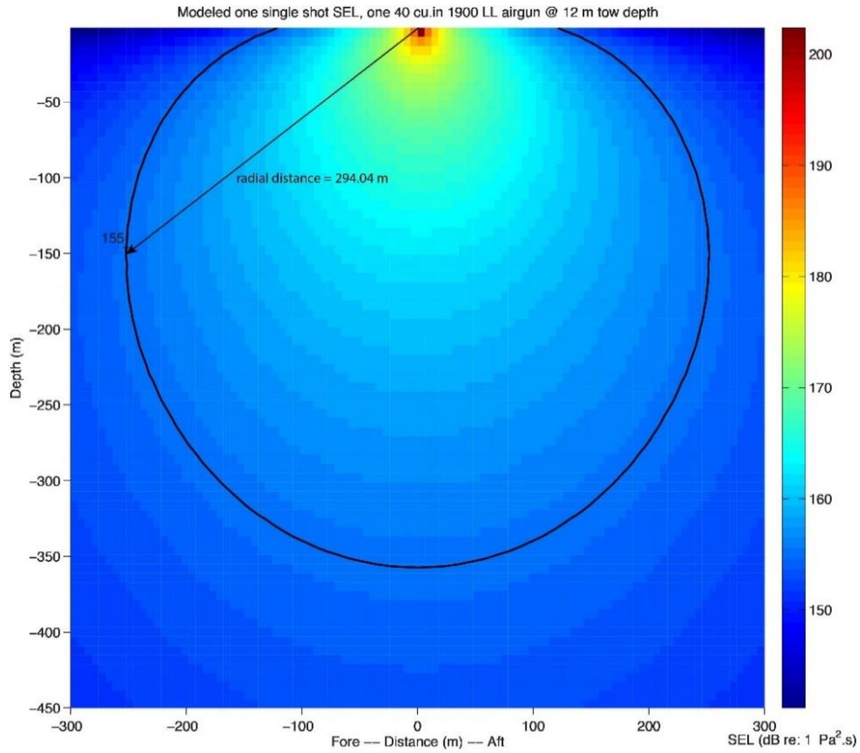


FIGURE A-14. Modeled received sound levels (SELs) in deep water from one 40-in^3 airgun at a 12-m tow depth. The plot provides the distance from the geometrical center of the source array to the 155-dB SEL isopleth (294.04 m).

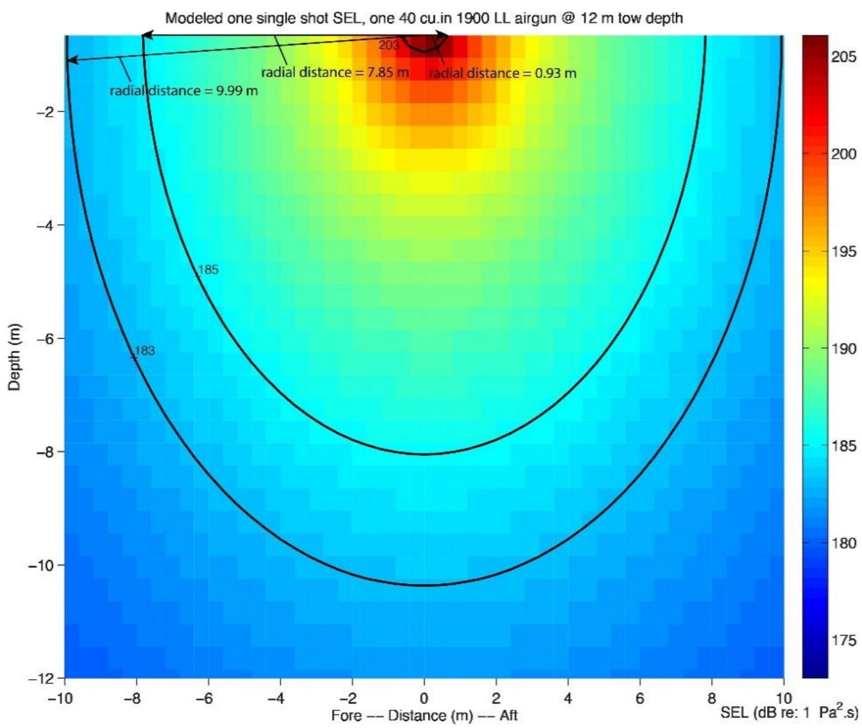


FIGURE A-15. Modeled received sound levels (SELs) in deep water from one 40-in^3 airgun at a 12-m tow depth. The plot provides the distance from the geometrical center of the source array to the 183–185 dB and 203 dB SEL isopleths.

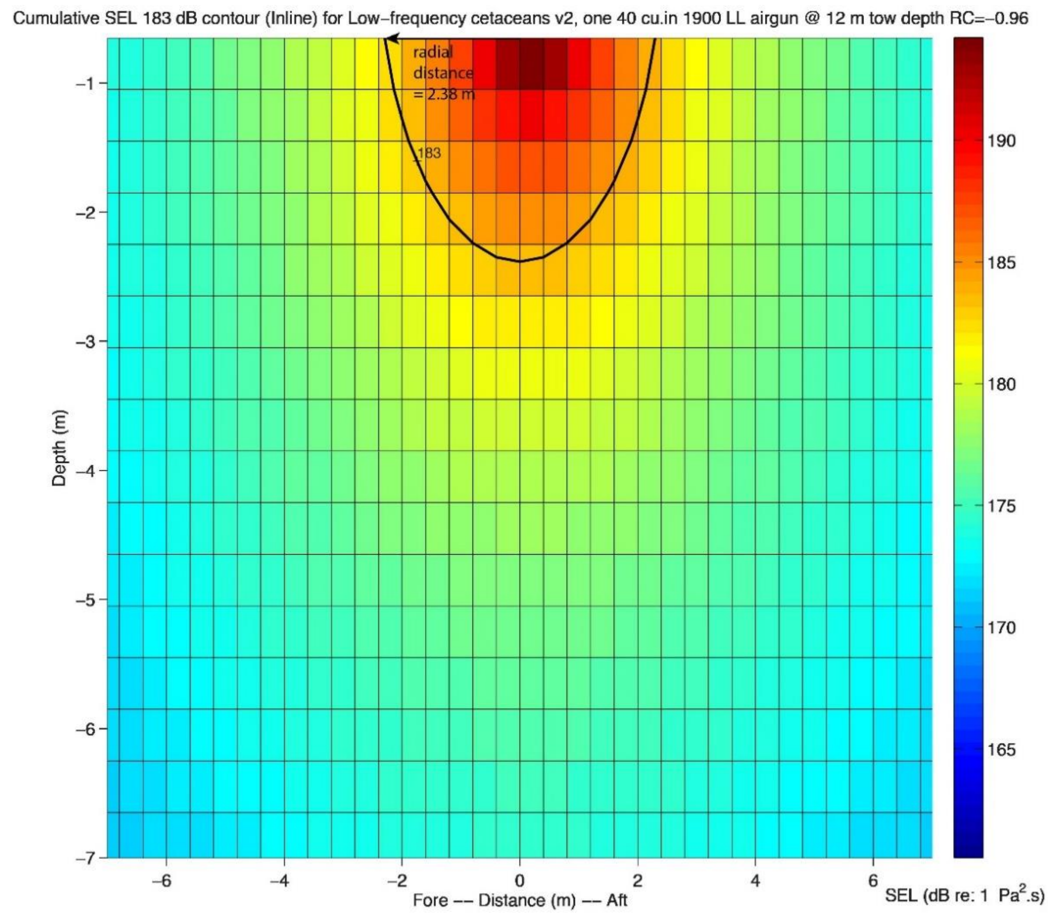


FIGURE A-16. Modeled received sound exposure levels (SELs) from one 40-in³ mitigation at a 12-m tow depth, after applying the auditory weighting function for the LF cetaceans hearing group following the NMFS Technical Guidance. The plot provides the radial distance to the 183-dB SEL_{cum} isopleth for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

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

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

N.A. means not applicable or not available.

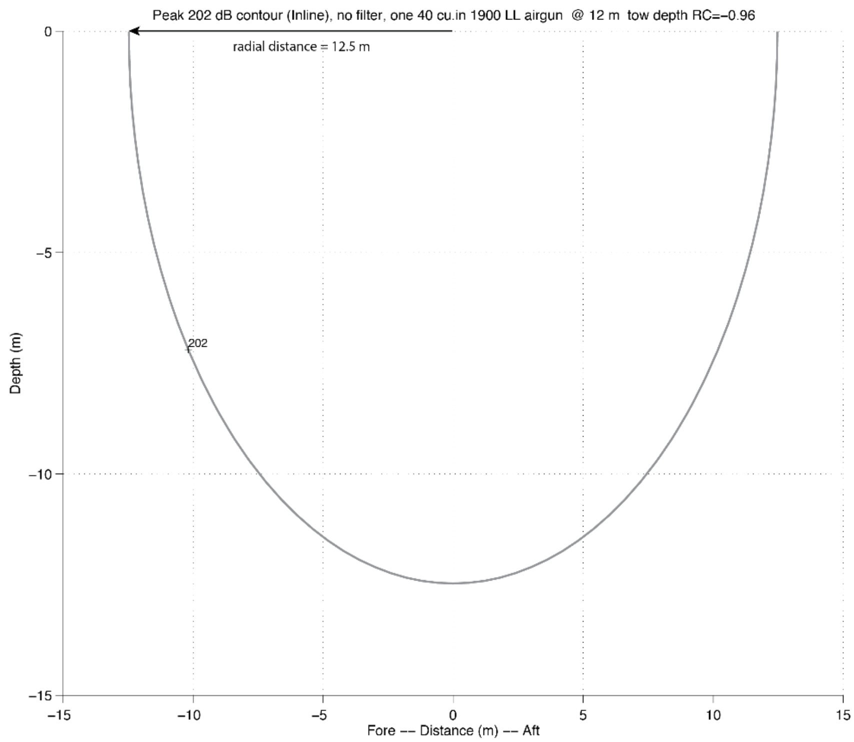


FIGURE A-17. Modeled deep-water received Peak SPL from one 40 in^3 airgun at a 12-m tow depth. The plot provides the radial distance from the source geometrical center to the 202-dB Peak isopleth.

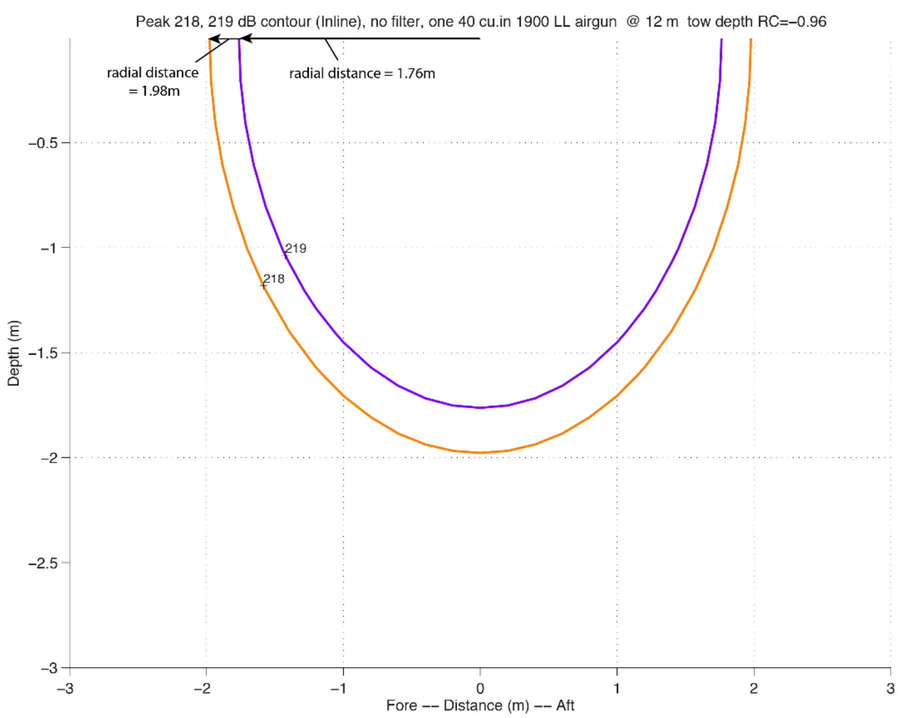


FIGURE A-18. Modeled deep-water received Peak SPL from one 40 in^3 airgun at a 12-m tow depth. The plot provides the radial distances from the source geometrical center to the 218 and 219-dB Peak isopleths.

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ADDENDUM

Using Empirical Data for Estimation of Level B Radii

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

To estimate Level B (behavioral disturbance or harassment) radii in shallow and intermediate water depths, we used the received levels from MCS data collected by R/V *Langseth* during the COAST survey (Crone et al. 2014). Streamer data in shallow water collected in 2012 have the advantage of including the effects of local and complex subsurface geology, seafloor topography, and water column properties and thus allow us to establish mitigation radii more confidently than by using the data from calibration experiments in the Gulf of Mexico (Tolstoy et al. 2004, 2009; Diebold et al. 2010).

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

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

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

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Extracted from Crone et al. 2014 – Section 4.1

4. Discussion

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

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

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

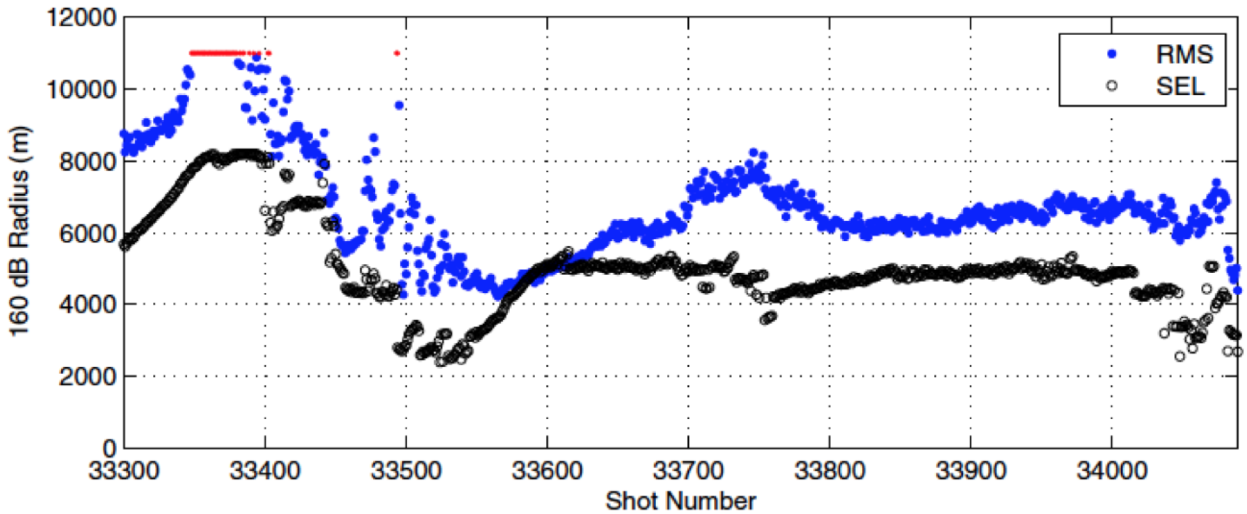

FIGURE 1. Measured radius distances to the 160 dB radii for both SEL and RMS along line A/T collected in 2012 at Cascadia with R/V *Langseth* 6600 in^3 airgun array towed at a depth of 9 m (Fig. 12 from Crone et al. 2014). This line extends across the shelf from ~50m water depth (Shot 33,300), 100m water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

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

Summary

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

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

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

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

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

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

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

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

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

For the proposed surveys, NMFS recommended the use of habitat-based stratified marine mammal densities developed by the U.S. Navy for assessing potential impacts of training activities in the Temporary Marine Activities Area (TMAA) of the GOA (DoN 2021) and densities for Behm Canal in Southeast Alaska (DoN 2019). A combination of these densities were used for the majority of species (see below); based on recommendations by NMFS, the GOA densities were used for offshore areas, and the Behm Canal densities were used for coastal waters, when available. In the Draft EA, densities from the GOA were based on DoN (2014); thus take estimates are different for the Final EA. In DoN (2021), densities are provided for four strata that were designed to encompass the four distinct habitats within the TMAA and greater GOA. The four strata include (1) Inshore: all waters <1000 m deep; (2) Slope: from 1000 m water depth to the Aleutian trench/subduction zone; (3) Offshore: waters offshore of the Aleutian trench/subduction zone; and (4) Seamount: waters within defined seamount areas.

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

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

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

All take calculations are shown in Table B-2.

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

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

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

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

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

N.A. means not available or not applicable.

[1] No takes expected for Southern Resident DPS.

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APPENDIX C: SEA OTTER DENSITIES AND TAKE CALCULATIONS

APPENDIX C: SEA OTTER DENSITIES AND TAKE CALCULATIONS

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

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

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

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

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

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

Appendix D: Ensonified Areas for Take Calculations for Cetaceans, Pinnipeds, and Sea Turtles

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

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

APPENDIX E: USFWS ESA LOC

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United States Department of the Interior

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

In Reply Refer to:
FWS/IR11/AFWCO

April 8, 2021

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

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

Dear Ms. Smith:

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

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

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

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

INTERIOR REGION 11 · ALASKA

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

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

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

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

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

Sincerely,

DOUGLASS COOPER

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

Douglass M. Cooper
Branch Chief, Ecological Service

APPENDIX F: USWF OTTER FED REG

APPENDIX F: USWF OTTER FED REG

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

DEPARTMENT OF THE INTERIOR

Fish and Wildlife Service

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

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

AGENCY: Fish and Wildlife Service, Interior.

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

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

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

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

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

- *U.S. mail:* Public Comments Processing, Attn: Docket No. FWS–R7–ES–2020–0132, U.S. Fish and Wildlife Service, MS: PRB/3W, 5275 Leesburg Pike, Falls Church, Virginia 22041–3803.
- *Electronic submission:* Federal eRulemaking Portal at: *http://www.regulations.gov*. Follow the instructions for submitting comments to Docket No. FWS–R7–ES–2020–0132. We will post all comments at *http://www.regulations.gov*. You may request that we withhold personal identifying information from public review; however, we cannot guarantee that we will be able to do so. See Request for Public Comments for more information.

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

SUPPLEMENTARY INFORMATION:

Background

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

The term "take," as defined by the MMPA, means to harass, hunt, capture, or kill, or to attempt to harass, hunt, capture, or kill any marine mammal (16 U.S.C. 1362(13)). Harassment, as defined by the MMPA, means any act of pursuit, torment, or annoyance that (i) has the potential to injure a marine mammal or marine mammal stock in the wild (the MMPA defines this as "Level A harassment"), or (ii) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering (the MMPA defines this as "Level B harassment").

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

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

Summary of Request

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

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

Description of Specified Activities and Geographic Region

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

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

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

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

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

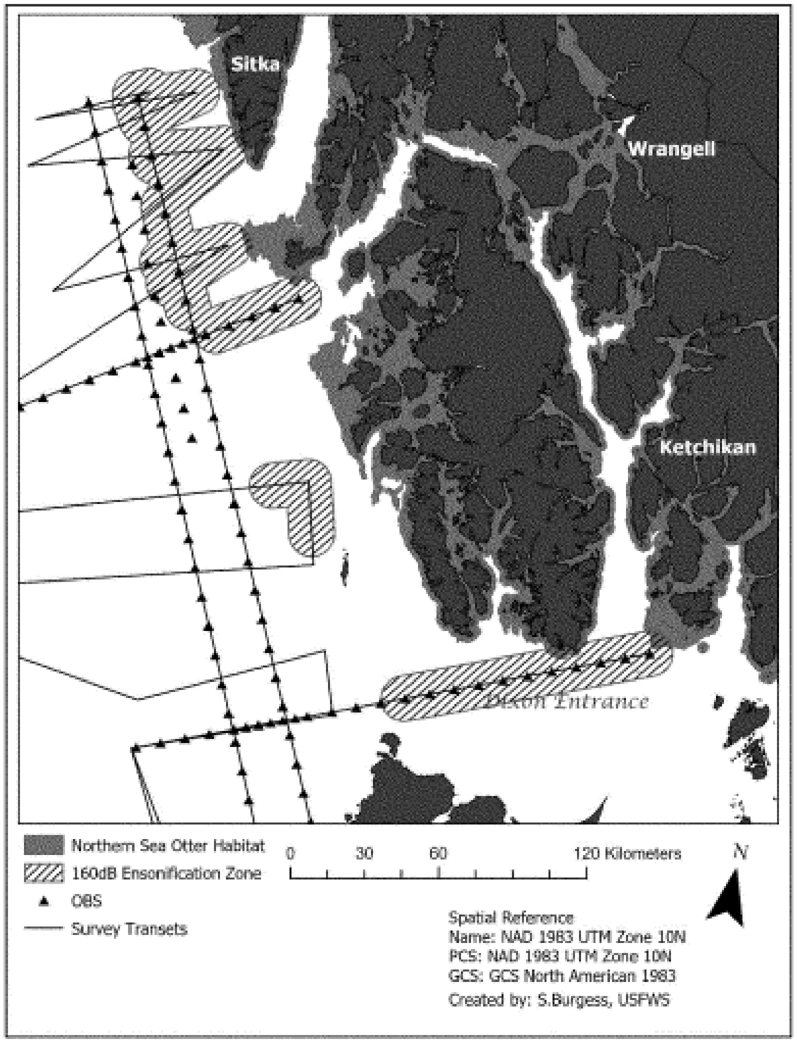

Figure 1. Specified geographic area for the National Science Foundation and Lamont-Doherty Earth Observatory seismic survey planned for summer 2021.

Description of Marine Mammals in the Specified Activity Area

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

Sea otters may be distributed anywhere within the specified project area other than upland areas; however, they generally occur in shallow water near the shoreline. They are most commonly observed within the 40-m (131-ft) depth contour (USFWS 2014), although they can be found in areas with deeper water. Ocean depth is generally correlated with distance to shore, and sea otters typically remain within 1 to 2 km (0.62 to 1.24 mi) of shore (Riedman and Estes 1990). They tend to be found closer to shore during storms, but they venture farther out during good weather and calm seas (Lensink 1962; Kenyon 1969). In the 14 aerial surveys conducted from 1995 to 2012 in Southeast Alaska, 95 percent of otters were found in areas shallower than 40 m (131 ft) (Tinker *et al.* 2019). Areas important to mating for the Southeast Alaska stock include marine coastal regions containing adequate food resources within the 40-m (131-ft) depth contour.

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

Otter densities within the Southeast Alaska stock have been calculated for 24 subdivisions (Tinker *et al.* 2019). The density of otters in the affected subdivisions ranged from 0.175 to 1.333 otters per km^2. Distribution of the population during the proposed project is likely to be similar to that detected during sea otter surveys, as work will occur during the same time of the year that these surveys were conducted.

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

Potential Effects of the Specified Activities

Exposure of Sea Otters to Noise

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

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

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

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

Sea Otter Hearing

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

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

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

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

Exposure Thresholds

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

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

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

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

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

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

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

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

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

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

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

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

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

Evidence From Sea Otter Studies

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

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

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

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

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

Consequences of Disturbance

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

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

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

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

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

Effects on Habitat and Prey

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

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

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

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

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

Potential Impacts on Subsistence Uses

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

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

Mitigation and Monitoring

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

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

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

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

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

Estimated Incidental Take

Characterizing Take by Level B Harassment

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

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

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

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

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

Calculating Take

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

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

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

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

The Level A ensonification zone did not overlap with either high- or low-density habitat areas. To determine the amount (km²) of Level B ensonified habitat in each subregion, the high- and low-density habitat shapefiles were clipped using the Level B ensonification shapefiles in ArcGIS Pro. The area impacted in each subregion was multiplied by the estimated otter density in that region to determine the number of otters that will experience Level B sound levels (Table 2). The total number of takes was predicted by estimating the projected days of activity in each subregion using survey start points supplied by the applicant. In several areas, the length and direction of the proposed survey transects make it highly unlikely that impacts will last only one day. In these instances, we estimated two days of disturbance, and thus two takes for each otter.

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

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

Subreg.	Habitat type	Density (otters/km²)	Area impacted (km²)	Estimated take/day	Projected days of take	Estimated survey total takes
N06	High (<40 m)	0.778	4.66	4	1	4
S05	High (<40 m)	1.333	8.74	12	2	24
S12	High (<40 m)	0.1748	2.56	1	2	2
N06	Low (40–100 m)	0.034	15.69	1	1	1
S01	Low (40–100 m)	0.064	42.31	4	2	8
S05	Low (40–100 m)	0.123	31.32	4	2	8
S12	Low (40–100 m)	0.0092	647.62	1	2	2
Total				27		49
Current Stock Total.		25,584				
Percentage of Stock.				0.001		

Critical Assumptions

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

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

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

Finally, we estimated the repeated take of a portion of the otters affected by the proposed action due to the presence of the R/V *Langseth* for more than one day. We assume, due to the proposed survey transects, start points, and speed of the R/V *Langseth*, that otters within subregions S01, S05, and S12 will be ensonified for two days each. The applicant has listed a number of potential yet unanticipated reasons the R/V *Langseth* may remain in one area for an extended period of time, including poor data quality, inclement weather, or mechanical issues with the research vessel and/or equipment. However, except for the case of a reshoot due to poor data quality, the vessel's airgun array (*i.e.*, the source of take) will not be operational during extended delays of operations.

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

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

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

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

Findings

Small Numbers

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

Negligible Impact

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

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

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

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

Impact on Subsistence

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

Required Determinations

National Environmental Policy Act (NEPA)

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

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

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

Endangered Species Act (ESA)

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

Government-to-Government Coordination

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

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

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

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

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

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

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

Proposed Authorization

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

A. General Conditions for Issuance of the Proposed IHA

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

2. If take exceeds the level or type identified in the proposed authorization (*e.g.*, greater than 49 incidents of incidental take of 27 otters by Level B harassment), the IHA will be invalidated and the Service will reevaluate its findings. If project activities cause unauthorized take, such as any injury due to seismic noise, acute distress, or any indication of the separation of mother from pup, NSF/L–DEO must take the following actions: (i) Cease its activities immediately (or reduce activities to the minimum level necessary to maintain safety); (ii) report the details of the incident to the Service's MMM within 48 hours; and (iii) suspend further activities until the Service has reviewed the circumstances, determined whether additional mitigation measures are necessary to avoid further unauthorized taking, and notified NSF/L–DEO that it may resume project activities.

3. All operations managers and vessel operators must receive a copy of the IHA and maintain access to it for reference at all times during project work. These personnel must understand, be fully aware of, and be capable of implementing the conditions of the IHA at all times during project work.

4. The IHA will apply to activities associated with the proposed project as described in this document and in NSF/L–DEO's amended application (LGL 2020). Changes to the proposed project without prior authorization may invalidate the IHA.

5. NSF/L–DEO's IHA application will be approved and fully incorporated into the IHA, unless exceptions are specifically noted herein or in the final IHA. The application includes:

- NSF/L–DEO's original request for an IHA, dated December 19, 2019;
- NSF/L–DEO's response to requests for additional information from the Service, dated January 22, February 19, and February 26, 2020; and
- A revised application, dated October 29, 2020.

6. Operators will allow Service personnel or the Service's designated representative to visit project work sites to monitor impacts to sea otters and subsistence uses of sea otters at any time throughout project activities so long as it is safe to do so. "Operators" are all personnel operating under the NSF/L–DEO's authority, including all contractors and subcontractors.

B. Avoidance and Minimization

7. Seismic surveys must be conducted using equipment that generates the lowest practicable levels of underwater sound within the range of frequencies audible to sea otters.

8. Vessels will not approach within 100 m (328 ft) of individual sea otters or 500 m (0.3 mi) of rafts of otters. Operators will reduce vessel speed if a sea otter approaches or surfaces within 100 m (328 ft) of a vessel.

9. Vessels may not be operated in such a way as to separate members of a group of sea otters from other members of the group.

10. All vessels must avoid areas of active or anticipated subsistence hunting for sea otters as determined through community consultations.

C. Mitigation During Seismic Activities

11. Designated trained and qualified PSOs must be employed to monitor for the presence of sea otters, initiate mitigation measures, and monitor, record, and report the effects of the activities on sea otters. NSF/L–DEO is responsible for providing training to PSOs to carry out mitigation and monitoring.

12. NSF/L–DEO must establish mitigation zones for their 2D seismic

surveys, which generate underwater sound levels at or more than or 160 dB between 125 Hz and 38 kHz. Mitigation zones must include all in-water areas where work-related sound received by sea otters will match the levels and frequencies above. Mitigation zones will be designated as follows:

- Exclusion Zones (EZ) will be established with the following minimum radii: 500 m (0.3 mi) from the source for the full seismic array and 100 m (328 ft) for the single bolt airgun (655 cm^3 or 40 in^3).
- A Safety Zone (SZ) is an area larger than the EZ and will include all areas within which sea otters may be exposed to noise levels that will likely result in Level B take.
- Both the EZ and SZ will be centered on the sound source (the seismic array).
- The radius of the SZs are shown in Table 3 (as calculated based on modeling techniques described herein and in Appendix A of NSF/L–DEO's application).

TABLE 3—ESTIMATED RADIAL DISTANCES FROM THE SEISMIC SOUND SOURCE TO THE 160-dB ISOPLETH

[The area within the isopleth is designated as the Safety Zone (SZ)]

Source and volume	Water depth (m)	Predicted distances (in m) to the 160 dB received sound level
Single Bolt airgun, 40 in^3	>1,000 m	[1] 431
	100–1,000 m	[2] 647
	<100 m	[3] 1,041
	<1000 m	[1] 6,733
4 strings, 36 airguns, 6600 in^3	100–1,000m	[4] 9,468
	<100m	[4] 12,650

[1] Distance is based on L–DEO model results.
[2] Distance is based on L–DEO model results with a 1.5 × correction factor between deep and intermediate water depths.
[3] Distance is based on empirically derived measurements in the GOM with scaling applied to account for differences in tow depth.
[4] Based on empirical data from Crone et al. (2014); see Appendix A of the NSF/L–2012;DEO IHA application for details.

13. PSOs must conduct visual monitoring of the entire EZ and the visible SZ continuously during all seismic work occurring in daylight hours.

14. Prior to seismic work, a "ramp-up" procedure must be used to increase the levels of underwater sound at a gradual rate.

- A ramp-up will be used at the initial start of airgun operations and prior to restarting after any period greater than 30 minutes (min) without airgun operations, including a power-down or shutdown event.
- Visual monitoring must begin at least 30 min prior to and continue throughout ramp-up efforts.
- During geophysical work, the number and total volume of airguns will be increased incrementally until the full volume is achieved.
- The rate of ramp-up will be no more than 6 dB per 5-min period. Ramp-up will begin with the smallest gun in the array that is being used for all airgun array configurations. During the ramp-up, the applicable mitigation zones (based on type of airgun and sound levels produced) must be maintained.
- It will not be permissible to ramp-up the full array from a complete shutdown in thick fog or at other times when the outer part of the EZ is not visible.
- Ramp-up of the airguns will not be initiated if a sea otter is sighted within the EZ at any time.
- If sea otters are observed during a ramp-up effort or prior to startup, a PSO must record the observation and monitor the animal's position until it moves out of visual range. Seismic work may commence if, after a full and gradual effort to ramp up the underwater sound level, the sea otter is outside of the EZ and does not show signs of visible distress (for example, vocalizing, repeatedly spy-hopping, or fleeing).

15. The following actions must be taken in response to sea otters in mitigation zones:

- Seismic work will be shut down completely if a sea otter is observed within the 500-m (0.3-mi) EZ for the full array or the 100-m (328-ft) EZ for the 40-cui array.
- When sea otters are observed in visible distress (for example, vocalizing, repeatedly spy-hopping, or fleeing), seismic work must be immediately shut down or powered down to reduce noise exposure.
- The shutdown procedure will be accomplished within several seconds of the determination that a sea otter is in the applicable EZ or as soon as practicable considering worker safety and equipment integrity.
- Following a shutdown, seismic work will not resume until the sea otter has cleared the EZ. The animal will be considered to have cleared the EZ if it is visually observed to have left the EZ or has not been seen within the EZ for 30 minutes or longer.
- Any shutdown due to sea otters sighted within the EZ must be followed by a 30-minute all-clear period and then a standard full ramp-up.
- Any shutdown for other reasons resulting in the cessation of seismic work for a period greater than 30 minutes must also be followed by full ramp-up procedures.

16. Operators may reduce power to seismic equipment as an alternative to a shutdown to prevent a sea otter from entering the EZ. A power-down procedure involves reducing the volume of underwater sound generated. Vessel speed or course may be altered to achieve the same task.

- Whenever a sea otter is detected outside the EZ and, based on its position and motion relative to the seismic work, appears likely to enter the EZ but has not yet done so, the operator may power down to reduce high-level noise exposure.
- When a sea otter is detected in the SZ, an operator may choose to power down when practicable to reduce Level B take, but is not required to do so.
- During a power-down, the number of airguns in use will be reduced to a single mitigation airgun (airgun of small volume such as the 655-cm^3 (40-in^3) gun), such that the EZ is reduced, making the sea otters unlikely to enter the EZ.
- After a power-down, noise-generating work will not resume until the sea otter has cleared the EZ for the full airgun array. The animal will be

considered to have cleared the EZ if it is visually observed to have left the EZ and has not been seen within the zone for 30 minutes.

17. Visual monitoring must continue for 30 minutes after the use of the acoustic source ceases or the sun sets, whichever is later.

D. Monitoring

18. Operators shall work with PSOs to apply mitigation measures and shall recognize the authority of PSOs up to and including stopping work, except where doing so poses a significant safety risk to vessels and personnel.

19. Duties of PSOs include watching for and identifying sea otters, recording observation details, documenting presence in any applicable monitoring zone, identifying and documenting potential harassment, and working with vessel operators to implement all appropriate mitigation measures.

20. A sufficient number of PSOs will be onboard to meet the following criteria: 100 percent monitoring coverage during all daytime periods of seismic activity; a maximum of four consecutive hours on watch per PSO; a maximum of approximately 12 hours on watch per day per PSO; and at least one observer each on the source vessel and support vessel.

21. All PSOs will complete a training course designed to familiarize individuals with monitoring and data collection procedures. A field crew leader with prior experience as a marine mammal observer will supervise the PSO team. New or inexperienced PSOs will be paired with experienced PSOs so that the quality of marine mammal observations and data recording is kept consistent. Resumes for candidate PSOs will be made available for the Service to review.

22. Observers will be provided with reticule binoculars (10×42), big-eye binoculars or spotting scopes (30×), inclinometers, and range finders. Field guides, instructional handbooks, maps and a contact list will also be made available.

E. Measures To Reduce Impacts to Subsistence Users

23. Prior to conducting the work, NSF/L–DEO will take the following steps to reduce potential effects on subsistence harvest of sea otters:

• Avoid work in areas of known sea otter subsistence harvest;

• Discuss the planned activities with subsistence stakeholders including Southeast Alaska villages and traditional councils;

• Identify and work to resolve concerns of stakeholders regarding the project's effects on subsistence hunting of sea otters; and

• If any concerns remain, develop a POC in consultation with the Service and subsistence stakeholders to address these concerns.

F. Reporting Requirements

24. NSF/L–DEO must notify the Service at least 48 hours prior to commencement of activities.

25. Reports will be submitted to the Service's MMM weekly during project activities. The reports will summarize project work and monitoring efforts.

26. A final report will be submitted to the Service's MMM within 90 days after completion of work or expiration of the IHA. It will summarize all monitoring efforts and observations, describe all project activities, and discuss any additional work yet to be done. Factors influencing visibility and detectability of marine mammals (*e.g.*, sea state, number of observers, fog, and glare) will be discussed. The report will describe changes in sea otter behavior resulting from project activities and any specific behaviors of interest. Sea otter observation records will be provided in the form of electronic database or spreadsheet files. The report will assess any effects NSF/–DEO's operations may have had on the availability of sea otters for subsistence harvest and if applicable, evaluate the effectiveness of the POC for preventing impacts to subsistence users of sea otters.

27. Injured, dead, or distressed sea otters that are not associated with project activities (*e.g.*, animals found outside the project area, previously wounded animals, or carcasses with moderate to advanced decomposition or scavenger damage) must be reported to the Service within 24 hours of discovery. Photographs, video, location information, or any other available documentation shall be provided to the Service.

28. All reports shall be submitted by email to *fw7_mmm_reports@fws.gov*.

29. NSF/L–DEO must notify the Service upon project completion or end of the work season.

Request for Public Comments

If you wish to comment on this proposed authorization, the applicability of NSF's draft EA to the proposed action, or the proposed adoption of NSF's EA, you may submit your comments by any of the methods described in **ADDRESSES**. Please identify if you are commenting on the proposed authorization, draft EA, or both, make your comments as specific as possible, confine them to issues pertinent to the proposed authorization or draft EA, and explain the reason for any changes you recommend. Where possible, your comments should reference the specific section or paragraph that you are addressing. The Service will consider all comments that are received before the close of the comment period (see **DATES**).

Comments, including names and street addresses of respondents, will become part of the administrative record for this proposal. Before including your address, telephone number, email address, or other personal identifying information in your comment, be advised that your entire comment, including your personal identifying information, may be made publicly available at any time. While you can ask us in your comments to withhold from public review your personal identifying information, we cannot guarantee that we will be able to do so.

Gregory Siekaniec,

Regional Director, Alaska Region.

[FR Doc. 2021–12134 Filed 6–8–21; 8:45 am]

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DEPARTMENT OF THE INTERIOR

Geological Survey

[GX21EE000101100]

Public Meeting of the National Geospatial Advisory Committee

AGENCY: U.S. Geological Survey, Interior.

ACTION: Notice of public meeting.

SUMMARY: In accordance with the Federal Advisory Committee Act of 1972, the U.S. Geological Survey (USGS) is publishing this notice to announce that a Federal Advisory Committee meeting of the National Geospatial Advisory Committee (NGAC) will take place.

DATES: The meeting will be held as a webinar on Tuesday, June 29, 2021 from 1:00 p.m. to 5:00 p.m., and on Wednesday, June 30, 2021 from 1:00 p.m. to 5:00 p.m. (Eastern Daylight Time).

ADDRESSES: The meeting will be held on-line and via teleconference. Instructions for accessing the meeting will be posted at *www.fgdc.gov/ngac*. Comments can be sent to Ms. Dionne Duncan-Hughes, Group Federal Officer by email to *gs-faca-mail@usgs.gov*.

FOR FURTHER INFORMATION CONTACT: Mr. John Mahoney, Federal Geographic Data Committee (FGDC), USGS, 909 First Avenue, Suite 800, Seattle, WA 98104; by email at *jmahoney@usgs.gov*; or by telephone at (206) 220–4621.

APPENDIX G: EFH

APPENDIX G: EFH

From: "John V. Olson - NOAA Federal" <john.v.olson@noaa.gov>
Date: Wednesday, June 2, 2021 at 1:04 PM
To: "Smith, Holly E." <hesmith@nsf.gov>
Subject: Re: [EXTERNAL] - Re: EFH Request - NSF marine geophysical survey in the Northeast Pacific Ocean, Queen Charlotte Fault

thank you Holly. The additional information was useful as we try to coordinate responses between marine mammal and EFH issues.

I have reviewed your updated EFH assessment and have no issues with the survey as documented.

John

--
John V. Olson
Fisheries Biologist, Habitat Conservation Division/Alaska Region
NOAA Fisheries | U.S. Department of Commerce
Office: (907) 271-1508
Mobile: (907) 830-5146
Teleworking 7:30-4:00
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