Final Environmental Analysis of Marine Geophysical Surveys by R/V *Marcus G. Langseth* in the Eastern Tropical Pacific

Prepared for

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12 February 2026

LGL Report FA26006.31-03

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ABSTRACT

Researchers from the University of California, San Diego (UCSD), and Woods Hole Oceanographic Institution (WHOI) with funding from the U.S. National Science Foundation (NSF), and in collaboration with the Institut de Physique du Globe de Paris (IPGP), propose to conduct marine geophysical research in Eastern Tropical Pacific or ETP (Proposed Action). The research would include high-energy seismic surveys using an 18-airgun array, with a total discharge volume of approximately (~) 3300 in^3 conducted from the research vessel (R/V) *Marcus G. Langseth* (*Langseth*), which is owned and operated by Lamont-Doherty Earth Observatory (L-DEO) of Columbia University. The project would acquire three-dimensional (3-D) multi-channel seismic (MCS) reflection data in International Waters 2500 to 3200 m deep.

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 geophysical research 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. The acquired seismic data would be used to address the evolution of fast-spreading mid-ocean ridge magmatic systems at the East Pacific Rise (EPR) in the ETP.

This Final Environmental Analysis (EA) addresses NSF's requirements under Executive Order 12114, "Environmental Effects Abroad of Major Federal Actions", for the proposed federal action in International Waters. L-DEO, on behalf of itself, NSF, UCSD, and WHOI, have requested an Incidental Harassment Authorization (IHA) from the U.S. National Marine Fisheries Service (NMFS) to authorize the incidental (i.e., not intentional) harassment of small numbers of marine mammals should this occur during the seismic surveys. The analysis in this document supports the IHA application process and provides additional information on marine species that are not addressed by the IHA application, including sea turtles, seabirds, fish, and marine invertebrates that are listed under the U.S. Endangered Species Act (ESA), as well as candidate species. As analysis on endangered and threatened species was included, the Draft and Final EA were used to support ESA Section 7 consultations with NMFS. Alternatives addressed in the 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 could occur in the proposed study area in the ETP. Under the U.S. ESA, several of these species are listed as ***endangered***, including the sei, fin, blue, and sperm whale, and the Central America Distinct Population Segment (DPS) of the humpback whale. The ***threatened*** Mexico DPS of the humpback whale could potentially also occur in the proposed study area. ESA-listed sea turtle species that could occur in the study area include the ***endangered*** leatherback turtle, hawksbill turtle, North Pacific Ocean DPS of loggerhead turtle, and Mexico's Pacific coast breeding population of olive ridley turtle, and the ***threatened*** East Pacific DPS of green turtle. ESA-listed fish that could occur in the area include the ***endangered*** Eastern Pacific DPS of scalloped hammerhead shark and the ***threatened*** oceanic whitetip shark and giant manta ray. ESA-listed seabirds that could be encountered in the area include the ***threatened*** Galápagos petrel.

Potential impacts of the proposed seismic surveys on the environment would be primarily a result of the operation of the airgun array. Other acoustic sources, including a multibeam echosounder (MBES) and sub-bottom profiler (SBP) 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.

Proposed protection measures designed to mitigate the potential environmental impacts to marine mammals, and ESA-listed sea turtles and seabirds include the following: ramp ups; two dedicated observers maintaining a visual watch during all daytime airgun operations; two observers before and during ramp ups during the day; passive acoustic monitoring (PAM) via towed hydrophones during both day and night to complement visual monitoring during the high-energy surveys; and shut downs when marine mammals are detected in or about to enter designated exclusion zones (EZ). The acoustic source would also be shut down in the event an ESA-listed sea turtle or seabird (diving/foraging) would be observed 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.

With the planned monitoring and mitigation measures, unavoidable impacts to each species of marine mammal 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, seabirds, fish, the populations to which they belong, or their habitats. NSF followed the National Oceanic and Atmospheric Administration's (NOAA) *Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing* (NMFS 2024) to estimate Level A takes for marine mammal species, although Level A takes are very unlikely. No significant impacts would be expected on the populations of those species for which a Level A take is permitted.

LIST OF ACRONYMS

~	approximately
3-D	three-dimensional
4-D	four-dimensional
ADCP	Acoustic Doppler Current Profiler
AEP	Auditory Evoked Potential
AIDCP	Agreement on the International Dolphin Conservation Program
AMVER	Automated Mutual-Assistance Vessel Rescue
CBD	Convention on Biological Diversity
CITES	Convention on International Trade in Endangered Species
CMS	Convention on Migratory Species
CRD	Costa Rica Dome
dB	decibel
DFO	Canadian Department of Fisheries and Oceans
DoN	Department of the Navy
DPS	Distinct Population Segment
EA	Environmental Analysis
EBSA	Ecologically or Biologically Significant Marine Areas
EEZ	Exclusive Economic Zone
EIS	Environmental Impact Statement
EO	Executive Order
EPR	East Pacific Rise
ESA	(U.S.) Endangered Species Act
ETP	Eastern Tropical Pacific
EZ	Exclusion Zone
FAO	Food Agricultural Organization
FM	Frequency Modulated
FONSI	Finding of No Significant Impact
GIS	Geographic Information System
h	hour
HAPC	Habitat Area of Particular Concern
hp	horsepower
Hz	Hertz
IATTC	Inter-American Tropical Tuna Commission
IBA	Important Bird Area
IHA	Incidental Harassment Authorization (under MMPA)
in	inch
IPGP	Institut de Physique du Globe de Paris
ITCZ	Intertropical Convergence Zone
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)
m	meter
MBES	Multibeam Echosounder
MCS	Multi-Channel Seismic
MFA	Mid-frequency Active (sonar)
min	minute
MMC	Marine Mammal Commission
MMPA	(U.S.) Marine Mammal Protection Act
MPA	Marine Protected Area

ms	millisecond
M/SI	mortality and serious injuries
NMFS	(U.S.) National Marine Fisheries Service
nmi	nautical mile
NOAA	National Oceanic and Atmospheric Administration
NRC	(U.S.) National Research Council
NSF	National Science Foundation
OEIS	Overseas Environmental Impact Statement
p or pk	peak
PEIS	Programmatic Environmental Impact Statement
PI	Principal Investigator
PSO	Protected Species Observer
PTS	Permanent Threshold Shift
rms	root-mean-square
ROD	Record of Decision
R/V	research vessel
s	second
SBP	Sub-bottom Profiler
SEA	Supplemental Environment Assessment
SEL	Sound Exposure Level (a measure of acoustic energy)
SOSUS	(U.S. Navy) Sound Surveillance System
SPL	Sound Pressure Level
SWFSC	Southwest Fisheries Science Center
SWOT	State of the World's Sea Turtles
t	tonnes
TTS	Temporary Threshold Shift
UCSD	University of California, San Diego
U.K.	United Kingdom
UN	United Nations
UNEP	United Nations Environment Programme
UNGA	United Nations General Assembly
U.S.	United States of America
USCG	United States Coast Guard
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
µPa	microPascal
vs.	versus
WCMC	World Conservation Monitoring Centre
WHOI	Woods Hole Oceanographic Institution

I PURPOSE AND NEED

Researchers from the University of California, San Diego (UCSD), and Woods Hole Oceanographic Institution (WHOI) with funding from the U.S. National Science Foundation (NSF), and in collaboration with the Institut de Physique du Globe de Paris (IPGP), propose to conduct marine geophysical research in Eastern Tropical Pacific or ETP (Proposed Action). The research would include high-energy seismic surveys using an 18-airgun array conducted from the research vessel (R/V) *Marcus G. Langseth* (*Langseth*), which is owned and operated by Lamont-Doherty Earth Observatory (L-DEO) of Columbia University. The project would acquire three-dimensional (3-D) multi-channel seismic (MCS) reflection data in the ETP.

This Final Environmental Analysis (EA) was prepared pursuant to 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. It also builds upon the "*Environmental Assessment of two Marine Geophysical Surveys by R/V Marcus G. Langseth in the Eastern Tropical Pacific*" (LGL Limited 2007) which resulted in a Finding of No Significant Impact (FONSI) for similar seismic surveys conducted in the area during summer 2008. 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.

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 marine invertebrates. The Draft EA was used in support of other regulatory processes, including an application for an Incidental Harassment Authorization (IHA) and Section 7 consultation under the *Endangered Species Act* (ESA) with the National Marine Fisheries Service (NMFS). 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 NOAA *Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing* (NMFS 2024), Level A takes will be 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.

1.1 Mission of NSF

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 support marine geophysical research, including seismic surveys that enable scientists to collect data essential to understanding the complex Earth

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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.

processes beneath the ocean floor. The purpose of the proposed marine geophysical research is to address the evolution of fast-spreading mid-ocean ridge magmatic systems at the East Pacific Rise (EPR) in the ETP. The Proposed Action would meet the agency's critical need to foster an understanding of Earth processes.

1.3 Background of NSF-supported 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*;
- *Marine Mammal Protection Act* (MMPA) of 1972 (16 USC 1631 *et seq.*); and
- *Endangered Species Act* (ESA) of 1973 (16 USC ch. 35 §1531 *et seq.*).

II ALTERNATIVES INCLUDING PROPOSED ACTION

In this Final EA, two alternatives are evaluated: (1) Proposed Action: conducting the proposed marine geophysical research, including seismic surveys, and associated issuance of an 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 marine geophysical research, is described in the following subsections.

2.1.1 Project Objectives and Context

The Principal Investigators (PI) from UCSD and WHOI, in collaboration with the IPGP, propose to conduct marine geophysical research in the ETP using the seismic surveying capability of R/V *Langseth* (Fig. 1). The main goal of the high-energy seismic program proposed by PIs Drs. R. Parnell-Turner (UCSD) and J.P. Canales (WHOI), with international collaboration from Dr. M. Marjanović (IPGP and UCSD), is to collect seismic reflection data of volcanic cycles and to examine the active magmatic system at the EPR.

In order to study volcanic cycles on decadal timescales, the proposed project would consist of 3-D MCS surveys at the 9°50'N segment of the EPR, thereby repeating the same experiment conducted in 2008 on board R/V *Langseth*. The two datasets would be processed together using the latest elastic full waveform inversion techniques, in order to obtain high-resolution imagery that would be used to investigate how the magmatic and hydrothermal plumbing systems beneath this submarine volcanic ridge have changed since 2008, thereby allowing for a unique four-dimensional (4-D) time-lapse study. The time-lapse imagery would allow the PIs to test long-debated hypotheses about the eruption cycle for the first time, by distinguishing characteristic changes in the shape and melt content of the magmatic system.

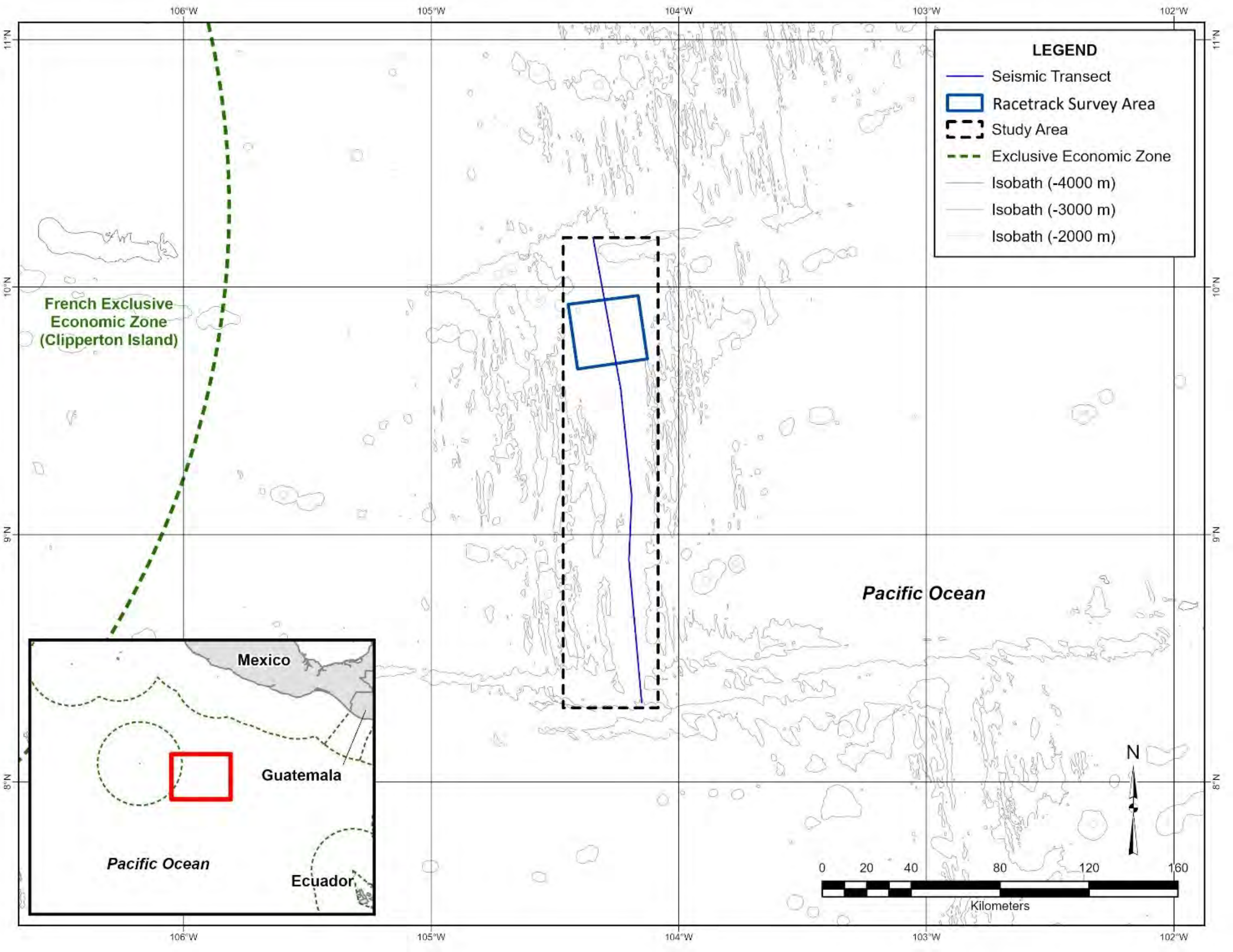

FIGURE 1. Location of the proposed seismic surveys in the ETP.

2.1.2 Proposed Activities

2.1.2.1 Location of the Survey Activities

The proposed marine seismic surveys would occur in International Waters within the study area depicted in Figure 1, bounded by the following coordinates: 10.2°N, 104.5°W; 10.2°N, 104.1°W; 8.3°N, 104.1°W; and 8.3°N, 104.5°W. The water depths in the study area range from 2500 to 3200 m. As described further in this document, some deviation in the tracklines or 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, the seismic surveys could occur anywhere within the study area and general coordinates noted above.

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 conducted by L-DEO and would use conventional seismic methodology. The surveys would involve one source vessel, R/V *Langseth*, which would tow two 18-airgun arrays with a discharge volume of ~3300 in^3 each, at a depth of 7.5 m. The two linear airgun arrays would fire in an alternate “flip-flop” mode every 37.5 m (~16 s). The main receiving system would consist of four 5850-m long solid-state hydrophone streamers, separated by 150 m (solid flexible polymer – not gel nor oil filled). As the airgun arrays are towed along the survey lines, the hydrophone streamers will receive the returning acoustic signals and transfer the data to the on-board processing system.

The majority of the surveys would be acquired in a racetrack formation, a pattern whereby the next acquisition line is several kilometers away from and traversed in the opposite direction of the trackline just completed (see LGL Limited 2007). The acquisition pattern would consist of two racetracks – one with 49 cross-axis transect lines and one with 40 cross-axis transect lines. There would be a total of 89 lines, spaced ~300 m apart. Each line would be 26 km long, for a total of 2314 km line km; however, with infill or repeat acquisition along some transects, the total for the racetrack survey is expected to be ~2900 km. Data would not be acquired during turns; thus, turns are not included in the total. In addition, one single along-axis transect, 210-km long, would be acquired (Fig. 1). Thus, total survey effort would consist of ~3110 km of seismic acquisition. All effort would occur in water more than 2000 m deep. There could be additional seismic operations associated with 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 arrays, other acoustic sources, including a multibeam echosounder (MBES), sub-bottom profiler (SBP), and an Acoustic Doppler Current Profiler (ADCP), would be operated from R/V *Langseth* continuously during the seismic surveys. All planned marine-based 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 high-energy surveys with the alternating 18-airgun arrays would be expected to take place during February−March 2026 for a period of ~35 days; this includes up to 20 days of seismic operations, 4 days of equipment deployment/recovery, 6 days of contingency, and 5 days of transit. R/V *Langseth* would likely leave out of and return to port in Manzanillo, Mexico (nearly 1000 km north of the proposed study area). Equipment deployment and recovery times would vary and occur anytime during the planned survey, except during transits. L-DEO strives 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 long timeline associated with the ESA Section 7 consultation and IHA processes, not all research project 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.

2.1.2.4 Vessel Specifications

R/V *Langseth* is described in § 2.2.2.1 of the PEIS; the gross tonnage of R/V *Langseth* is 3834 t. The vessel speed during seismic operations with the 18-airgun arrays would be ~4.5 kt (~8.3 km/h) during MCS reflection data acquisition; during turns between seismic lines when airguns are not firing, the vessel speed would drop to 3.8 kt (7.0 km/h). When R/V *Langseth* tows the airgun arrays and hydrophone streamers, the turning rate of the vessel would be limited to five degrees per minute. Thus, the maneuverability of the vessel would be limited during operations with the streamer. Protected species observers (PSOs) would have a 360-degree view from the vessel's observation tower.

2.1.2.5 Airgun Description

During the seismic surveys, R/V *Langseth* would tow four strings (each ~16 m long) with 36 airguns (plus 4 spares); however, only 18 airguns in two strings would be firing at one time. During the surveys, the two 18-airgun arrays would fire in an alternate "flip-flop" mode every 37.5 m (16 s). The total discharge volume would be 3300 in^3, and the array would be towed at a depth of 7.5 m. The two strings in each 18-airgun array would be separated by 8 m, and the two "flip-flop" arrays would be spaced 75 m apart. The airgun strings would be towed ~265 m behind R/V *Langseth*.

The airgun arrays consists of a mixture of Bolt 1500LL and Bolt 1900LLX airguns. The airgun array and its source level and frequency components are described in § 2.2.3.1 of the PEIS and summarized below, and the airgun configuration is illustrated in Figure 2-11 of the PEIS. During firing, a brief pulse of sound with a duration of ~0.1 s would be emitted. The airguns would be silent during the intervening periods. During operations, airguns would be operated 24/7 for multiple days to meet science objectives unless maintenance or mitigation measures warranted.

18-Airgun Array Specifications

Energy Source	Eighteen Bolt airguns of 40−360 in^3,
Source output (downward)	0-pk is 42 bar-m (252 dB re 1 µPa · m); pk-pk is 87 bar · m (259 dB)
Air discharge volume	~3300 in^3
Dominant frequency components	0−188 Hz
Firing Pressure	~2000 psi

2.1.2.6 Additional Acoustical Data Acquisition Systems

Along with the airgun operations, three additional acoustical data acquisition systems (an MBES, SBP, and ADCP) would be operated from R/V *Langseth* continuously during the proposed surveys, including during transits. 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 as well below.

The MBES is a hull-mounted system operating at 10.5−13 kHz (usually 12 kHz). The transmitting beam width would be one or two degrees fore-aft and 150 degrees (maximum) athwartship or perpendicular to the ship's line of travel. The maximum sound source level would be 242 dB re 1 µPa-m. Each ping consists of eight (in water >1000 m) or four (in water <1000 m) successive fan-shaped transmissions, each ensonifying a sector that extends one degree fore-aft. Continuous-wave signals increase from 2−15 milliseconds long in water depths up to 2600 m, and frequency modulated chirp signals up to 100 milliseconds long are used in water >2600 m. The successive transmissions span an overall cross-track angular extent of ~150 degrees, with two millisecond gaps between the pings for successive sectors.

The Knudsen 3260 SBP would be operated to provide information about the near sea floor sedimentary features and the bottom topography that would be mapped simultaneously by the MBES. The beam would be transmitted as a 27-degree cone, which would be directed downward by a 3.5-kHz transducer in the hull of R/V *Langseth*. The nominal power output would be 10 kilowatts, but the actual maximum radiated power would be 3 kilowatts or 222 dB_{rms} re 1 µPa at 1 m. The ping duration would be up to 64 milliseconds, and the ping interval would be one second. A common mode of operation is to broadcast five pulses at one-second intervals followed by a five-second pause. The SBP would be capable of reaching depths of 10,000 m.

A Teledyne RDI 75 kHz Ocean Surveyor ADCP would be used to measure water current velocities. It would have a maximum source level of 224 dB re 1µPa-1 m over a conically-shaped 30° beam and a ping rate of 0.7 Hz.

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 Sourc*e.—**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 energy source level must be the same as the airgun array that was used during the 2008 surveys in order to meet time-lapse imagery objectives.

***Survey Location and Timing*.—**The PIs, along with L-DEO and NSF, considered 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*. Winter was determined to be the most practical timing for the proposed surveys based on the occurrence of marine mammals, weather conditions, other operational requirements, and availability of researchers.

***Mitigation Zones*.—**During the planning phase, mitigation zones for the proposed marine seismic surveys using the 18-airgun array (at a tow depth of 7.5 m) were not derived from the farfield signature but based on modeling by L-DEO for both the exclusion zones (EZ) for Level A takes and exposure zones (160 dB re $1\mu\text{Pa}_{\text{rms}}$) for Level B takes. The background information and methodology for this are provided in Appendix A. L-DEO model results are used to determine the 160-dB_{rms} radius for the airgun source down to a maximum depth of 2000 m (see Appendix A), as animals are generally not anticipated to dive below 2000 m (Costa and Williams 1999).

Table 1 shows the distances at which the 160-dB re $1\mu\text{Pa}_{\text{rms}}$ sound levels are expected to be received for the 18-airgun array. 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 $1\mu\text{Pa}_{\text{rms}}$ sound level is expected to be received for the various airgun sources; this level is used by NMFS, based on DoN (2017a), to determine behavioral disturbance for sea 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}).

TABLE 1. Predicted distances to behavioral disturbance sound levels ≥160-dB re 1 µPa$_{rms}$ and ≥175-dB re 1 µPa$_{rms}$ that could be received during the proposed surveys with the 18-airgun array in the Eastern Tropical Pacific. The 160-dB criterion applies to all hearing groups of marine mammals (Level B harassment), and the 175-dB criterion applies to sea turtles.

2 strings, 18 airguns, 3300 in^3	7.5	>1000 m	3,526	763

[1] Distance is based on L-DEO model results.

Different thresholds are available for the various hearing groups, including low-frequency (LF) cetaceans (e.g., baleen whales), high-frequency (HF) cetaceans (e.g., most delphinids), very high-frequency (VHF) cetaceans (e.g., harbor porpoise and *Kogia* spp.), phocids underwater (PW), and otariids underwater (OW) (NMFS 2024), and sea turtles (DoN 2017a). Per the *Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing* (NMFS 2024), 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 LF cetaceans, and Peak SPL is used for all other marine mammal hearing groups (Table 2).

TABLE 2. Level A (PTS) threshold distances for different marine mammal hearing groups for the 18-airgun array in the Eastern Tropical Pacific. Consistent with NMFS (2024), 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. PTS threshold distances for sea turtles are also shown.

	Level A Threshold Distances (m) for Various Hearing Groups					
	Low-Frequency Cetaceans	**High-Frequency Cetaceans**	**Very High-Frequency Cetaceans**	**Phocid Pinnipeds**	**Otariid Pinnipeds**	**Sea Turtles**
PTS SEL$_{cum}$	**157.5**	0.1	0.6	7.4	0.3	**250.2**
PTS Peak	23.4	**13.4**	**164.6**	**21.6**	**13.4**	11.9

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 for marine mammals, monitor an additional 500-m buffer zone beyond the EZ for marine mammals prior to ramp up, and implement a 150-m EZ for sea turtles. A 150-m EZ was also monitored for shut downs for and diving/foraging ESA-listed seabirds. Enforcement of EZs via shut downs would be implemented as described below.

2.1.3.2 Operational Phase

Marine mammals and sea turtles are known to occur in the proposed study area. However, the number of individual animals expected to be approached closely during the proposed activities would be 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, ESA-listed sea turtles and seabirds (diving/foraging) 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; shut down and ramp up procedures; and special mitigation measures for rare species, species concentrations, and sensitive habitats). It would be unlikely that concentrations of large whales would be encountered within the 160-dB isopleth, but if they were, they would be avoided.

During daytime, the PSO(s) would scan the area around the vessel systematically with reticle binoculars (e.g., 7×50 Fujinon), Big-eye binoculars (25×150), and with the naked eye. During darkness, night vision devices (NVDs) would be available (ITT F500 Series Generation 3 binocular-image intensifier or equivalent), when required. Mitigation measures that would be adopted during the proposed surveys include (1) shut down procedures and (2) ramp up procedures. These measures are proposed by L-DEO based on past experience and for consistency with the PEIS.

***Shut down Procedures*.**—The operating airguns would be shut down if a marine mammal was seen within or approaching the EZ. Shut downs would not be required for small dolphins that are most likely to approach the vessel. The airgun array would be shut down if ESA-listed sea turtles or seabirds (diving/foraging) were observed within a 150-m designated EZ. Following a shut down, airgun activity would not resume until the marine mammal, ESA-listed sea turtle or seabird has cleared the EZ. The animal would be considered to have cleared the EZ if

- it was visually observed to have left the EZ, or
- it was not seen within the zone for 15 min in the case of small odontocetes, ESA-listed seabirds and sea turtles, or
- it was not seen within the zone for 30 min in the case of mysticetes and large odontocetes, including sperm, pygmy sperm, dwarf sperm, and beaked whales.

The airgun array would be ramped up gradually after a shut down for marine mammals but would not be required for ESA-listed sea turtles or seabirds. Ramp up procedures are described below.

***Ramp up Procedures*.**—A ramp up procedure would be followed when the airgun array begins operating after a specified period without airgun operations. It is proposed that this period would be 30 min, as long as PSOs have maintained constant visual and acoustic observations and no detections within the EZ have occurred. Ramp up would not occur if a marine mammal has not cleared the EZ as described earlier. As previously noted, for shut downs implemented for sea turtles and ESA-listed seabirds, no ramp up would be required, as long as the animal was no longer observed within the EZ.

Ramp up would begin with the smallest airgun in the array. Ramp up would begin by activating a single airgun of the smallest volume in the array and shall continue in stages by doubling the number of active elements at the commencement of each stage, with each stage of approximately the same duration. Airguns would be added in a sequence such that the source level of the array would increase in steps not exceeding 6 dB per 5-min period. During ramp up, the PSOs would monitor the EZ, and if marine mammals or ESA-listed sea turtles/seabirds (diving/foraging) are sighted, a shut down would be implemented, respectively, as though the full array were operational. Ramp up would only commence at night or during poor visibility if the EZ has been monitored acoustically with PAM for 30 min prior to the start of operations without any marine mammal detections during that period.

The proposed operational mitigation measures are standard for seismic cruises, per the PEIS. 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. One PSO would conduct PAM during day- and night-time seismic operations. Monitoring and mitigation measures are further described in the IHA application.

A monitoring report would be provided to NMFS, both the Permits and Conservation Division and the ESA Interagency Cooperation Division, per the IHA and Biological Opinion. With the proposed monitoring and mitigation provisions, potential effects on most, if not all, individual marine mammals and sea turtles would be expected to be limited to minor behavioral disturbance. Those potential effects would be expected to have negligible impacts both on individuals 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

Table 3 provides a summary of the Proposed Action and the alternatives.

2.3.1 Alternative E1: Alternative Location

The proposed study returns to an area of the EPR that was previously surveyed with 3-D MCS. The new data collected during the proposed surveys would create high-resolution imagery to investigate how the magmatic and hydrothermal plumbing systems beneath the submarine volcanic ridge has changed, which will allow for a 4-D timelapse study of how magma bodies evolve over decadal timescales and novel eruption cycle hypothesis testing. The area of the EPR at 9°50'N is an ideal location to conduct this study because it was previously surveyed by 3-D MCS in 2008, and continuous vent temperature monitoring over the past 5 years predicts new eruptions in the region, as shown in the eruption at Tica vent in April 2025. The proposed experiment would also bridge a critical gap between existing seismic datasets and offers a unique opportunity to characterize changes in the shape and melt content of the magmatic system of the EPR over time. The proposed survey location is the only place on Earth where the appropriate data has been previously collected and volcanic eruptions are predicted to occur in the next few years. Thus, an alternative location would not meet the purpose of the proposed surveys.

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 ETP	Under this action, research activities are proposed to study Earth processes and would involve 3-D marine seismic surveys. The cruise would be 35 days long, with active seismic operations expected to take up to 20 days. The affected environment, environmental consequences, and reasonably foreseeable effects 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, with the aim to examine a timelapse of crustal mantle body changes within or between volcanic cycles, would not be collected. In addition, 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	The proposed timelapse experiment to investigate the eruption cycle requires pre-existing 3-D seismic baseline data which is only available from the 2008 survey collected at 9°50'N at the EPR and during the 2019 seismic survey at the Axial Seamount on the Juan de Fuca Ridge. The goal of the proposed survey is to image changes in the geometry of the magma body. The Axial Seamount dataset has not been fully processed and was collected 4 years after the last documented eruption with indications that the magma has been in a steady state since 2024 with little possibility of another eruption in the near future. In contrast, 9°50'N vent temperatures over the past 5 years predict new eruptions at the EPR within the next year or two. The proposed survey location at 9°50'N is the only feasible place to conduct a 4-D timelapse study of how magma bodies evolve over decadal timescales and novel eruption cycle hypothesis testing. Thus, an alternative location would not meet the purpose of the surveys.
Alternative E2: Alternative Survey Timings	The surveys are proposed for February to March 2026. This timeframe is outside of the hurricane season for the region when weather conditions will be more favorable at this location.
Alternative E3: Use of Alternative Technologies	The goal of the project is to conduct a 4-D study of an eruption cycle. Thus, the technology used for data collection must produce a comparable dataset using similar methodology to the data collected during the baseline surveys in 2008. At this time, alternate technologies are not appropriate to meet the Purpose and Need.

2.3.2 Alternative E2: Use of Alternative Technologies

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

III AFFECTED ENVIRONMENT

As described in the PEIS, Chapter 3, the description of the affected environment focuses only on those resources potentially subject to impacts. Accordingly, the discussion of the affected environment (and associated analyses) focuses mainly on those related to marine biological resources, as the proposed short-term marine activity has the potential to impact marine biological resources within the study 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 Action determined that the following resource areas did not require further analysis in this EA:

- *Air Quality*—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 study area. To reduce impacts on air quality, R/V *Langseth* uses Ultra-Low Sulfur fuel (<15 ppm Sulfur) and employs a Ship Energy Efficiency Management Plan to reduce and minimize fuel consumption (e.g., speed optimization) resulting in overall lower emissions.
- *Land Use*—All activities are proposed to occur in the marine environment. Thus, no changes to current land uses or activities in the proposed study 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 not involve placement of equipment on the seafloor; therefore, disturbances to geologic resources would not be anticipated. Thus, 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 study area. Therefore, there would be no impacts to water resources resulting from the proposed Project activity.
- *Terrestrial Biological Resources*—All proposed 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 and located far offshore. During operations, the vessel would not be within the viewshed of the coast.

3.1 Physical Environment and Productivity

The center of the ETP is characterized by warm, tropical waters (Reilly and Fiedler 1994). Cooler, high-salinity water is found along the Equator and the eastern boundary current waters of Peru and California; this cool water is brought to the surface by upwelling, causing nutrient enrichment and increased productivity during most periods of the year (Reilly and Fiedler 1994). The two different habitats are generally thought to support different cetacean species (Au and Perryman 1985; Ballance et al. 2006), but both systems are thought to be highly productive (Au and Perryman 1985).

The Peru and California currents feed into the westward-flowing South and North Equatorial currents (Reilly and Fiedler 1994). Between the equatorial currents at 3−10°N is the eastward-flowing North Equatorial Countercurrent (NECC), part of which turns north and becomes the Costa Rica Current when it reaches Central America, and flows along the coast until it turns west off the coast of Mexico and joins the North Equatorial Current. The pattern of cyclonic flow exists only in summer-fall, when it flows around the Costa Rica Dome (CRD), a shoaling of the generally strong and shallow thermocline of the ETP. The NECC does not extend east of 100°W during February−April (Fiedler 2002). The NECC is strong during September−December and weak during February−April (Reilly and Fiedler 1994).

There are several regions of increased biological productivity in the ETP. For example, Kessler (2006) and Pennington et al. (2006) noted that the NECC is associated with a band of higher productivity. Several studies have correlated zones of high productivity with concentrations of cetaceans (Volkov and Moroz 1977; Reilly and Thayer 1990; Wade and Gerrodette 1993). Au et al. (1980, *in* Polacheck 1987) noted an association between cetaceans and the equatorial surface water masses in the ETP, which are thought to be highly productive. The ETP is also characterized by a shallow thermocline and a pronounced oxygen minimum layer (Au and Perryman 1985; Fiedler and Talley 2006). Those features are thought to result in an "oxythermal floor" 20−100 m below the surface, which may cause large groups of cetaceans to concentrate in the warm surface waters (Scott and Cattanach 1998).

The mean productivity is estimated to be 292.335 $mgC/m^2/day$ in the eastern Central Pacific offshore area where the proposed program is anticipated to occur (Sea Around Us 2024). A major factor influencing productivity in waters of the ETP is the Intertropical Convergence Zone (ITCZ). At the ITCZ, the northeast and southeast trade winds flow together, characterized by strong upward motion and heavy rainfall, which affect the transport of species from the Northern to the Southern Hemispheres and vice versa (Millero 1996). In the Pacific, the ITCZ is substantially shifted north of the Equator compared to the Atlantic, because of the considerably larger percentage of land that lies in the Northern Hemisphere in comparison to the Southern Hemisphere (Brown 1995). During July (the Northern Hemisphere summer) and January (the northern winter), the largest effects and fluctuations are seen in the ITCZ. Consequently, areas near the Equator generally experience a drop in productivity during July and January as the productive waters move north with the ITCZ. Interannual variation in the oceanography of the ETP is greater than in any other area of the world because of the quasi-periodic El Niño−Southern Oscillation (ENSO; Fiedler and Talley 2006). Interannual variation usually exceeds any seasonal variation in the equatorial and upwelling zones, but is comparable to seasonal variations in the warm pool (Fiedler and Talley 2006; Pennington et al. 2006).

3.2 Marine Protected Areas

There are no marine protected areas (MPA) near the proposed study area in the ETP; the closest MPA is located within the territorial waters of Clipperton Island ~500 km west of the proposed study area. The Clipperton Atoll ecologically or biologically significant marine area (EBSA) extends out to 200 km from the island. Clipperton Atoll is the only atoll in the ETP and represents a unique ecosystem in the region (CBD 2025). The atoll appears to be a reproductive area for sharks, such as the white tip shark (*Carcharhinus albimarginatus*) (CBD 2025). Clipperton Atoll is also an Important Bird Area (IBA); ~110,000 masked booby (*Sula dactylatra*) occur there, including 20,000 breeding pairs, making it the largest masked booby colony in the world (CBD 2025). The 200-km extent of the EBSA around Clipperton Island is based on the masked booby foraging area (CBD 2025). The Equatorial High-Productivity Zone EBSA is located ~360 km south of the proposed study area. This EBSA is associated with the Equatorial Current System and spans nearly the entire width of the Pacific Basin between 5°N and 5°S (CBD 2025).

The winds in this region bring nutrient-rich water to the surface, thereby increasing primary productivity (CBD 2025). This EBSA is associated with high sperm whale abundance (CBD 2025).

3.3 Marine Mammals

Twenty-eight marine mammal species could occur in or near the proposed study area, including 6 mysticetes (baleen whales) and 22 odontocetes (toothed whales, such as dolphins) (Table 4). Several species that could occur in the proposed study area are listed under the U.S. ESA as ***endangered***, including the sei, fin, blue, sperm, and Central America DPS of humpback whale. The ***threatened*** Mexico DPS of the humpback whale could possibly occur in the proposed study area. The ***threatened*** Guadalupe fur seal is unlikely to occur in the study area.

Another 11 cetacean species that occur in the Northeast Pacific Ocean are unlikely to occur in the proposed study area and are not discussed further, including the North Pacific right whale (*Eubalaena japonica*), gray whale (*Eschrichtius robustus*), Hubbs' beaked whale (*Mesoplodon carlhubbsi*), Stejneger's beaked whale (*M. stejnegeri*), Perrin's beaked whale (*M. perrini*), Baird's beaked whale (*Berardius bairdii*), vaquita (*Phocoena sinus*), harbor porpoise (*Phocoena phocoena*), Dall's porpoise (*Phocoenoides dalli*), Pacific white-sided dolphin (*Lagenorhynchus obliquidens*), and northern right whale dolphin (*Lissodelphis borealis*).

The most extensive regional distribution and abundance data for cetaceans that encompass the entire study area come primarily from multi-year vessel surveys conducted in the wider ETP by the NMFS Southwest Fisheries Science Center (SWFSC). Ferguson and Barlow (2001) reported on data collected from 1986–1996, and Forney et al. (2012) used SWFSC data collected during 1986–2006 to develop species-habitat models for the ETP. Initial systematic studies of cetaceans in the ETP were prompted by the incidental killing of dolphins in the purse-seine fishery for yellowfin tuna in the area (Smith 1983). Background information on incidental dolphin mortalities during the tuna fishery is discussed in Section 4.1.5, Reasonably Foreseeable Effects. 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. In the PEIS, the Southern California detailed analysis area (DAA) is located northeast of the proposed study area, and the Galápagos Ridge DAA is located south of the study area. The general distribution of mysticetes, odontocetes, and pinnipeds in these areas is discussed in § 3.6.2, § 3.7.2, and § 3.8.2 of the PEIS, respectively.

Although there are seven species of pinnipeds known to occur in the ETP including the California sea lion (*Zalophus californianus californianus*), Galápagos sea lion (*Zalophus wollebaeki*), Galápagos fur seal (*Arctocephalus galapagoensis*), Guadalupe fur seal (*Arctocephalus townsendi*), South American fur seal (*A. australis*), South American sea lion (*Otaria flavescens*), and northern elephant seal (*Mirounga angustirostris*), pinnipeds likely would not be encountered during the proposed seismic surveys. Neither Jackson et al. (2004), Smultea and Holst (2003), nor Hauser et al. (2008) encountered any pinnipeds in offshore waters near the proposed study area.

The distributional ranges of the Guadalupe fur seal, California sea lion, and northern elephant seal lie to the north of the proposed study area. Guadalupe fur seals typically occur only off California and Baja California, northern elephant seals occur from Baja California to Alaska, and California sea lions are distributed from southern Mexico north to southwestern Canada. However, the California sea lion has been documented off Costa Rica on several occasions (e.g., Acevedo-Gutierrez 1994, 1996; Cubero-Pardo and Rodríguez 2000; Rodríguez-Herrera et al. 2002; May-Collado 2009), and Guadalupe fur seals have also been reported there (May-Collado 2009).

TABLE 4. The habitat, occurrence, population sizes, and conservation status of marine mammals that could occur in or near the proposed study area in the Eastern Tropical Pacific.

Species	**Occurrence In Study Area During Surveys[1]**	**Habitat**	**Abundance**		**Conservation Status**		
			North Pacific	**ETP[2]**	**U.S. ESA[3]**	**IUCN[4]**	**CITES[5]**
Mysticetes							
Humpback whale	Rare	Mainly nearshore, banks	1496[6] 3477[7] 21,063[8]	2566	EN/T[22]	LC	I
Common minke whale	Rare	Coastal, pelagic	20,000[9]	115	NL	LC	I
Bryde's whale	Uncommon	Coastal, pelagic	-	10,411	NL	LC	I
Sei whale	Rare	Mostly pelagic	29,600[10]	0	EN	EN	I
Fin whale	Rare	Slope, pelagic	13,620–18,680[11]	574	EN	VU	I
Blue whale	Rare	Coastal, pelagic	2500[12]	1415	EN	EN	I
Odontocetes							
Sperm whale	Uncommon	Pelagic, steep topography	-	4145	EN	VU	I
Pygmy sperm whale	Rare	Deeper waters off shelf	4111[13]	-	NL	LC	II
Dwarf sperm whale	Rare	Deeper waters off shelf	-	11,200[14]	NL	LC	II
Cuvier's beaked whale	Uncommon	Pelagic	90,725[15]	20,000[16]	NL	LC	II
Longman's beaked whale	Rare	Pelagic	291[15]	1007	NL	LC	II
Blaineville's beaked whale	Rare	Pelagic	32,678[17]	25,300[18]	NL	LC	II
Ginkgo-toothed beaked whale	Rare	Pelagic	32,678[17]	25,300[18]	NL	DD	II
Deraniyagala's beaked whale	Rare	Pelagic	32,678[17]	25,300[18]	NL	DD	II
Pygmy beaked whale	Rare	Pelagic	32,678[17]	25,300[18]	NL	LC	II
Risso's dolphin	Uncommon	Shelf, slope, seamounts	-	110,457	NL	LC	II
Rough-toothed dolphin	Uncommon	Mainly pelagic	-	107,663	NL	LC	II
Common bottlenose dolphin	Common	Coastal, shelf, pelagic	-	335,834	NL	LC	II
Pantropical spotted dolphin	Common	Coastal and pelagic	-	857,884[19]	NL	LC	II
Spinner dolphin	Common	Coastal and pelagic	-	1,797,716[20]	NL	LC	II
Striped dolphin	Common	Off continental shelf	-	964,362	NL	LC	II
Common dolphin	Common	Shelf, pelagic, seamounts	-	3,127,203	NL	LC	II
Fraser's dolphin	Common	Pelagic	-	289,300[16]	NL	LC	II
Short-finned pilot whale	Uncommon	Pelagic, high-relief	-	589,315[21]	NL	LC	II

Species	Occurrence In Study Area During Surveys[1]	Habitat	Abundance		Conservation Status		
			North Pacific	ETP[2]	U.S. ESA[3]	IUCN[4]	CITES[5]
Killer whale	Rare	Widely distributed	-	8500[16]	EN	DD	II
False killer whale	Uncommon	Pelagic	-	39,800[16]	NL	NT	II
Pygmy killer whale	Uncommon	Pelagic	-	38,900[16]	NL	LC	II
Melon-headed whale	Uncommon	Pelagic	-	45,400[16]	NL	LC	II

\- Not available or not applicable.
[1] Occurrence in area at the time of the surveys; based on professional opinion and available data, including densities.
[2] Abundance for the ETP from NMFS (2015) unless otherwise stated.
[3] U.S. Endangered Species Act (ESA): EN = Endangered; T = Threatened; NL = Not listed.
[4] International Union for the Conservation of Nature Red List of Threatened Species, version 2025-1 (IUCN 2025): EN = Endangered; VU = Vulnerable; LC = Least Concern; NT = Near Threatened; DD = Data Deficient.
[5] Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES; UNEP-WCMC 2025): Appendix I = Threatened with extinction; Appendix II = not necessarily now threatened with extinction but may become so unless trade is closely controlled.
[6] Central America/Southern Mexico – CA-OR-WA stock (Carretta et al. 2024a).
[7] Mainland Mexico – CA-OR-WA (Carretta et al. 2024a).
[8] North Pacific (Barlow et al. 2011).
[9] Northwest Pacific and Okhotsk Sea for 2003 (IWC 2025).
[10] Central and Eastern North Pacific (IWC 2025).
[11] North Pacific (Ohsumi and Wada 1974).
[12] Eastern North Pacific (IWC 2025).
[13] Abundance for U.S. West Coast (Carretta et al. 2024a).
[14] Estimate for ETP is mostly for *K. sima* but may also include some *K. breviceps* (Wade and Gerrodette 1993).
[15] Eastern North Pacific (Ferguson and Barlow 2001 *in* Barlow et al. 2006).
[16] Wade and Gerrodette (1993).
[17] This estimate for the Eastern North Pacific includes all species of the genus *Mesoplodon* (Ferguson and Barlow 2001 *in* Barlow et al. 2006).
[18] This estimate for the ETP includes all species of the genus *Mesoplodon* (Wade and Gerrodette 1993).
[19] Northeastern offshore stock.
[20] Includes several stocks added together.
[21] Based on surveys in 2000 (Gerrodette and Forcada 2002).
[22] Central America DPS is endangered; Mexico DPS is threatened.

Galápagos sea lions and Galápagos fur seals occur around the Galápagos Islands and generally are not seen more than ~185 km west of the Galápagos Islands (J. Barlow, NMFS, pers. comm. to LGL Limited 2008). However, Galápagos sea lions are seen occasionally along the coasts of Colombia and Ecuador and as far north as Isla del Coco, Costa Rica, an island 500 km southwest of Costa Rica (Acevedo-Gutiérrez 1994; Capella et al. 2002). A few Galápagos fur seals have also been reported along the coast of South America (D. Palacios, Oregon State University, pers. comm. to LGL Limited 2008).

Southern sea lions and South American fur seals are distributed along the coast of South America. The northernmost breeding colony of southern sea lions occurs on the Peruvian coast (Vaz-Ferreira 1981), but vagrant individuals have been seen along the coast of Colombia (Capella et al. 2002) and as far north as Panama (Méndez and Rodriguez 1984). The northernmost sighting of the South American fur seal was recorded off the Colombian coast (Capella et al. 2002).

3.3.1 Mysticetes

3.3.1.1 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 2016a). If humpbacks are encountered during the proposed surveys, they could be from either the Central America or Mexico DPSs (see Steiger et al. 1991; Calambokidis et al. 2008; Martien et al. 2021; Carretta et al. 2023; Martínez-Loustalot et al. 2023).

NMFS recently evaluated the North Pacific DPSs with respect to demographically independent populations (DIPs) and "units" that contain one or more DIPs (Martien et al. 2021; Taylor et al. 2021; Wade et al. 2021; Oleson et al. 2022). Based on these DIPs and units, NMFS has designated five stocks including: the Central America/Southern Mexico − California/Oregon/Washington stock (part of the Central America DPS), the Mainland Mexico − California/Oregon/Washington and Mexico-North Pacific stocks (part of the Mexico DPS), the Hawai'i stock, and the Western North Pacific stock (Carretta et al. 2023).

Whales in the Central America/Southern Mexico − CA-OR-WA stock winter off the coasts of Nicaragua, Honduras, El Salvador, Guatemala, Panama, Costa Rica, and southern Mexico including the states of Oaxaca and Guerrero, with some animals ranging even farther north (Taylor et al. 2021); they summer off California, Oregon, and Washington (Calambokidis et al. 2017). Whales from the Mainland Mexico − CA-OR-WA stock mainly winter off the Mexican state of Nayarit and Jalisco, with some animals occurring as far south as Colima and Michoacán; this stock summers off California, Oregon, Washington (Martien et al. 2021), as well as southern B.C., Alaska, and the Bering Sea. The Mexico − North Pacific stock winters off Mexico and the Revillagigedo Archipelago, and most individuals summer in Alaska (Martien et al. 2021).

In the Mexican Pacific, there are three main locations where humpbacks aggregate including the southern end of Baja California, the central portion of the mainland, and the Revillagigedo Archipelago; they also aggregate in the northern Gulf of California (Urbán and Aguayo 1987; Urbán et al. 2000). Most northeastern Pacific humpbacks spend the northern winter off the Baja California Peninsula and mainland Mexico, and summer off the western coast of North America from California to Alaska (Urbán and Aguayo 1987; Urbán et al. 2000). While on wintering grounds, humpbacks occur predominantly in coastal waters. The Northern Hemisphere humpbacks occur in the Mexican Pacific from as early as September through the winter to mid-May (Urbán and Aguayo 1987). However, they have been reported in the Gulf of California throughout the year (Bean et al. 1999 *in* Heckel et al. 2020), so it is likely that not all whales undergo the migration (Guerrero et al. 2006).

During surveys of the Pacific EEZ of Mexico, Gerrodette and Palacios (1996) reported 10 sightings of humpback whales. However, during 1986−1996 summer/fall surveys of the ETP, the density of humpback whales in the proposed study area was zero (Ferguson and Barlow 2001). Similarly, Jackson et al. (2004) did not encounter any humpbacks in the proposed study area during surveys in July−December 2003. There are no sightings in the OBIS database for the waters in and adjacent to the proposed study area

(OBIS 2025). Although sightings are regularly made in coastal areas of the ETP during winter, encounters in the offshore survey area are unlikely.

3.3.1.2 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).

Gerrodette and Palacios (1996) reported eight sightings of minke whales during surveys of the Pacific EEZ of Mexico. González et al. (2008) also noted the presence of minke whales off the Pacific coast of Mexico, south of 18°N. Rankin and Barlow (2005) reported acoustic recordings of minke whale calls (boings) between 15° and 35°N in the central and eastern North Pacific Ocean; eastern-type ‘boings’ were recorded off the coast of Mexico. However, no minke whales were seen in the proposed offshore study area from 1986 through 1996 (Ferguson and Barlow 2001; Jackson et al. 2004; Forney et al. 2012). In the OBIS database, there are no sightings for the waters in or adjacent to the proposed study area. However, there are two records for November between 14.8°–17.2°N and 112.5°–115.5°W (OBIS 2025). Minke whales are expected to be rare in the offshore study area.

3.3.1.3 Bryde’s Whale (*Balaenoptera edeni/brydei*)

Bryde’s whale occurs in all tropical and warm temperate waters in the Pacific, Atlantic, and Indian oceans, between 40°N and 40°S (Kato and Perrin 2018). It is one of the least known large baleen whales, and it remains uncertain how many species are represented in this complex (Kato and Perrin 2018). *B. brydei* is commonly used to refer to the larger form or “true” Bryde’s whale and *B. edeni* to the smaller form; however, some authors apply the name *B. edeni* to both forms (Kato and Perrin 2018). Bryde’s whale remains in warm (>16°C) water year-round, although seasonal movements have been recorded towards the Equator in winter and offshore in summer (Kato and Perrin 2018). However, Debrot (1998) noted that this species is sedentary in the tropics. Bryde’s whales are known to occur in both shallow coastal and deeper offshore waters (Jefferson et al. 2015).

During surveys of the Pacific EEZ of Mexico, 12 sightings of *B. edeni* were made (Gerrodette and Palacios 1996). Based on July–December 1986–1996 surveys, the density of Bryde’s whales in the proposed study area ranged up to 0.0003/km^2 (Ferguson and Barlow 2001). Sightings were made near the proposed study area during surveys in 1998–2000 (Forney et al. 2012) and east of the study area during July–December 2003 (Jackson et al. 2004). There are no confirmed sightings in the OBIS database for the proposed study area (OBIS 2025). However, there is one record at 8.2°N, 104.6°W during September 2000, and two sei/Bryde’s whale records for August 1989 (9.33°N, 105.5°W) and September 1986 (10.23°N, 103.3°W) (OBIS 2025).

3.3.1.4 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). On summer feeding grounds, sei whales associate with oceanic frontal systems (Horwood 1987) such as the cold eastern currents in the North Pacific (Perry et al. 1999). In the North Pacific during summer, the sei whale can be found from the Bering Sea to the Gulf of Alaska and down to the Baja California Peninsula, as well as in the western Pacific from Japan to Korea. Its winter distribution is concentrated at ~20°N (Rice 1998). 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).

Sei whales may have been sighted during surveys in the greater ETP (Wade and Gerrodette 1993; Kinzey et al. 1999, 2000, 2001; Ferguson and Barlow 2001). However, it is difficult to distinguish sei whales from Bryde's whales. Because sei whales generally have a more northerly and temperate distribution (Leatherwood et al. 1988), Wade and Gerrodette (1993) classified any tentative sei whale observations in the ETP as Bryde's whale sightings. Ferguson and Barlow (2001) did not report any sei whales in the ETP south of 30°N during surveys conducted during July–December 1986–1996; however, the density of Bryde's/sei whales in the proposed study area ranged up to 0.0001/km^2 (Ferguson and Barlow 2001). There are no confirmed sightings in the OBIS database for the proposed study area (OBIS 2025). However, there are two unconfirmed sightings (identified as Sei or Bryde's whale) in adjacent waters for August 1989 (9.33°N, 105.5°W) and September 1986 (10.23°N, 103.3°W) (OBIS 2025).

3.3.1.5 Fin Whale (*Balaenoptera physalus physalus*)

The fin whale is widely distributed in all the World's oceans (Gambell 1985), 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 1985). Information about the seasonal distribution of fin whales in the North Pacific has been obtained from the detection of fin whale calls by bottom-mounted, offshore hydrophone arrays along the U.S. Pacific coast, in the central North Pacific, and in the western Aleutian Islands (Moore et al. 1998, 2006; Watkins et al. 2000a,b; Stafford et al. 2007, 2009). Fin whale calls are recorded in the North Pacific year-round (e.g., Moore et al. 2006; Stafford et al. 2007, 2009; Edwards et al. 2015).

Gerrodette and Palacios (1996) reported an abundance of 145 fin whales for the EEZ of Pacific Mexico, and González et al. (2008) also reported the presence of this species off the west coast of Mexico south of 23°N. Edwards et al. (2015) reported sightings and acoustic detection for the Gulf of California and Baja California, as well as sightings near the proposed study area during December–February and acoustic detections from March–November. However, no sightings were made in the proposed study area during July–December surveys during 1986–1996 and 2003 (Ferguson and Barlow 2001; Jackson et al. 2004). There are no sightings in the OBIS database for the waters in and adjacent to the proposed study area, but there are two records between 15.8°–21.0°N and 116.1°–119.6°W during November and December (OBIS 2025). Fin whales are considered rare in the proposed study area.

3.3.1.6 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). Blue whales are most often found in cool, productive waters where upwelling occurs (Reilly and Thayer 1990). 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 in the Pacific: the eastern and central (formerly western) stocks (Carretta et al. 2024b). 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 Gulf of Alaska, during summer (Sears and Perrin 2018; Carretta et al. 2024b). However, Busquets-Vass et al. (2021) suggested that most blue whales from the North Pacific feed in the California Current System, whereas some individuals occur in the Gulf of California or CRD for most of the year. The central North Pacific stock feeds off Kamchatka, south of the Aleutians and in the Gulf of Alaska 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. 2024b).

In the Northeast Pacific Ocean, including the ETP, blue whale calls are detected year-round (Stafford et al. 1999, 2001, 2009; Monnahan et al. 2014). Stafford et al. (2009) reported that sea-surface temperature is a good predictor variable for blue whale call detections. In the ETP, blue whales have been sighted mainly off the Baja California Peninsula, near Costa Rica particularly the CRD, at and near the Galápagos Islands, and along the coasts of Ecuador and northern Peru (Clarke 1980; Donovan 1984; Reilly and Thayer 1990; Mate et al. 1999; Palacios 1999; Palacios et al. 2005; Branch et al. 2006). Sightings have also been made off the mainland coast of Mexico (Fiedler 2002; Arroyo 2017). In Mexican waters, blue whales generally occur from December–April (Rice 1974; Yochem and Leatherwood 1985; Gendron 2002 *in* Heckel et al. 2020), after which time they migrate northward; a large proportion occurs off California during the summer (Sears and Perrin 2018).

During surveys within the EEZ of Pacific Mexico, 30 sightings of blue whales were reported by Gerrodette and Palacios (1996). The density of blue whales in the proposed study area was zero based on July–December surveys during 1986–1996 (Ferguson and Barlow 2001). However, sightings have been made just east of the proposed study area (Ferguson and Barlow 2001; Jackson et al. 2004; Forney et al. 2012). There are no sightings of blue whales in the OBIS database for the proposed study area (OBIS 2025). However, there are two records for adjacent waters (8.5°N, 102.5° and 9.5°N, 102.5°W) which were made in February 2006 (OBIS 2025). Blue whales are likely to be uncommon to rare in the proposed study area.

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 (Whitehead 2018).

Sperm whales are distributed widely across the North Pacific (Rice 1989). Males migrate north in the summer to feed in the Gulf of Alaska, Bering Sea, and waters around the Aleutian Islands (Kasuya and Miyashita 1988). During summer and fall, sperm whales are widely distributed in the ETP, although they are generally more abundant in deep "nearshore" waters than far offshore (e.g., Polacheck 1987; Wade and Gerrodette 1993). It is not clear whether sperm whales seen in the ETP are part of the Northern or Southern Hemisphere stocks, or whether they should be considered a separate stock (Berzin 1978). More than 180 sightings have been reported for the ETP, with the highest concentrations at 10°N–10°S, 80°–100°W (Guerrero et al. 2006).

During surveys of the EEZ of Pacific Mexico, 46 sightings of sperm whales were made (Gerrodette and Palacios 1996). In the proposed study area, the sperm whale density ranged up to 0.0012/km^2 according to surveys conducted in July–December 1986–1996 (Ferguson and Barlow 2001). No sightings were made in the offshore study area during July–December surveys in 2003 (Jackson et al. 2004). However, sperm whales were seen within and near the proposed study area during surveys in April–August 2008 (Hauser et al. 2008). There are no records of sperm whales within the study area in the OBIS database (OBIS 2025). However, there are eight non-whaling records in the OBIS database for the adjacent waters, all of which occurred in August 1989 (OBIS 2025).

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

The pygmy and dwarf sperm whales are distributed widely throughout tropical and temperate seas, but their precise distributions are unknown because much of what we know of the species comes from strandings (McAlpine 2018). It has been suggested that the pygmy sperm whale is more temperate and the dwarf sperm whale more tropical, based at least partially on live sightings at sea from a large database from the ETP (Wade and Gerrodette 1993). Both *Kogia* species are sighted primarily along the continental shelf edge and slope and over deeper waters off the shelf (Hansen et al. 1994; Davis et al. 1998; Jefferson et al. 2015). However, McAlpine (2018) noted that dwarf sperm whales may be more pelagic than pygmy sperm whales. *Kogia* spp. are difficult to sight at sea, because of their dive behavior and perhaps because of their avoidance reactions to ships and behavior changes in relation to survey aircraft (Würsig et al. 1998). Although there are few useful estimates of abundance for pygmy or dwarf sperm whales anywhere in their range, they are thought to be fairly common in some areas.

Vocalizations of *Kogia* spp. have been recorded in the North Pacific Ocean (Merkens et al. 2016). During surveys of the Pacific EEZ of Mexico, eight sightings of pygmy sperm whales and 29 sightings of dwarf sperm whales were made (Gerrodette and Palacios 1996). The density of dwarf sperm whales in the proposed study area was 0.021/km^2 during July–December 1986–1996 surveys in the ETP; the density of pygmy sperm whales was zero (Ferguson and Barlow 2001). Dwarf sperm whales were seen near the proposed study area during 1998–2000 (Forney et al. 2012) but not during 2003 (Jackson et al. 2004). One sighting of *Kogia* sp. was seen just west of the proposed study area during surveys in April–August 2008 (Hauser et al. 2008). There are no records of dwarf sperm whales in the OBIS database for the proposed study area, but there are five confirmed records and one unconfirmed sighting (identified as pygmy or dwarf whale) in adjacent waters for August to November (OBIS 2025). There are no confirmed records of pygmy sperm whales within or near the study area (OBIS 2025).

3.3.2.3 Cuvier's Beaked Whale (*Ziphius cavirostris*)

Cuvier's beaked whale is probably the most widespread and common of the beaked whales, although it is not found in high-latitude polar waters (Heyning 1989; Baird 2018a). It is rarely observed at sea and is known mostly from strandings; it strands more commonly than any other beaked whale (Heyning 1989). Cuvier's beaked whale is found in deep water in the open ocean and over and near the continental slope (Gannier and Epinat 2008; Baird 2018a). Ferguson et al. (2006) noted that in the ETP, the mean water depth where Cuvier's beaked whales were sighted was ~3.4 km. 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 whales are widely distributed in the ETP (see Ferguson et al. 2006), and MacLeod and Mitchell (2006) identified this region as a key area for beaked whales. During surveys within the Pacific EEZ of Mexico, 18 sightings of Cuvier's beaked whales were made (Gerrodette and Palacios 1996). Ferguson et al. (2006) reported 90 sightings in the ETP during 1986−1990 and 1993 surveys. During surveys conducted in the ETP during July−December 1986−1996, the density of Cuvier's beaked whales within the proposed study area was 0.003/km^2 (Ferguson and Barlow 2001). In addition, several sightings were made near the proposed study area during surveys in 1998−2000 (Forney et al. 2012) and in 2003 (Jackson et al. 2004). There are no sightings of Cuvier's beaked whales in the OBIS database for the proposed study area; however, there is one confirmed record and seven unconfirmed records in adjacent waters for September through November (OBIS 2025).

3.3.2.4 Longman's Beaked Whale (*Indopacetus pacificus*)

Longman's beaked whale, also known as the Indo-Pacific beaked whale or tropical bottlenose whale, occurs in tropical waters throughout the Indo-Pacific (Pitman 2018a). Longman's beaked whale is most often sighted in waters with temperatures ≥21°C and over or adjacent to continental slopes (Anderson et al. 2006; Jefferson et al. 2015). Longman's beaked whale is rare in the eastern Pacific (Pitman 2018a; Heckel et al. 2020). In the ETP, most tropical bottlenose whale sightings have been made between 3°N and 10°N (Pitman et al. 1999). Kinzey et al. (2001) noted one sighting of *I. pacificus* in the ETP at ~6.9°N, 135.5°W. Pitman et al. (1999) suggested that several sightings of *Hyperoodon* spp. in the ETP were actually misidentifications (e.g., Wade and Gerrodette 1993) and were, in fact, sightings of tropical bottlenose whales.

Both Ferguson and Barlow (2001) and Jackson et al. (2004) reported *I. pacificus* in the ETP. The density of tropical bottlenose whales in the proposed study area was zero based on 10 years of surveys during July−December; however, to the southwest of the study area, the density was reported as 0.004/km^2 (Ferguson and Barlow 2001). There are no sightings in the OBIS database within or near the proposed study area, but there is one record for September 1987 at 14.7°N, 101.6°W and 11 records for November 1989 at 5.3°N, 111.6°W (OBIS 2025).

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

Blainville's beaked whale is found in tropical and warm temperate waters of all oceans; it has the widest distribution throughout the world of any *Mesoplodon* species (Pitman 2018b). Occasional occurrences in cooler, higher-latitude waters are presumably related to warm-water incursions (Reeves et al. 2002). Like other beaked whales, Blainville's beaked whale is generally found in waters 200−1400 m deep

(Gannier 2000; Jefferson et al. 2015). In the ETP, Blainville's beaked whales have been sighted in offshore as well as nearshore areas of Central and South America (Pitman et al. 1987; Ferguson and Barlow 2001; Pitman and Lynn 2001). MacLeod et al. (2005) reported stranding and sighting records in the eastern Pacific ranging from 37.3°N to 41.5°S. MacLeod and Mitchell (2006) identified the ETP as a key area for beaked whales. During surveys of the EEZ of Pacific Mexico, one sighting of Blaineville's beaked whale was made (Gerrodette and Palacios 1996). Heckel et al. (2020) reported additional sightings off Mexico. However, no sightings were made within the proposed study area during July−December 1986−1996 surveys (Ferguson and Barlow 2001). There are no sightings in the OBIS database for the waters in and adjacent to the proposed study area, but there are three records for October 1998 at 6.2°N, 105.6°W (OBIS 2025).

3.3.2.6 Ginkgo-toothed Beaked Whale (*Mesoplodon ginkgodens*)

The ginkgo-toothed beaked whale is only known from stranding and capture records (Mead 1989; Jefferson et al. 2015). It is hypothesized to occupy tropical and warm temperate waters of the Indian and Pacific oceans (Pitman 2018b). Its distributional range in the North Pacific extends from Japan to the Galápagos Islands, and there are also records for the South Pacific as far south as Australia and New Zealand (Jefferson et al. 2015). The species is thought to occupy relatively cool areas in the temperate and tropical Pacific, where upwelling is known to occur, such as in the California and Peru currents and the equatorial front (Palacios 1996). Heckel et al. (2020) reported one record off Baja California. The density of unidentified *Mesoplodon* sp. in the proposed study area was 0.0027/km^2 based on July−December 1986−1996 surveys (Ferguson and Barlow 2001); some of these sightings could have potentially been gingko-toothed beaked whales. There are no records for ginkgo-toothed beaked whales in the OBIS database for the proposed study area (OBIS 2025).

3.3.2.7 Deraniyagala's Beaked Whale (*Mesoplodon hotaula*)

Deraniyagala's beaked whale is a newly recognized species of whale that has been described for the tropical Indo-Pacific, where it is thought to occur between ~15°N and ~10°S (Dalebout et al. 2014). Strandings have been reported for the Maldives, Sri Lanka, Seychelles, Kiribati, and Palmyra Atoll (Dalebout et al. 2014), and acoustic detections have been made at Palmyra Atoll and Kingman Reef in the Line Islands (Baumann-Pickering et al. 2014). It is closely related to ginkgo-toothed beaked whale, but DNA and morphological data have shown that the two are separate species (Dalebout et al. 2014). It is possible that this species could occur in the proposed study area. However, there are no records in the OBIS database for the study area (OBIS 2025).

3.3.2.8 Pygmy Beaked Whale (*Mesoplodon peruvianus*)

The pygmy beaked whale is the smallest mesoplodont (Reyes 1991). This eastern-Pacific species is thought to occur between 25°N and 15°S, from the Baja California Peninsula to Peru, foraging in mid-to-deep waters (Urbán-Ramírez and Aurioles-Gamboa 1992). However, Pitman and Lynn (2001) noted a stranding record for the species in Chile, at 29.25°S. Pitman and Lynn (2001) noted that the species may have been known previously as *M.* sp. "A". The pygmy beaked whale is believed to be widespread in the ETP and is the most frequently sighted *Mesoplodon* sp. there (Pitman 2018b); it appears to be concentrated off central Mexico (Pitman and Lynn 2001). Wade and Gerrodette (1993) reported several sightings for *M. peruvianus* as well as *M.* sp. "A" in the ETP.

During surveys of the Pacific EEZ of Mexico, 13 sightings of *Mesoplodon* sp. A were made (Gerrodette and Palacios 1996). Densities of *Mesoplodon* sp. A based on July−December 1986−1996 surveys was 0.0007/km^2 for the proposed study area (Ferguson and Barlow 2001). However, no sightings of pygmy beaked whales were made in the proposed study area during July−December 2003 (Jackson et al.

2004). There are no sightings in the OBIS database for the proposed study area, but there are two record for September 2007 at 12.5°N, 104.4°W (OBIS 2025).

3.3.2.9 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). Polacheck (1987) noted that the highest encounter rates of Risso's dolphin in the ETP were in (relatively) nearshore areas. During surveys of the EEZ of Pacific Mexico, 73 sightings of Risso's dolphins were made (Gerrodette and Palacios 1996). Densities up $0.0172/km^2$ were reported for the proposed study area based on July−December 1986−1996 surveys (Ferguson and Barlow 2001). Sightings of Risso's dolphins were made also made near the study area during surveys in 1998−2000 (Forney et al. 2012) and 2003 (Jackson et al. 2004). Jefferson et al. (2014) also reported sightings within the proposed study area. Schwarz et al. (2010) reported sightings between 12°−17°N and 104°−108°W, from late August−November 2007. There are no sightings in the OBIS database for the waters in and adjacent to the proposed study area, but there are 31 sightings between 9.8°N−11.3°N and 101.8°W−102.9°W for September and October 1998−2003 (OBIS 2025).

3.3.2.10 Rough-toothed Dolphin (*Steno bredanensis*)

The rough-toothed dolphin is distributed worldwide in tropical to warm temperate oceanic waters (Miyazaki and Perrin 1994). In the Pacific, it occurs from central Japan and northern Australia to the Baja California Peninsula, Mexico, and southern Peru (Jefferson et al. 2015). It generally occurs in deep, oceanic waters, but can be found in shallower coastal waters in some regions (Jefferson et al. 2015). In the ETP, sightings of rough-toothed dolphins have been reported by Perrin and Walker (1975), Pitman and Ballance (1992), Wade and Gerrodette (1993), Kinzey et al. (1999, 2000, 2001), Ferguson and Barlow (2001), Jackson et al. (2004), and May-Collado et al. (2005).

Gerrodette and Palacios (1996) reported an abundance of 37,511 rough-toothed dolphins for the EEZ of Pacific Mexico. Based on surveys conducted during July−December 1986−1996, densities of rough-toothed dolphins in the proposed study area ranged up to $0.0362/km^2$ (Ferguson and Barlow 2001). Sightings of rough-toothed dolphins were made in and near the proposed study area during surveys conducted in 1998−2000 (Forney et al. 2012), but not during 2003 (Jackson et al. 2004). Schwarz et al. (2010) also reported sightings between 12°−17°N and 104°−108°W, from late August−November 2007 (Schwarz et al. 2010). There are no records in the OBIS database for the proposed study area, but there are 97 records in adjacent waters for September through November (OBIS 2025).

3.3.2.11 Common Bottlenose Dolphin (*Tursiops truncatus*)

The bottlenose dolphin is distributed worldwide in coastal and shelf waters of tropical and temperate oceans (Jefferson et al. 2015). There are two distinct bottlenose dolphin types: a shallow water type, mainly found in coastal waters, and a deep water type, mainly found in oceanic waters (Duffield et al. 1983; Hoelzel et al. 1998; Walker et al. 1999). Coastal common bottlenose dolphins exhibit a range of movement patterns including seasonal migration, year-round residency, and a combination of long-range movements and repeated local residency (Wells and Scott 2018). In the ETP, bottlenose dolphins tend to be more abundant close to the coasts and islands (Scott and Chivers 1990); they also seem to occur more inshore than other dolphin species (Wade and Gerrodette 1993).

During surveys of the Pacific EEZ of Mexico, 163 sightings of bottlenose dolphins were made (Gerrodette and Palacios 1996). Densities of up to 0.0118/km^2 were reported for the proposed study area based on surveys conducted during July−December 1986−1996 (Ferguson and Barlow 2001). Sightings of bottlenose dolphins were also made in and near the proposed study area during surveys in 1998−2000 (Forney et al. 2012) and 2003 (Jackson et al. 2004). Schwarz et al. (2010) also reported sightings during surveys between 12°−17°N and 104°−108°W, from late August−November 2007. Acoustic detections were reported near the proposed study area during summer/fall of 1998 and 1999 (Oswald et al. 2003). There are two records in the OBIS database for the proposed study area and 58 records in adjacent waters; records were for August through November (OBIS 2025).

3.3.2.12 Pantropical Spotted Dolphin (*Stenella attenuata*)

The pantropical spotted dolphin is one of the most abundant cetaceans and is distributed worldwide in tropical and some subtropical waters, between ~40°N and 40°S (Jefferson et al. 2015). In the ETP, this species ranges from 25ºN off the Baja California Peninsula to 17ºS, off southern Peru (Perrin and Hohn 1994). Au and Perryman (1985) noted that the pantropical spotted dolphin occurs primarily north of the Equator, off southern Mexico, and westward along 10ºN. There are two forms of pantropical spotted dolphin (Perrin 2018a): coastal (*S. a. graffmani*) and offshore (*S. a. attenuata*). Along the coast of Latin America, the coastal form typically occurs within 20 km from shore (Urbán 2008 *in* Heckel et al. 2020). There are currently three recognized stocks of spotted dolphins in the ETP: the coastal stock and two offshore stocks − the northeast stock (which is most likely to occur in the proposed study area) and the west/south stock (Wade and Gerrodette 1993; Leslie et al. 2019). However, based on more recent data, there are at least nine genetically distinct stocks of this species in coastal areas from the Baja California Peninsula south to Ecuador (Rosales and Escorza-Treviño 2005; Escorza-Treviño et al. 2005).

Much of what is known about the pantropical spotted dolphin in the ETP is related to the tuna purse-seine fishery in that area (Perrin and Hohn 1994). There was an overall stock decline of spotted dolphins from 1960−1980 because of the fishery (Allen 1985). This stock is still considered depleted and may be slow to recover due to continued chase and encirclement by the tuna fishery, which may in turn affect reproductive rates (Cramer et al. 2008; Kellar et al. 2013; Ballance et al. 2021). Gerrodette and Forcada (2005) noted that the population of offshore northeastern spotted dolphins (the stock likely to occur in the proposed study area) had not yet recovered from the earlier population declines; possible reasons for the lack of growth were attributed to unreported bycatch, effects of fishing activity on survival and reproduction, and long-term changes in the ecosystem. In 1979, the population size of spotted dolphins in the ETP was estimated at 2.9−3.3 million (Allen 1985). For 1986−1990, Wade and Gerrodette (1993) reported an estimate of 2.1 million. In 2006, the combined population estimate for the northeastern offshore, western-southern offshore, and coastal stocks in the ETP was ~1.6 million, with ~640,000 northeastern offshore dolphins (Gerrodette et al. 2008).

During surveys of the Pacific EEZ of Mexico, 251 sightings of offshore and eight sightings of coastal spotted dolphins were made (Gerrodette and Palacios 1996). Densities of offshore pantropical spotted dolphins in the proposed study area ranged up to 0.4208/km^2 based on surveys conducted during July−December 1986−1996 (Ferguson and Barlow 2001). Sightings of spotted dolphins were made in and near the proposed study area during surveys in 1998−2000 (Forney et al. 2012) and 2003 (Jackson et al. 2004). Schwarz et al. (201) reported sightings between 12°−17°N and 104°−108°W, from late August−November 2007. There are 250 records in the OBIS database for the proposed study area and ~2000 records for adjacent waters; records were reported from August through November (OBIS 2025).

3.3.2.13 Spinner Dolphin (*Stenella longirostris*)

The spinner dolphin is pantropical in distribution, including oceanic tropical and sub-tropical waters between 40ºN and 40ºS (Jefferson et al. 2015). It is generally considered a pelagic species, but it can also be found in coastal waters (Perrin 2018b). In the Pacific, Au and Perryman (1985) noted that the spinner dolphin occurs primarily north of the Equator, off southern Mexico, and westward along 10ºN; they also noted its occurrence in seasonal tropical waters south of the Galápagos Islands. In the ETP, three types of spinner dolphins have been identified and two of those are recognized as subspecies: the eastern spinner dolphin (*S.l. orientalis*), considered an offshore species, the Central American spinner (*S.l. centroamericana*; also known as the Costa Rican spinner), considered a coastal species occurring from southern Mexico to Costa Rica (Perrin 1990; Dizon et al. 1991), and the 'whitebelly' spinner is thought to be a hybrid of the eastern spinner and Gray's spinner (*S.l. longirostris*). The whitebelly spinner dolphin is common in oceanic waters of the ETP (Heckel et al. 2020).

Although there is a great deal of overlap between the ranges of eastern and whitebelly spinner dolphins, the eastern form generally occurs in the northeastern portion of the ETP, whereas the whitebelly spinner occurs in the southern portion of the ETP, ranging farther offshore (Wade and Gerrodette 1993; Reilly and Fiedler 1994). Reilly and Fiedler (1994) noted that eastern spinners are associated with waters that have high surface temperatures and chlorophyll and shallow thermoclines, whereas whitebelly spinners are associated with cooler surface temperatures, lower chlorophyll levels, and deeper thermoclines. The eastern spinner dolphins are the most likely to occur in the proposed study area (see Ferguson and Barlow 2001), as this subspecies occurs in the ETP, east of 145°W, between 24°N off the Baja California Peninsula and 10°S off Peru (Perrin 1990).

Gerrodette and Forcada (2005) noted that the population of eastern spinner dolphins had not yet recovered from the earlier population declines due to the tuna fishery, but it appears to be slowly increasing (Gerrodette et al. 2008). The population estimate for eastern spinner dolphins in 2003 was 612,662 (Gerrodette et al. 2005), and it was 1,062,879 in 2006 (Gerrodette et al. 2008). The whitebelly spinner dolphin population was estimated at 734,837 in 2006 (Gerrodette et al. 2008). Possible reasons why the eastern spinner dolphin population has been slow to recover include under-reported bycatch, effects of fishing activity on survival and reproduction, and long-term changes in the ecosystem (Gerrodette and Forcada 2005). The continued chase and encirclement by the tuna fishery may be affecting the reproductive rates of the eastern spinner dolphin (Cramer et al. 2008).

During surveys of the Pacific EEZ of Mexico, 163 sightings of eastern spinner dolphin were made (Gerrodette and Palacios 1996). Based on surveys conducted during July−December 1986−1996, densities of eastern spinner dolphin ranged up to was 0.2191/km^2 in the proposed study area; densities for the whitebelly spinner dolphin ranged up to 0.0581/km^2 (Ferguson and Barlow 2001). During 1998−2000 and 2003 surveys, sightings of eastern spinner dolphins were made in the proposed study area; whitebelly spinner dolphins were sighted near the proposed study area (Jackson et al. 2004; Forney et al. 2012). Schwarz et al. (2010) reported sightings of spinner dolphins during surveys between 12°−17°N and 104°−108°W, from late August−November 2007. One individual was seen in the proposed study area during surveys in April−August 2008 (Hauser et al. 2008). There are 91 records in the OBIS database for the proposed study area and ~2000 records in adjacent waters; records were reported from August through November (OBIS 2025).

3.3.2.14 Striped Dolphin (*Stenella coeruleoalba*)

The striped dolphin has a cosmopolitan distribution in tropical to warm temperate waters from ~50°N to 40°S (Perrin et al. 1994a; Jefferson et al. 2015). It is typically found in waters outside the continental shelf and is often associated with convergence zones and areas of upwelling; however, it has also been observed approaching shore where there is deep water close to the coast (Jefferson et al. 2015). It is common in the ETP up to 25°N (Perrin et al. 1985). In the ETP, striped dolphin distribution is associated with cool, upwelling areas along the Equator (Au and Perryman 1985).

During surveys of the EEZ of Pacific Mexico, 160 sightings of striped dolphins were made (Gerrodette and Palacios 1996). Polacheck (1987) noted that the highest encounter rates in the ETP were off western Mexico. Based on surveys conducted during July−December 1986−1996, Ferguson and Barlow (2001) reported a density of up to 0.1417/km^2 for the proposed study area. Sightings of striped dolphins were also made in and near the proposed study area during surveys in 1998−2000 (Forney et al. 2012) and 2003 (Jackson et al. 2004). Schwarz et al. (2010) reported sightings during surveys between 12°−17°N and 104°−108°W, from late August−November 2007. There are 77 records in the OBIS database for the proposed study area and 863 records in adjacent waters; records were reported for August through November (OBIS 2025).

3.3.2.15 Common Dolphin (*Delphinus delphis*)

The common dolphin is found in oceanic and nearshore waters of tropical and warm temperate oceans around the world, ranging from ~60ºN to ~50ºS (Jefferson et al. 2015). Based on Perrin (2018c), here we assume that there are currently three recognized subspecies of common dolphin, including *D. delphis delphis* (the short-beaked form), *D. delphis bairdii* (the long-beaked form, formerly known as *D. capensis*), and *D. delphis tropicalis* (Indian Ocean subspecies). However, Jefferson et al. (2024) consider the long-beaked form that occurs in the ETP as a separate species (*D. bairdii*). The long-beaked form generally prefers shallower water (Perrin 2018c), typically occurring within 180 km from shore (Jefferson et al. 2015). The common dolphin is very abundant in the ETP (Perrin 2018c) and its distribution there is associated with cool, upwelling areas along the Equator and off the Baja California Peninsula, Central America, and Peru (Au and Perryman 1985; Reilly 1990; Reilly and Fiedler 1994; Ballance et al. 2006). Reilly (1990) noted no seasonal changes in common dolphin distribution, although Reilly and Fiedler (1994) observed interannual changes in distribution that were likely attributable to El Niño events.

Only the short-beaked form is expected to occur within the proposed study area. During surveys of the Pacific EEZ of Mexico, 92 sightings of short-beaked and 74 sightings of long-beaked common dolphins were made. The density of both the short- and long-beaked forms of common dolphin were reported as zero for the proposed study area based on July−December 1986−1996 surveys (Ferguson and Barlow 2001). However, sightings of the short-beaked form of common dolphins were also made in the proposed study area during surveys in 1998−2000 (Forney et al. 2012) and 2003 (Jackson et al. 2004). Schwarz et al. (2010) reported sightings between 12°−17°N and 104°−108°W, from late August−November 2007. Common dolphins were seen south of the proposed study area during surveys in April−August 2008 (Hauser et al. 2008). There are no records of short-beaked common dolphins in the OBIS database for the proposed study area, but there are four sightings in adjacent waters during November; there are no records for the long-beaked form (OBIS 2025).

3.3.2.16 Fraser's Dolphin (*Lagenodelphis hosei*)

Fraser's dolphin is a tropical oceanic species distributed between 30°N and 30°S that generally inhabits deep oceanic water (Dolar 2018). It occurs rarely in temperate regions and then only in relation to temporary oceanographic anomalies such as El Niño events (Perrin et al. 1994b). The species occurs throughout the ETP (Perrin et al. 1973, 1994b) and has been sighted there at least 15 km from shore in waters 1500−2500 m deep (Dolar 2018). Wade and Gerrodette (1993) showed a mainly equatorial distribution in the ETP and estimated its abundance in the area at 289,300 individuals. Pitman and Ballance (1992) also noted its occurrence in the ETP. González et al. (2008) reported the presence of Fraser's dolphin off the west coast of Mexico between 18° and 23°N, as well as the possible presence south of 18°N. The density of Fraser's dolphin in the proposed study area was zero based on 1986−1996 surveys, but the density to the southwest was 0.0379/km^2 (Ferguson and Barlow 2001). There are no sightings for the waters in or near the proposed study area in the OBIS database (OBIS 2025).

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

The short-finned pilot whale is found in tropical and warm temperate waters (Olson 2018); it is seen as far south as ~40ºS and as far north as ~50ºN (Jefferson et al. 2015). Pilot whales are generally nomadic, but may be resident in certain locations, such as California and Hawaii (Olson 2018). Pilot whales occur on the shelf break, over the slope, and in areas with prominent topographic features (Olson 2018). Based on genetic data, Van Cise et al. (2016) suggested that two types of short-finned pilot whales occur in the Pacific − one in the western and central Pacific, and one in the Eastern Pacific; they hypothesized that prey distribution rather than sea surface temperature determine their latitudinal ranges.

Pilot whales have a wide distribution throughout the ETP, but are most abundant in colder waters where upwelling occurs (Wade and Gerrodette 1993). Polacheck (1987) noted that encounter rates for pilot whales in the ETP were highest inshore, and that offshore concentrations may also occur, but at lower densities (Polacheck 1987). During surveys of the EEZ of Pacific Mexico, 15 sightings of short-finned pilot whales were made (Gerrodette and Palacios 1996). Densities in the proposed study area ranged up to 0.01/km^2 based on 1986−1996 surveys (Ferguson and Barlow 2001). Sightings within or near the proposed study area were also made during July−December surveys in 1998−2000 (Forney et al. 2012), during July−December 2003 (Jackson et al. 2004), and April−August 2008 (Hauser et al. 2008). There are no records in the OBIS database for the proposed study area, but there are 256 records for adjacent waters during August through November (OBIS 2025).

3.3.2.18 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 tend to be more common in nearshore areas and at higher latitudes (Jefferson et al. 2015). Nonetheless, they can be found throughout the ETP (Pitman and Ballance 1992; Wade and Gerrodette 1993), but are most densely distributed near the coast from 35ºN to 5ºS (Dahlheim et al. 1982). Dahlheim et al. (1982) noted the occurrence of a cluster of sightings at two offshore locations in the ETP. One location was bounded by 7−14ºN and 127−139ºW, and the other was within a band between the Equator and 5ºN and from the Galápagos Islands to 115ºW.

During surveys of the EEZ of Pacific Mexico, 15 sightings of killer whales were made (Gerrodette and Palacios 1996). Densities of killer whales in the proposed study area based on 1986−1996 surveys ranged up to 0.0007/km^2 (Ferguson and Barlow 2001). One sighting was made west of the proposed study area during July−December surveys in 2003 (Jackson et al. 2004). There are no records in the OBIS database for the proposed study area, but there are 12 records in adjacent waters; records were reported for August through September (OBIS 2025).

3.3.2.19 False Killer Whale (*Pseudorca crassidens*)

The false killer whale is found worldwide in tropical and temperate waters, generally between 50ºN and 50ºS (Odell and McClune 1999). It is widely distributed, but rare to uncommon throughout its range (Baird 2018b). The false killer whale generally inhabits deep, offshore waters, but sometimes is found over the continental shelf and occasionally moves into very shallow water (Jefferson et al. 2015). In the North Pacific, it occurs from Japan and southern California, southward and across the Pacific, including Hawaii.

Wade and Gerrodette (1993) noted the occurrence of false killer whales especially along the Equator. False killer whales in the ETP are usually seen far offshore (Wade and Gerrodette 1983). During surveys of the EEZ of Pacific Mexico, during July−December 1986−1990, 1992 and 1993, three sightings of false killer whales were made (Gerrodette and Palacios 1996). Douglas et al. (2023) reported 24 sightings totaling 103 false killer whales in the Pacific waters of Mexico from 1991 to 2022. The density of this species in the proposed study area based on 1986−1996 surveys was zero, although adjacent areas had densities up to 0.0043/km^2 (Ferguson and Barlow 2001). There are no sightings in the OBIS database for the waters in and adjacent to the proposed study area (OBIS 2025).

3.3.2.20 Pygmy Killer Whale (*Feresa attenuata*)

The pygmy killer whale has a worldwide distribution in tropical waters (Baird 2018c), generally not ranging south of 35°S (Jefferson et al. 2015). In the North Pacific, it occurs from Japan and to the Baja California Peninsula, southward and across the Pacific Ocean, including Hawaii. In warmer water, it is usually seen close to the coast (Wade and Gerrodette 1993), but it is also found in deep waters. Pygmy killer whales are known to occur in the ETP (e.g., Van Waerebeek and Reyes 1988; Pitman and Ballance 1992; Wade and Gerrodette 1993; Gerrodette and Palacios 1996). During surveys of the EEZ of Pacific Mexico, during July−December 1986−1990, 1992 and 1993, 13 sightings of pygmy killer whales were made (Gerrodette and Palacios 1996). Densities of this species in the proposed study area, based on 1986−1996 surveys, ranged up to 0.0154/km^2 (Ferguson and Barlow 2001). Sightings were also made during surveys between 12°−17°N and 104°−108°W, from late August−November 2007 (Schwarz et al. 2010). A group of three pygmy killer whales was seen in the proposed study area during surveys in April−August 2008 (Hauser et al. 2008). There are no records in the OBIS database for the proposed study area, but there are five records in adjacent waters during October 1998 (OBIS 2025).

3.3.2.21 Melon-headed Whale (*Peponocephala electra*)

The melon-headed whale is an oceanic species found worldwide in tropical and subtropical waters from ~40°N to 35°S (Jefferson et al. 2015). It is commonly seen in mixed groups with other cetaceans (Jefferson and Barros 1997). It occurs most often in deep offshore waters and occasionally in nearshore areas where deep oceanic waters occur near the coast (Perryman and Danil 2018). In the North Pacific, it is distributed south of central Japan and southern California, as well as across the Pacific, including Hawaii. Au and Perryman (1985) and Perryman et al. (1994) reported that the melon-headed whale occurs primarily in equatorial waters, although Wade and Gerrodette (1993) noted its occurrence in non-equatorial waters. Based on surveys conducted during 1986−1996, the density of this species in the proposed study area ranged up to 0.0007/km^2 (Ferguson and Barlow 2001). There are no sightings in the OBIS database within the proposed study area, but there were 327 records for September 1989 and October 2003 between 11.3°−12.8°N and 102.9°−103.0°W (OBIS 2025).

3.4 Sea Turtles

Five sea turtle species could occur in the proposed study area (Table 5). Under the ESA, the leatherback, hawksbill, and North Pacific Ocean DPS of the loggerhead turtle are listed as ***endangered***, and the olive ridley population on the Pacific coast of Mexico is listed as ***endangered*** whereas other populations are listed as ***threatened***; the East Pacific DPS of the green turtle is also listed as ***threatened***.

TABLE 5. The habitat, occurrence, and conservation status of sea turtles that could occur in or near the proposed study area in the Eastern Tropical Pacific.

Species	Habitat	Occurrence in Study Area	ESA[1]	IUCN[2]	CITES[3]
Leatherback sea turtle	Beaches (nesting females); oceanic (juveniles and foraging adults)	Uncommon	EN	VU	I
Loggerhead sea turtle *North Pacific Ocean DPS*	Beaches (nesting females); coastal/oceanic (juveniles); coastal (foraging adults); oceanic (migration)	Uncommon	T	VU	I
Green sea turtle *East Pacific DPS*	Beaches (nesting females); oceanic (juveniles and migrating adults); coastal (foraging adults)	Uncommon	T	EN	I
Hawksbill sea turtle	Beaches (nesting females); coastal/oceanic (juveniles); coastal (foraging adults)	Uncommon	EN	CR	I
Olive ridley sea turtle	Beaches (nesting females); coastal/oceanic (juveniles); coastal (foraging adults)	Common	EN	VU	I

[1] U.S. Endangered Species Act (ESA): EN = Endangered; T = Threatened.

[2] International Union for the Conservation of Nature Red List of Threatened Species, version 2025-1 (IUCN 2025): CR = Critically Endangered; E = Endangered; VU = Vulnerable.

[3] Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES; UNEP-WCMC 2025): Appendix I = Threatened with extinction.

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 Southern California and the Galápagos Ridge are discussed in § 3.4.2.3 and 3.4.2.5 of the PEIS, respectively. The rest of this section deals specifically with the distribution of sea turtles within the proposed study area in the ETP.

3.4.1 Leatherback Turtle (*Dermochelys coriacea*)

The leatherback turtle is the largest and most widely distributed sea turtle, occurring from 71°N to 47°S (Eckert et al. 2012). It ranges far from its tropical and subtropical breeding grounds to feed (Plotkin 2003). During the non-breeding season, leatherback turtles range far from their tropical and subtropical nesting grounds to feed (Plotkin 2003). Nesting beaches are generally 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).

Leatherback turtles in the Pacific are divided into two genetically distinct stocks: the East Pacific stock or DPS nests at rookeries along the west coast of the Americas from Mexico to Ecuador; and the West Pacific stock or DPS nests at rookeries in Papua, Indonesia; Papua New Guinea; and the Solomon Islands (Dutton 2006; Wallace and Hutchinson 2016; NMFS and USFWS 2020). 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); however, individuals from the West Pacific DPS typically do not occur within the proposed study area.

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.

There have been significant declines and some extirpations of nesting populations in the Pacific (Spotila et al. 2000; Dutton et al. 2007). 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). There were also large declines at Mexican beaches (Benson et al. 2015), with 70,000 nesting females in 1982 plummeting to <250 in 1998 (Spotila et al. 2000). Sarti et al. (1994 *in* NMFS and USFWS 2020) noted the declines were due to egg harvesting, killing of adult female, and changes in reproductive biology. Currently, it is estimated that there are 755 nesting females in the East Pacific DPS and 1277 breeding females in the West Pacific DPS (NMFS and USFWS 2020).

In the eastern Pacific, leatherbacks nest primarily along the coast of Mexico, Costa Rica, and Nicaragua, from September–March. Telemetry data has shown that most nesting females moved south (through the proposed study area) from Mexiquillo towards the Southeast Pacific Ocean to forage (Eckert and Sarti 1997). The largest nesting aggregations are found in Mexico, where nesting occurs in 11 states (Sarti 2002 *in* NMFS and USFWS 2020). The majority of turtles (70–75%) nest at Playa Mexiquillo (Michoacán); Playa de Tierra Colorada (Guerrero); and Cahuitán, Chacahua, and Barra de la Cruz in Oaxaca (Gaona Pineda and Barragán Rocha 2016 *in* NMFS and USFWS 2020). The mean clutch frequency is 5.5 nests per season; clutch size averages 62–64 eggs (Sarti Martínez et al. 2007; NMFS and USFWS 2020). The proposed study area is expected to have a low probability of encounter (Lopez et al. 2024) and low use by leatherbacks (Roe et al. 2014). However, some sightings have been made within and near the study area (Pitman 1990; Smultea and Holst 2003; Roe et al. 2014; Lopez et al. 2024). There are no records in the OBIS database for the waters in or adjacent to the proposed study area (OBIS 2025).

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 (Seminoff et al. 2015). Each female has an average of 3.1 nests/year at Michoacán (Seminoff et al. 2015).

Nesting occurs in Michoacán, Mexico, from August−January, with a peak in October−November (Alvarado and Figueroa 1995). Green sea turtles also nest in Central America (SWOT 2011). Sightings of possible green sea turtles were seen within the proposed study area during surveys in July 2003 (Smultea and Holst 2003) and in April−August 2008 (Hauser et al. 2008). There are no records in the OBIS database for the waters in and adjacent to the proposed study area (OBIS 2025).

3.4.3 Hawksbill Sea Turtle (*Eretmochelys imbricata*)

Hawksbill turtles are the most tropical of all sea turtles. They occur in the waters of at least 82 nations and nest on the beaches of ~60 of those (Spotila 2004). The hawksbill is a solitary nester, and population trends or estimates are difficult to determine. However, a minimum of 20,000−26,000 females are thought to nest annually (Spotila 2004); since females nest once every three years, the total adult female population is estimated at 60,000−78,000 females (Spotila 2004).

Nesting is confined to areas where water temperature is 25º−35ºC and occurs in the spring and summer. Hawksbill turtles nest on low and high-energy beaches, often sharing high-energy locations with green turtles. Hawksbill turtles most commonly perform short-distance movements between nesting beaches and offshore feeding banks, although long-distance movements are also known. Post-hatchlings are believed to be pelagic, taking shelter in weed lines around convergence zones, and they re-enter coastal waters once attaining a length of ~20−25 cm. Hawksbill turtles are observed in shallow waters with seagrass or algal meadows, and are most common where reef formations are present. They live in clear, littoral waters of mainland and island shelves.

No major nesting sites for hawksbill turtles occur on the Pacific coast of Mexico or Central America, although a few hawksbills are known to nest at the La Flor National Wildlife Refuge in Nicaragua (SWOT 2008) and at Punta Banco, Caña Blanca, and Playa Caletas in Costa Rica (Gaos et al. 2006; SWOT 2008). Hawksbill turtles also reportedly nested at Barra de Santiago in El Salvador decades ago, but now only occur there sporadically (Hasbún and Vásquez 1999). Chiriqui Beach in western Panama was once famous for its huge nesting colony of hawksbill turtles (Spotila 2004), but was essentially abandoned by 1990 due to overharvesting. Efforts to restore the beach have progressed and in recent years several hundred nests have been observed (Spotila 2004). The nesting season of the hawksbill turtle is approximately six months in duration; nesting generally occurs from June−December. For the ETP, Pitman (1990) reported three sightings off Mexico and one sighting off Central America. There are no sightings in the OBIS database for the proposed study area, but there are three records in adjacent waters from August to November (OBIS 2025).

3.4.4 Olive Ridley Sea Turtle (*Lepidochelys olivacea*)

Olive ridley turtles are pantropical, occurring in waters with temperatures of at least 20ºC or 68ºF; they have a large range in the Pacific, Indian, and South Atlantic oceans. They travel between breeding and feeding grounds in continental coastal waters and are rare around oceanic islands. The worldwide population of olive ridley turtles is estimated at 2 million nesting females (Spotila 2004).

Most olive ridleys nest synchronously in huge colonies called “arribadas”, with several thousand females nesting at the same time; others nest alone, out of sequence with the arribada (Kalb and Owens 1994). The arribadas usually last from three to seven nights (Aprill 1994). Satellite telemetry of nesting cohorts (small groups of females that arrive at the nesting beach at the same time) indicates that an arribada is not a social event, but rather an aggregation of turtles reacting in a similar way to as-yet-unknown common stimuli (Plotkin et al. 1991). Most females lay two clutches of eggs with an inter-nesting period of 1−2 months (Plotkin et al. 1994a). Radio-tracking studies have shown that females that nested in arribadas remain within 5 km of the beach most of the time during the inter-nesting period (Kalb and Owens 1994).

Reasons for the timing of, and even the occurrence of, arribadas are not clear. Chaves et al. (1994) reported that arribadas follow a lunar cycle, with nesting during the new moon, in the darkest nights, starting during the high tide. At Playa La Flor, Nicaragua, during August 1993−January 1994, six arribadas occurred, arriving every 23−30 days without relation to the moon phase (Ruiz 1994). During the same period, turtles emerged during the day and night in September and October, but only at night in the other months (Cerna et al. 1996). In some cases, an arribada will skip a month. In a study of inter-nesting behavior at Nancite, Costa Rica, in 1990 and 1991, Plotkin et al. (1995) noted that there were arribadas in September and November, but not in October, contrary to expectations. In 1991, there were arribadas in each month from September−December. Hatching success of olive ridley nests in arribada beaches is low. Especially when the arribadas are large, many of the eggs are destroyed by the turtles themselves (Alvarado 1990).

Although most mating is generally assumed to occur near nesting beaches, Pitman (1990) observed olive ridleys mating at sea in the ETP, as far as 1850 km from the nearest mainland, during every month of the year except March and December. However, there was a sharp peak in offshore mating activity during August and September, corresponding with peak breeding activity in mainland populations. Fifty of 324 turtles observed during NMFS/SWFC dolphin surveys during July−December 1998 and 1999 were involved in mating (Kopitsky et al. 2002). Aggregations of turtles[2], sometimes >100 individuals, have been observed as far offshore as 120°W, ~3000 km from shore (Arenas and Hall 1991). Arribadas take place in Oaxaca at Ixtapilla, Santuario Playa de Escobilla (the largest), and Morro Ayuta; the number of clutches at each of these sites falls within the range of 100,000 to 1 million (SWOT 2021).

Outside of the breeding season, the turtles disperse, but little is known of their behavior. Neither males nor females migrate to one specific foraging area, but exhibit a nomadic movement pattern and occupy a series of feeding areas in oceanic waters (Plotkin et al. 1994a,b, 2010). Typically, turtles will feed during the morning and bask on the water's surface in the afternoon. Olive ridleys are primarily carnivorous, feeding on crabs, jellyfish, and fish eggs. They feed on algae if no other food is available. They are generally thought to be surface feeders, but have been caught in trawls at depths of 80−110 m (NMFS and USFWS 1998).

The Pacific population migrates from their nesting grounds in Mexico and Central America to the North Pacific (NMFS 2002). The post-nesting migration routes of olive ridleys tracked via satellite from Costa Rica traversed thousands of kilometers of deep oceanic waters ranging from Mexico to Peru, and more than 3000 km out into the central Pacific (Plotkin et al. 1994b, 2010). The olive ridley is considered the most abundant sea turtle in the open ocean waters of the ETP (Pitman 1990), and the population there is estimated to number 1.39 million (Eguchi et al. 2007). Pitman (1990) compiled sightings of hardshell turtles (the vast majority were olive ridleys) in the ETP for a period of 15 years; in the vicinity of the proposed study area, densities ranged up to 75 turtles per 2° square. Eguchi et al. (2007) estimated at-sea densities of olive ridleys in the ETP from surveys conducted in summer/autumn from 1992−2006; in the northern stratum, which includes the proposed study area, olive ridley densities ranged from ~0.02−0.16 turtles/km^2. Satellite-tracked olive ridleys have been recorded in the proposed study area (Figgener et al. 2022), and Hauser et al. (2008) also reported olive ridley sea turtles within the proposed study area during surveys in April−August 2008. Montero et al. (2016) reported bycatch of olive ridleys in the purse-seine fishery within the proposed study area. There are no records in the OBIS database for

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[2] Of sea turtles observed at sea, 75% were olive ridleys.

the proposed study area, but there are five records in adjacent waters for September to November (OBIS 2025).

3.4.5 Loggerhead Sea Turtle (*Carretta caretta*)

The loggerhead turtle is a widely distributed species occurring in coastal tropical and subtropical waters around the world. The global population is estimated at 43,320−44,560 nesting females (Spotila 2004). Loggerhead turtles (juveniles and adults) are suspected to take long migrations using warm water currents such as the Gulf Stream that bring them far from their breeding grounds. Loggerheads may be seen in the open seas during these migrations and may actually remain in pelagic existence for many years (e.g., for up to 12 years in the North Atlantic Gyre). Loggerheads prefer to feed in coastal bays and estuaries, and in the shallow waters along the continental shelves of the Atlantic, Pacific, and Indian oceans. Adult loggerheads feed on a variety of benthic fauna like conchs, crabs, shrimp, sea urchins, sponges, and fish. During the migration through the open sea, they eat jellyfish, pteropods, floating mollusks, floating egg clusters, flying fish, and squid.

Major nesting areas are located in the southeastern U.S., Yucatán Peninsula of Mexico, Columbia, Cuba, South Africa, eastern Australia, and Japan (Márquez 1990). During or shortly after the March−August breeding season, females disperse to distant feeding grounds via poorly delineated migration routes. While the loggerhead turtle is found in eastern Pacific waters, nesting in the Pacific is largely restricted to Japan and eastern Australia (Spotila 2004). The size structure of loggerheads in coastal and nearshore waters of the eastern and western Pacific suggest that Pacific loggerheads have a pelagic stage similar to that in the Atlantic (NMFS 2002); loggerheads spend the first 2−6 years of their lives at sea. Large aggregations (thousands) of mainly juveniles and subadult loggerheads are found off the southwestern coast of Baja California (Nichols et al. 2000). Pitman (1990) also reported sightings off Baja California. When they mature, they return to breed at the western Pacific beaches where they were hatched. Migratory routes across the Pacific appear to occur north of the proposed study area (SWOT 2018; Nichols et al. 2000). Telemetry data did not show any records of loggerheads within the proposed study area (SWOT 2018). There are no records in the OBIS database for the waters adjacent to the proposed study area (OBIS 2025).

3.5 Seabirds

One ESA-listed seabird species, the ***threatened*** Galápagos petrel, could occur in the proposed study area in the ETP. This species is listed as critically endangered on the IUCN Red List of Threatened Species (IUCN 2025).

3.5.1 Galápagos Petrel (*Pterodroma phaeopygia*)

The population of the Galápagos petrel has been reduced to an estimated 10,000−19,999 individuals (BirdLife International 2018). This decline is attributed to introduced predators and habitat destruction, the latter caused in part by introduced plant species and by herbivory and trampling from introduced livestock (Carboneras et al. 2020). Current threats include collisions with powerlines and towers, long-line fisheries, and climate change (BirdLife International 2018; Carboneras et al. 2020).

The Galápagos petrel nests in humid highlands on several of the islands of the Galápagos archipelago (Brooke 2004). The timing of the breeding season is variable and is occasionally drawn out (Carboneras et al. 2020). Egg laying usually takes place from May to October, but occasionally from November to March. This species is colonial, with nests in burrows excavated amongst dense vegetation (BirdLife International 2018). The single egg is incubated for 46 to 53 days and the nestling fledges 98 to 112 days after hatching (Carboneras et al. 2020). At sea, the Galápagos petrel occurs in the ETP east of 120°W and primarily between 20°N and 20°S (Bartle et al. 1993; Spear et al. 1995). During the breeding season it is found primarily within 500 km of the colonies (Carboneras et al. 2020). The Galápagos petrel could be encountered in small numbers in the proposed study area.

3.6 Fish of Conservation Concern

Three ESA-listed fish species could occur in the proposed study area in the ETP: the ***threatened*** oceanic whitetip shark and giant manta ray, and the ***endangered*** Eastern Pacific DPS of scalloped hammerhead shark (Table 6); these species are described below. No marine invertebrate species listed under the ESA occur within or near the proposed study area. There are currently no marine fish or invertebrate species proposed for listing under the ESA. However, the tope shark (*Galeorhinus galeus*) and smalltail shark (*Carcharhinus porosus*) are candidate species for listing, but are unlikely to occur in the deep offshore study area; thus, these two species are not discussed further.

3.6.1 Scalloped Hammerhead Shark (*Sphyrna lewini)*

The scalloped hammerhead shark inhabits warm temperate and tropical waters (Maguire et al. 2006; Miller et al. 2014). It occurs in coastal and estuarine waters, but also inhabits open water over continental and insular shelves, as well as deeper waters, with depths up to 1000 m (Miller et al. 2014). Reproduction occurs annually, with a gestation time of 9−12 months (Florida Museum 2025). Females move inshore to give birth to litters of 1–41 pups (Miller et al. 2014). The scalloped hammerhead shark is very mobile and partly migratory (Maguire et al. 2006), traveling distances up to 1941 km between aggregations of food sources (Bessudo et al. 2011), eventually returning to its original habitat, displaying site fidelity (Miller et al. 2014). Juveniles and adults can be solitary or travel in pairs; they also school in productive regions, such as over seamounts or near islands (Miller et al. 2014).

TABLE 6. The habitat and conservation status of ESA-listed fish species that could occur in or near the proposed study area in the Eastern Tropical Pacific.

Species	Habitat	ESA[1]	IUCN[2]	CITES[3]
Scalloped Hammerhead Shark	Coastal, shelf, pelagic; partly migratory	EN	CR	II
Giant Manta Ray	Coastal-pelagic; migratory; deep-diving	T	EN	II
Oceanic Whitetip Shark	Pelagic; migratory	T	CR	II

NL = Not listed/not listed in Mexico.

[1] U.S. Endangered Species Act (ESA): EN = Endangered, T = Threatened.

[2] International Union for the Conservation of Nature Red List of Threatened Species, version 2025-1 (IUCN 2025): CR = Critically Endangered, E = Endangered, VU = Vulnerable.

[3] Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES; UNEP-WCMC 2025): Appendix I = Threatened with extinction; Appendix II = not necessarily now threatened with extinction but may become so unless trade is closely controlled.

3.6.2 Oceanic White Tip Shark (*Carcharhinus longimanus)*

The oceanic white tip shark is an offshore pelagic species inhabiting surficial waters in the open ocean, occurring worldwide typically between 20ºN and 20ºS but also at higher latitudes during the summer months (Lessa et al. 1999). This species spends most of its time in waters <200 m but has been found down to 1082 m (Howey-Jordan et al. 2013). Oceanic whitetip sharks are aggressive and persistent and prey on bony fishes such as tunas, barracuda, white marlin, dolphinfish, lancetfish, oarfish, threadfish and swordfish, along with threadfins, stingrays, sea turtles, seabirds, gastropods, squid, crustaceans, and mammalian carrion (NOAA 2025a). Oceanic whitetip sharks can reach a maximum size of 395 cm (Lessa et al. 1999) and can live up to 18 years (D'Alberto et al. 2016).

3.6.3 Giant Manta Ray (*Mobula birostris)*

Giant manta rays are migratory and cold-water tolerant, with highly fragmented populations sparsely distributed in tropical, subtropical, and temperate waters of the world (NOAA 2025b) in water depths up to 1000 m deep (Marshall et al. 2008). Giant manta rays are the largest living ray in the world, reaching a disc width of 7 m (Marshall et al. 2008) and weighing >1300 kg (Bigelow and Schroeder 1953). Giant manta rays tend to be solitary (DoW 2015); however, aggregations can occur in predictable foraging grounds (NOAA 2025b). This species filter-feeds virtually exclusively on plankton (DoW 2015). Female maturity is reached at 8−10 years, and they can live up to 40 years (Marshall et al. 2008). Regional population sizes are small and have generally declined in known areas except where specifically protected (Miller and Klimovich 2017).

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, 2019, 2022; Kunc et al. 2016; National Academies of Sciences, Engineering, and Medicine 2017; Weilgart 2017a; Bröker 2019; Rako-Gospić and Picciulin 2019; Burnham 2024). 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 (Hastie et al. 2019; Martin et al. 2020; Zeddies et al. 2024) and may become less harmful over distance from the source (Hastie et al. 2019).

Temporary Threshold Shift (TTS) is not considered an injury as it is a temporary impairment of hearing (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; Houser 2021). Although the possibility cannot be entirely excluded, based on the information provided below, it would be 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 were encountered during an active survey, 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 (e.g., Richardson et al. 1995; Southall et al. 2021). 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 (see summaries below; Richardson et al. 1995; Southall et al. 2021). 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 (the portion of time the array is actively operating), 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 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); reverberation can presumably reduce 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, 2020; Blackwell et al. 2013, 2015; Thode et al. 2020; Fernandez-Betelu et al. 2021; Noad and Dunlop 2023). 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. Kastelein et al. (2023) reported masking release at various frequencies in harbor seals exposed to noise with fluctuating amplitude; that is, masking was reduced when the noise had fluctuating amplitude. 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, 2023; New et al. 2013b; Nowacek et al. 2015; Forney et al. 2017). Kastelein et al. (2019a) surmised that if disturbance by noise would displace harbor porpoises from a feeding area or otherwise impair foraging ability for a short period of time (e.g., 1 day), they would be able to compensate by increasing their food consumption following the disturbance.

Southall et al. (2023) proposed data collection and analysis methods to examine the potential effects, including at the population level, of seismic surveys on whales. Several studies have attempted modeling to assess consequences of effects from underwater noise at the population level; this has proven to be complicated by numerous factors including variability in responses between individuals (e.g., New et al. 2013b; King et al. 2015; Costa et al. 2016a,b; Ellison et al. 2016; Harwood et al. 2016; Nowacek et al. 2016; Farmer et al. 2018; Dunlop et al. 2021; Gallagher et al. 2021; McHuron et al. 2021; Mortensen et al. 2021). Booth et al. (2020) examined monitoring methods for population consequences.

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; many data gaps remain where exposure criteria are concerned (Southall 2021).

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). Kavanagh et al. (2019) analyzed more than 8000 hr of cetacean survey data in the northeastern Atlantic Ocean to determine the effects of the seismic surveys on cetaceans. They found that sighting rates of baleen whales were significantly lower during seismic surveys compared with control surveys.

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, 2020). 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 $\mu\text{Pa}^2 \cdot \text{s}$ (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 $\mu\text{Pa}^2 \cdot \text{s}$ (Dunlop et al. 2017b, 2018). These results are consistent with earlier studies (e.g., McCauley et al. 2000). Dunlop et al. (2020) found that humpback whales reduce their social interactions at greater distances and lower received levels than regulated by current mitigation practices.

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; Stone et al. 2017). 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). During a seismic survey in Cook Inlet, AK, wide-scale displacement was documented for humpback whales; acoustic detections were reduced or absent during the seismic survey period, but detections increased after the survey finished (Castellote et al. 2020).

Matthews and Parks (2021) summarized the known responses of right whales to sounds; however, there are no data on reactions of right whales to seismic surveys. 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 $\text{CSEL}_{\text{10-min}}$ (SEL_{cum} over a 10-min period) of ~94 dB re 1 $\mu\text{Pa}^2 \cdot \text{s}$, decreased at $\text{CSEL}_{\text{10-min}}$ >127 dB re 1 $\mu\text{Pa}^2 \cdot \text{s}$, and whales were nearly silent at $\text{CSEL}_{\text{10-min}}$ >160 dB re 1 $\mu\text{Pa}^2 \cdot \text{s}$. Thode et al. (2020) reported similar changes in bowhead whale vocalizations when data were analyzed for the period 2008–2014. 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, despite rigorous monitoring and mitigation measures during multiple seismic surveys in 2015 (Aerts et al. 2022; Rutenko et al. 2022), data collected during a program with multiple seismic surveys in 2015 showed short-term and long-term displacement of animals from the feeding area, at least short-term behavioral changes, and responses to lower sound levels than expected (Gailey et al. 2017, 2022a,b; Sychenko et al. 2017). However, stochastic dynamic programming (SDP) model predictions showed similar reproductive success and habitat use by gray whales with or without exposure to airgun sounds during the 2015 program (Schwarz et al. 2022).

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; Stone et al. 2017). Sighting rates for fin and sei whales were similar when large arrays of airguns were operating vs. silent (Stone 2015; Stone et al. 2017). 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; Stone et al. 2017). 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; Stone et al. 2017). 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; Monaco et al. 2016; Stone et al. 2017; Barkaszi and Kelly 2024). 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; Stone et al. 2017). 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; Stone et al. 2017). 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; Stone et al. 2017). 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; Stone et al. 2017).

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.

Similarly, an analysis of protected species observer data from multiple seismic surveys in the northern Gulf of America from 2002−2015 found that delphinids occurred significantly farther from the airgun array when it was active versus silent (Barkaszi and Kelly 2024). Dolphins were sighted significantly farther from the active array during operations at minimum power versus full power. Blackfish were seen significantly farther from the array during ramp up versus full source and minimum source operations, and they were seen significantly closer to the array when it was silent versus during full source, minimum source, and ramp up operations.

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. However, Heide-Jørgensen et al. (2021) did report avoidance reaction at distances >11 km from an active seismic vessel, as well as an increase in travel speed and changes in direction of travel at distances up to 24 km from a seismic source; however, no long-term effects were reported. Tervo et al. (2021) reported that narwhal buzzing rates decreased in response to concurrent ship noise and airgun pulses (being 50% at 12 km from ship) and that the whales discontinued to forage at 7−8 km from the vessel. Tervo et al. (2023) also noted that narwhals showed increased shallow diving activity and avoided deeper diving, resulting in a reduction in foraging, when exposed to combined ship sounds and airgun pulses. Both studies found that exposure effects could still be detected >40 km from the vessel (Tervo et al. 2021, 2023).

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 America 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; Stone et al. 2017). Foraging behavior can also be altered upon exposure to airgun sound (e.g., Miller et al. 2009), which according to Farmer et al. (2018), could have significant consequences on individual fitness. Preliminary data from the Gulf of America show a correlation between reduced sperm whale acoustic activity and periods with airgun operations (Sidorovskaia et al. 2014). Barkaszi and Kelly (2024) found that sperm whales occurred at significantly farther CPAs from airgun array during full array activity versus silence based on data from multiple seismic surveys in the northern Gulf of America during 2002−2015; similar results were found for both dwarf and pygmy sperm whales.

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 would be 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; Stone et al. 2017). 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). Data from multiple seismic surveys in the northern Gulf of America from 2002−2015 showed no significant difference in beaked whale CPA distances to the airgun array during full power versus silent periods, but the sample size was small, and mean CPA was larger than in other species groups (Barkaszi and Kelly 2024).

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; Stone et al. 2017). 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; Stone et al. 2017). Thompson et al. (2013) reported decreased densities and reduced acoustic detections of harbor porpoise in response to a seismic survey in Moray Firth, Scotland, at ranges of 5−10 km (SPLs of 165−172 dB re 1 µPa, SELs of 145−151 dB $\mu Pa^2 \cdot s$). For the same survey, Pirotta et al. (2014) reported that the probability of recording a porpoise buzz decreased by 15% in the ensonified area, and that the probability was positively related to the distance from the seismic ship; the decreased buzzing occurrence may indicate reduced foraging efficiency. Nonetheless, animals returned to the area within a few hours (Thompson et al. 2013). Similar avoidance behavior and/or decreases in echolocation signals during 3-D seismic operations were reported for harbor porpoise in the North Sea (Sarnocińska et al. 2020). 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). During a seismic survey in Cook Inlet, AK, wide-scale displacement was documented for harbor porpoises; acoustic detections were reduced or absent during the seismic survey, but detections increased after the survey finished (Castellote et al. 2020).

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

Odontocete reactions to large arrays of airguns are variable and, at least for delphinids, seem to be confined to a smaller radius than has been observed for the more responsive of the mysticetes and some other odontocetes. A ≥170 dB disturbance criterion (rather than ≥160 dB) is considered appropriate for delphinids, which tend to be less responsive than the more responsive cetaceans. According to Scholik-Schlomer (2015), NMFS is developing new guidance for predicting behavioral effects. 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; Stone et al. 2017). No significant differences in detection rates were apparent for harbor seals during seismic and non-seismic periods (Stone 2015; Stone et al. 2017). There were no significant differences in CPA distances of gray or harbor seals during seismic vs. non-seismic periods (Stone 2015; Stone et al. 2017). 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 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). Additionally, Nelms et al. (2016) suggested that sea turtles could be excluded from critical habitats during seismic surveys. Green and hawksbill turtles were found to respond to low-frequency sounds (i.e., 0.2−1 kHz upsweeps), but did not respond to impulsive sounds (Kastelein et al. 2024a).

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 would 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, 2019; 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 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, 2023a; 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, 2020a,b,c,d,e,f, 2021a,b, 2022a,b; Supin et al. 2016; von Benda-Beckham et al. 2024). von Benda-Beckmann et al. (2022) suggested using kurtosis-corrected SELs to predict threshold shifts. Additionally, Gransier and Kastelein (2024) found that audiograms are not good predictors of frequency-dependent susceptibility to TTS.

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 an $\mathrm{SEL_{cum}}$ of up to ~195 dB re 1 $\mu\mathrm{Pa}^2 \cdot \mathrm{s}$ (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). Bottlenose dolphins exposed to 10-ms impulses at 8 kHz with SELs of 182−183 dB re 1 $\mu\mathrm{Pa}^2 \cdot \mathrm{s}$ produced a TTS of up to 35 dB (Mulsow et al. 2023).

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; Mulsow et al. 2023). 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 $\mathrm{SEL_{cum}}$ of 188 and 191 $\mu\mathrm{Pa}^2 \cdot \mathrm{s}$, 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; Finneran 2020; Kastelein et al. 2020g; Finneran et al. 2023b,c, 2024).

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. Based on studies that exposed harbor porpoises to one-sixth-octave noise bands ranging from 1−88.4 kHz, Kastelein et al. (2019c,d, 2020d,e,f) noted that susceptibility to TTS increases with an increase in sound less than 6.5 kHz but declines with an increase in frequency above 6.5 kHz. At a noise band centered at 0.5 kHz (near the lower range of hearing), the SEL required to elicit a 6 dB TTS is higher than that required at frequencies of 1−88.4 kHz (Kastelein et al. 2021a). Popov et al. (2011) examined the effects of fatiguing noise on the hearing threshold of Yangtze finless porpoises when exposed to frequencies of 32−128 kHz at 140−160 dB re 1 μPa for 1−30 min. They found that an exposure of higher level and shorter duration produced a higher TTS than an exposure of equal SEL but of lower level and longer duration. Popov et al. (2011) reported a TTS of 25 dB for a Yangtze finless porpoise that was exposed to high levels of 3-min pulses of half-octave band noise centered at 45 kHz with an SEL of 163 dB.

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

Initial evidence from exposures to non-pulses has also suggested that some pinnipeds (harbor seals in particular) incur TTS at somewhat lower received levels than do most small odontocetes exposed for similar durations (Kastak et al. 1999, 2005, 2008; Ketten et al. 2001; Kastelein et al. 2013a). 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. A maximum TTS >45 dB was elicited from a harbor seal exposed to 32 kHz at 191 dB SEL (Kastelein et al. 2020c). 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). Harbor seals appear to be equally susceptible to incurring TTS when exposed to sounds from 2.5−40 kHz (Kastelein et al. 2020a,b), but at frequencies of 2 kHz or lower, a higher SEL was required to elicit the same TTS (Kastelein et al. 2020c). 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). 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. Similarly, no TTS was measured when a bearded seal was exposed to a single airgun pulse with an unweighted SEL of 185 dB and an SPL of 207 dB; however, TTS was elicited at 400 Hz when exposed to four to ten consecutive pulses with an unweighted SEL_{cum} of 191−195 dB, and a weighted SEL of 167−171 dB (Sills et al. 2020). Kastelein et al. (2021b) found that susceptibility of TTS of California sea lions exposed to one-sixth-octave noise bands centered at 2 and 4 kHz is similar to that of harbor seals. Kastelein et al. (2024b) reported that TTS onset in California sea lions is not as closely associated with their hearing threshold as previously thought.

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 et al. 2007, 2008).

The noise exposure criteria for marine mammals that were released by NMFS (2016b, 2018) accounted 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. Southall et al. (2019) provided updated scientific recommendations regarding noise exposure criteria which are similar to those presented by NMFS (2016b, 2018), but include all marine mammals (including sirenians), and a re-classification of hearing groups. NMFS (2024) incorporated Southall et al. (2019) recommendations into updated guidance regarding noise exposure criteria. 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 Low-frequency (LF) cetaceans (e.g., baleen whales), high-frequency (HF) cetaceans (e.g., most delphinids; previously known as mid-frequency cetaceans), very-high frequency (VHF) cetaceans (e.g., porpoise and *Kogia* spp.; previously known as HF cetaceans), phocid pinnipeds underwater (PW), and otariid pinnipeds 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. Various authors have reported that sound could be a potential source of stress for marine mammals (e.g., Wright et al. 2011; Atkinson et al. 2015; Houser et al. 2016; Lyamin et al. 2016; Yang et al. 2021). Gray and Van Waerebeek (2011) 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. Williams et al. (2022) reported an increase in energetic cost of diving by narwhals that were exposed to airgun noise, as they showed marked cardiovascular and respiratory reactions.

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. Morell et al. (2021) also reported evidence of hearing loss in a harbor porpoise that stranded on the Dutch coast. Morell et al. (2020) described new methodology that visualizes scars in the cochlea to detect hearing loss in stranded marine mammals.

Since 1991, there have been 72 Marine Mammal Unusual Mortality Events (UME) in the U.S. (NOAA 2025c). In a hearing to examine the Bureau of Ocean Energy Management's 2017−2022 OCS Oil and Gas Leasing Program (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 America, and the greater activity of oil and gas exploration in the Gulf of America. 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). Studies of freshwater turtles have also shown that exposure to underwater sounds can cause TTS in turtles. Based on TTS from exposure to continuous broad-band in-air sound, Mannes et al. (2024) surmised that a freshwater turtle, the red-eared slider (*Trachemys scripta elegans*), would likely exhibit TTS when exposed to SEL of 160 dB re 1 $\mu Pa^2 \cdot s$ for an underwater sound. In fact, when Salas et al. (2023) used auditory evoked potentials measured at 400 Hz, they found a TTS in the red-eared slider when exposed to underwater noise (50−1000 Hz) at SELs varying from 155 to 193 dB re 1 $\mu Pa^2 \cdot s$. Shifts of up to 40 dB were observed; shift magnitude was positively related to exposure duration, amplitude, and SEL. Recovery rates from TTS varied from less than 1 h to greater than 2 days after exposure; recovery rates were usually greater after TTS of higher magnitude. In a later study on the eastern painted turtle (*Chrysemys picta picta*), Salas et al. (2024) found that this species experienced a TTS when exposed to noise (50−1000 Hz) at SELs ranging from 151 to 171 dB re 1 $\mu Pa^2 \cdot s$. TTS occurred in all individuals at both 400 Hz and 600 Hz, with shifts ranging from 6.1 to 41.4 dB; greater shifts were recorded at 600 Hz than at 400 Hz. The patterns of TTS growth and recovery were similar to that in the red-eared slider.

These studies suggest 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 2017a). 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 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 was the first known marine mammal mass stranding closely associated with the operation of an MBES. A leading scientific expert 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 R/V *Maurice 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 $\mathrm{SEL_{cum}}$ 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). However, Ruppel et al. (2022) found that MBESs, SBPs, sidescan sonars, ADCPs, and pingers are unlikely to result in take of marine mammals as these sources typically operate at frequencies inaudible to marine mammals, have low source and received levels, narrow beams, downward directed transmission, and/or have low exposure (e.g., short pulse lengths, intermittency of pulses).

There is little information available 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 and use of habitat by Cuvier's beaked whales during multibeam mapping with a 12 kHz MBES in southern California (Varghese et al. 2021). The study found that there was no significant difference between GVP during multibeam mapping and non-exposure periods, suggesting that the level of foraging and habitat use likely did not change during multibeam mapping. 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. 2020).

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).

Frankel and Stein (2020) reported that gray whales responded to a 21−25 kHz active sonar by deflecting 1−2 km away from the sound. Sperm whales exposed to sounds from a low-frequency 1−2 kHz sonar transitioned to non-foraging and non-resting states, but did not respond to 4.7−5.1 kHz or 6−7 kHz sonar signals (Isojunno et al. 2016). 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).

When green and hawksbill sea turtles were exposed to various sounds, they did not respond to impulses or helicopter long range active sonar down-sweeps (Kastelein et al. 2024a). 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 would not be likely to impact marine mammals and would not be 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 study 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. During seismic operations, R/V *Langseth* would be traveling at ~4.5 kt (8.3 km/h). Typical cruising speed during transit to and from port is 10−13 kt (~20−24 km/h); vessel speed is reduced to 10 kt or less when mother/calf pairs, pods, or large assemblages of cetaceans are observed near a vessel.

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; Veirs et al. 2016; Kyhn et al. 2019; Landrø and Langhammer 2020); 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 have also been shown to affect foraging behavior (Teilmann et al. 2015; Wisniewska et al. 2018; Tervo et al. 2023), habitat use (e.g., Rako et al. 2013; Carome et al. 2022; Gannier et al. 2022), and swim speeds and movement (e.g., Sprogis et al. 2020; Martin et al. 2023a) of cetaceans. Vessel noise has also been shown to affect the dive behavior of pinnipeds (Mikkelsen et al. 2019). 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, 2018; Erbe et al. 2016; Jones et al. 2017; Putland et al. 2017; Cholewiak et al. 2017; Groenewoud 2023). 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; Popov et al. 2020; Branstetter and Sills 2022). Branstetter et al. (2013) reported that time-domain metrics are also important in describing and predicting masking. Yurk et al. (2024) suggested that killer whales could avoid masking by using adaptive call design or vocalizing at different frequencies depending on noise levels in their environment.

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 vessels, 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; 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; Bittencourt et al. 2017; Fornet et al. 2018; Laute et al. 2022; Radtke et al. 2023; Brown et al. 2024).

In contrast, Sportelli et al. (2024) found that the whistle rates of captive bottlenose dolphins did not differ significantly during the initial sound exposure (e.g., ship noise) compared with before exposure. Similarly, harp seals did not increase their call frequencies in environments with increased low-frequency sounds (Terhune and Bosker 2016). However, harbor seals increased the minimum frequency and amplitude of their calls in response to vessel noise (Matthews 2017), and spotted seals increased the source levels of their growls in response to increased ambient noise (Yang et al. 2022). Holt et al. (2015) reported that changes in vocal modifications can have increased energetic costs for individual marine mammals.

In addition to masking, Erbe et al. (2019) noted that ship noise can elicit physical and behavioral responses in marine mammals, as well as stress. For example, Rolland et al. (2012) 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. However, shipping noise is typically not thought to produce sounds capable of eliciting hearing damage. Trigg et al. (2020) noted that gray seals are not at risk of TTS from shipping noise, based on modeling. 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 study area 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). Martin et al. (2023b) reported no long-range (up to 50 km) responses of bowhead whales to passing vessels; responses <8 km from vessels could not be examined. Reactions of humpback whales to boats are variable, ranging from approach to avoidance (Payne 1978; Salden 1993). Baker et al. (1982, 1983) and Baker and Herman (1989) found humpbacks often move away when vessels are within several kilometers. Humpbacks seem less likely to react overtly when actively feeding than when resting or engaged in other activities (Krieger and Wing 1984, 1986). Increased levels of ship noise have been shown to affect foraging by humpback whales (Blair et al. 2016) and killer whales (Williams et al. 2021). 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).

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. A free-swimming green sea turtle fitted with a data logger, camera, and a hydrophone reacted to increasing ship noise when travelling; it exhibited increasing amounts of vigilance (visual scanning, i.e., extending the neck, raising the head and moving it from side to side) (Parra Díaz et al. 2024). However, when at rest on the seabed, the turtle did not alter its scanning behavior in response to increasing noise levels.

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. At least 11 cetacean species are known to be hit by ships, with fin whales being most frequently struck, but right, humpback, sperm, and gray whales are also regularly reported in collisions (Laist et al. 2001). There are less frequent records of collisions with blue, sei, and minke whales (Laist et al. 2001). The rate of collision mortality varies by species (Garrison et al. 2025), but can also vary by age class due to age-specific behavior, with juvenile whales representing a higher proportion of strikes (Stepanuk et al. 2021).

Reducing ship speed has been shown to be an effective mitigation measure to reduce mortality and/or avoid ship strikes (Wiley et al. 2016; Currie et al. 2017; Garrison et al. 2025). Garrison et al. (2025) found that large vessels (≥20−107 m) had a predicted lethality for large whales of 38% at 5 knots, 54% at 10 knots, and 69% at 15 knots. 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 would be 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*.

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; two dedicated observers maintaining a visual watch during all daytime airgun operations; two PSOs for 30 min before and during ramp ups; PAM during the day and night to complement visual monitoring (unless the system and back-up systems are damaged during operations); shut downs when marine mammals are detected in or about to enter the designated EZ; and shut downs when ESA-listed sea turtles or seabirds (diving/foraging) 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). 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 Takes for Marine Mammals and Sea Turtle Exposures

All marine mammals 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 for marine mammals. 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 for the high-energy surveys, and we present estimates of the numbers of marine mammals that could be affected during the proposed seismic surveys (additional details are provided in Appendix B). 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 ETP.

The numbers of marine mammals that could be exposed to airgun sounds with received levels ≥160 dB re 1 μPa_{rms} (Level B) on one or more occasions have been estimated using a method recommended by NMFS for calculating the marine area that would be within the Level B threshold around the operating seismic source, along with the expected density of animals in the area. This method was developed to account in some way for the number of exposures as well as the number of individuals exposed. It involves selecting representative seismic tracklines that could be surveyed on one day (~200 km at 4.5 kt) that have the same or similar proportion of water depths to be surveyed as during the entire survey (in this case, >1000 m deep). The area expected to be ensonified on a single day was determined by "drawing" the applicable Level B and PTS threshold buffers around the representative lines for the racetrack surveys, as well as around the 210-km long seismic transect. The ensonified areas, increased by 25%, were then multiplied by the number of seismic days (18 days for the racetrack surveys; 2 days for the single 210-km long seismic transect line). This is equivalent to adding an additional 25% to the proposed line km (Appendix C). 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 same approach was used to determine the number of sea turtles that could be exposed to airguns sounds with received levels of ≥175 dB re 1 μPa_{rms}.

We used habitat-based stratified marine mammal densities for summer for the ETP when available (Barlow et al. 2009) and densities for the ETP from NMFS (2015) for all other species (Table 7). For the sei whale, for which NMFS (2015) reported a density of zero, we used the spring density for Baja from DoN (2017b). The habitat-based density models based on Barlow et al. (2009) consisted of 100 km x 100 km grid cells; densities in the grid cells that overlapped the proposed study area were averaged. The density for olive ridley sea turtles was obtained from Eguchi et al. (2007) for 2006 for the offshore northern stratum in the ETP. Densities for all other sea turtle species were derived from winter data collected in offshore waters off Mexico (Zepeda-Borja et al. 2017).

There is uncertainty about the representativeness of the data and the assumptions used to estimate exposures. Thus, for some species, the densities derived from the abundance models described above may not precisely represent the densities that would be encountered during the proposed seismic surveys. The estimated numbers of individuals potentially exposed are based on the 160-dB re 1 μPa_{rms} criterion for all marine mammals. It is assumed that marine mammals exposed to airgun sounds that strong could change their behavior sufficiently to be considered "taken by harassment". Table 8 shows the estimates of the number of marine mammals that potentially could be exposed to ≥160 dB re 1 μPa_{rms} during the proposed seismic surveys if no animals moved away from the survey vessel (see Appendix B for more details), along with the *Requested Take Authorization*.

TABLE 7. Densities of marine mammals in the ETP from Barlow et al. (2009) and NMFS (2015), as well as sea turtle densities. Densities in bold were used to estimate Level B and Level A takes for marine mammals and exposures of sea turtles.

	Density (#/km^2) in Study Area [Barlow et al. 2009]	Density (#/km^2) in wider ETP [NMSF 2015]	Density (#/km^2)
Baleen Whales			
Humpback whale		**0.00013**	
Minke whale		**0.00001**	
Bryde's whale	**0.00051**	0.00049	
Fin whale		**0.00003**	
Sei whale[1]		0	**0.00005**
Blue whale	**0.00008**	0.00019	
Odontocetes			
Sperm whale		**0.00019**	
Cuvier's beaked whale	**0.00084**	0.00094	
Longman's beaked whale		**0.00004**	
Mesplodon spp.	**0.00031**	0.00119	
Blaineville's beaked whale[2]			
Ginkgo-toothed beaked whale[2]			
Deraniyagala's beaked whale[2]			
Pygmy beaked whale[2]			
Risso's dolphin	**0.00455**	0.00517	
Rough-toothed dolphin	**0.00620**	0.00504	
Common bottlenose dolphin	**0.01308**	0.01573	
Pantropical spotted dolphin[3]	**0.07258**	0.12263	
Spinner dolphin (whitebelly)	**0.00889**	0.04978	
Spinner dolphin (eastern)	**0.08000**		
Striped dolphin	**0.08099**	0.04516	
Common dolphin	**0.03980**	0.14645	
Fraser's dolphin		**0.01355**	
Short-finned pilot whale[4]	**0.00867**	0.02760	
Killer whale		**0.00040**	
False killer whale		**0.00186**	
Pygmy killer whale		**0.00183**	
Melon-headed whale		**0.00213**	
Dwarf sperm whale		0.00053	
Kogia spp.	**0.00003**		
Sea Turtles			
Olive Ridley Sea Turtle[5]			**0.16000**
Green Sea Turtle[6]			**0**
Loggerhead Sea Turtle[6]			**0.03333**
Hawksbill Sea Turtle[6]			**0.00667**
Leatherback Sea Turtle[6]			**0.00667**

[1] Spring density for Baja (DoN 2017b).
[2] Density not available.
[3] Bold density for offshore stock only.
[4] Bold density for *Globicephala* spp.
[5] Density for 2006 for the northern offshore stratum in the ETP (Eguchi et al. 2007).
[6] Density for winter for waters offshore Mexico (Zepeda-Borja et al. 2017).

TABLE 8. Estimates of the possible numbers of individual marine mammals that could be exposed to Level B and Level A thresholds for various hearing groups during the proposed seismic surveys in the ETP.

Species	Level B Takes[1]	Level A Takes[2]	% of Pop. in ETP (Total Takes)[3]	Requested Level A+B Take Authorization[4]
LF Cetaceans				
Humpback whale[5]	2	0	0.07	2
Minke whale	0	0	0.87	**1**
Bryde's whale	5	1	0.06	6
Fin whale	0	0	0.35	**2**
Sei whale	1	0	0.01	**2**
Blue whale	1	0	0.14	**2**
HF Cetaceans				
Sperm whale	3	0	0.19	**8**
Cuvier's beaked whale	12	0	0.06	12
Longman's beaked whale	1	0	1.99	**20**
Mesoplodon spp.	5	0	N.A.	N.A.
Blainville's beaked whale	N.A.	N.A.	0.01	**3**
Ginkgo-toothed beaked whale	N.A.	N.A.	0.01	**3**
Deraniyagala's beaked whale	N.A.	N.A.	0.01	**3**
Pygmy beaked whale	N.A.	N.A.	0.01	**3**
Risso's dolphin	66	0	0.06	66
Rough-toothed dolphin	69	1	0.07	70
Common bottlenose dolphin	148	1	0.04	149
Pantropical spotted dolphin	1,050	7	0.12	1,057
Spinner dolphin (whitebelly)	129	1	0.02	**135**
Spinner dolphin (eastern)	1,157	8	0.11	1,165
Striped dolphin	1,171	8	0.12	1,179
Common dolphin	576	4	0.02	580
Fraser's dolphin	196	1	0.14	**395**
Short-finned pilot whale	125	1	0.02	126
Killer whale	6	0	0.08	**7**
False killer whale	27	0	0.07	27
Pygmy killer whale	26	0	0.07	26
Melon-headed whale	31	0	0.44	**200**
VHF Cetaceans				
Dwarf and pygmy sperm whales	0	0	0.02	**2**

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 expressed as % of population in the ETP, if available (see Table 4).

[4] Requested take authorization is Level A plus Level B calculated takes; numbers in bold are based on mean group sizes from Oliveira and DeAngelis (2024), except for those in italics which are from Wade and Gerrodette (1993). *For Longman's beaked whale, the upper end of the average group size range from NMFS (2025d) was used.

[5] One take each are requested for the Central America and Mexico DPSs.

It should be noted that the exposure estimates assume that the proposed surveys would be completed; in fact, the calculated takes for marine mammals ***have been increased by 25%***. Thus, the following estimates of the numbers of marine mammals potentially exposed to sounds ≥160 dB re 1 µPa$_{rms}$ are pre-cautionary and probably overestimate the actual numbers of marine mammals that could be involved. 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.

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 2013).

The context of an exposure of a marine mammal to sound can affect the animal's initial response to the sound (e.g., Ellison et al. 2012; NMFS 2013; Hückstädt et al. 2020; Hastie et al. 2021; Southall et al. 2021; Booth et al. 2022; Miller et al. 2022). Southall et al. (2021) provided a detailed framework for assessing marine mammal behavioral responses to anthropogenic noise and note that use of a single threshold can lead to large errors in prediction impacts due to variability in responses between and within species.

Estimates of the numbers of marine mammals that could be exposed to seismic sounds from the 18-airgun array 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 8. Those numbers likely overestimate actual Level A takes because the predicted Level A EZs are small and mitigation measures would further reduce the chances of, if not eliminate, any such takes. In addition, most marine mammals would move away from a sound source before they are exposed to sound levels that could result in a Level A take. Level A takes are considered highly unlikely for most marine mammal species that could be encountered in the proposed study area.

Table 9 shows the estimates of the numbers of sea turtles that potentially could be exposed to various sound thresholds (behavioral disturbance and PTS onset (see Appendix B for more details) during the proposed seismic surveys, based on densities provided in Table 7. Although the density for green sea turtles for the study area was zero based on data for offshore waters during winter (Zepeda-Burja et al. 2017), it is possible that some individuals could be encountered during the proposed surveys.

4.1.1.6 Conclusions for Marine Mammals and Sea Turtles

The proposed seismic surveys would involve towing an 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".

TABLE 9. Estimates of the possible numbers of sea turtle exposures during the proposed seismic surveys in the ETP.

	Behavioral Disturbance	PTS Onset Threshold
Olive Ridley Sea Turtle	472	54
Green Sea Turtle	0	0
Loggerhead Sea Turtle	98	11
Hawksbill Sea Turtle	20	2
Leatherback Sea Turtle	20	2

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, 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 involving the high-energy survey; 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 marine mammals potentially exposed to sound levels sufficient to cause Level A and/or B harassment are low percentages of the regional population sizes (Table 4). The proposed activities are likely to adversely affect ESA-listed marine mammal 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.

TABLE 10. ESA determination for marine mammal species that could potentially be encountered during the proposed surveys in the ETP.

	ESA Determination		
Species	No Effect	May Affect – Not Likely to Adversely Affect	May Affect – Likely to Adversely Affect
Humpback Whale (Central America DPS)			√
Humpback Whale (Mexico DPS)			√
Sei Whale			√
Fin Whale			√
Blue Whale			√
Sperm Whale			√

In decades of seismic surveys carried out by R/V *Langseth* and its predecessor, R/V *Maurice Ewing*, PSOs and other crew members have seen no seismic sound-related marine mammal injuries or mortality. Also, actual numbers of animals potentially exposed to sound levels sufficient to cause disturbance (i.e., are considered takes) have almost always been much lower than predicted and authorized takes. For example, during an NSF-funded, ~5000-km, 2-D seismic survey conducted by R/V *Langseth* off the coast of North Carolina in September−October 2014, only 296 cetaceans were observed within the predicted 160-dB zone and potentially taken, representing <2% of the 15,498 takes authorized by NMFS (RPS 2015). During an USGS-funded, ~2700 km, 2-D seismic survey conducted by R/V *Langseth* along the U.S. east coast in August−September 2014, only 3 unidentified dolphins were observed within the predicted 160-dB zone and potentially taken, representing <0.03% of the 11,367 authorized takes (RPS 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. Nonetheless, the proposed activities are likely to adversely affect ESA-listed sea turtles that could be encountered in the proposed study area (Table 11). However, in decades of seismic surveys carried out by R/V *Langseth* and its predecessor, R/V *Maurice Ewing*, PSOs and other crew members have seen no seismic sound-related sea turtle injuries or mortality.

4.1.2 Direct Effects on Marine Invertebrates, Fish, 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, 2020, 2021; Carroll et al. 2017; Hawkins and Popper 2017; Popper and Hawkins 2019; Wale et al. 2021; Hawkins 2022a,b; Popper et al. 2022; Pieniazek et al. 2023; Solé et al. 2023; Cones et al. 2024; Vereide and Kühn 2024), 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, 2019; McCauley et al. 2021; Azarm-Karnagh et al. 2024). 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. Rogers et al. (2021) found that sounds from a seismic survey measured above ambient conditions up to 10 km away for particle acceleration and up to 31 km for sound pressure.

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. Wang et al. (2024) showed that the pumping behavior of epibenthic polycheate worms can be affected by sound. 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 mollusks, were deemed to be the invertebrates most at risk from seismic impacts.

TABLE 11. ESA determination for sea turtle species that could be encountered during the proposed surveys in the ETP.

	ESA Determination		
Species	**No Effect**	**May Affect – Not Likely to Adversely Affect**	**May Affect – Likely to Adversely Affect**
Leatherback Turtle			√
Green Turtle (East Pacific DPS)			√
Loggerhead Turtle (North Pacific Ocean DPS)			√
Olive Ridley Turtle (Mexico Pacific coastal breeding population)			√
Hawksbill Turtle			√

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, mortalities (Wale et al. 2013a,b; Aguilar de Soto 2016; Edmonds et al. 2016; Carroll et al. 2017; Weilgart 2017b, 2023; Elliott et al. 2019; Day et al. 2021; Hawkins 2022a; Solé et al. 2023; Prosnier 2024; Vereide and Kühn 2024), hearing loss (Putland et al. 2023), and stress (Celi et al. 2013; Vazzana et al. 2020). Jézéquel et al. (2021) recently reported that noise (such as from shipping) can mask sounds produced by European lobster (*Homarus gammarus*) and that they may change sound production in response to noise. Cones et al. (2024) reported, based on a review of studies, that impacts tend to be more severe with increased sound levels or closer to the sound source.

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.

Vereide et al. (2023) conducted a field experiment that examined the effects of a seismic survey on the mortality and development of nauplii of the copepod *Acartia tonsa*. The nauplii were held in plastic bags that were suspended at a depth of 6 m; these were exposed at a distance of 50 m for 2.5 hours to discharges from two 40-in^3 airguns towed behind a vessel. Controls of the experiment included periods with vessel noise only (no airguns), as well as silence. After exposure, the nauplii were brought to the laboratory where greater immediate mortality (14%) was observed in the nauplii exposed to airgun sounds compared with those during the vessel only and silent controls. After 4 days, most of the exposed nauplii were dead, whereas most nauplii in the control groups were still alive 6 days after exposure. Exposed nauplii also had lower growth rates than those that were not exposed to airgun sounds. Vereide et al. (2024) found that a rapid pressure drop (~2 bar) associated with seismic exposure caused mortality and negatively affected swimming behavior of two common species of copepods, with *Acartia* sp. being more sensitive to the pressure drop than *Calanus* sp.

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

Parsons et al. (2023) conducted a large-scale experiment at a pearl oyster holding lease site to examine the effect of a seismic survey on mortality and productivity of silverlip pearl oysters (*Pinctada maxima*). The oysters were exposed to four days of seismic survey sounds using a 2600 in^3 airgun array with a peak to peak source level of 252 dB re 1 μPa at 1 m and a sound exposure level of 228 dB re 1 Pa^{2}m^{2}s; the experiment also included one vessel-control day. The oysters were monitored for a full two-year production cycle. Only two of 16 groups showed reduced survival and pearl productivity; thus, the study found no conclusive evidence that the commercial important oyster was impacted by the seismic survey sounds.

Hubert et al. (2022a) examined the response of wild-caught blue mussels to exposures of single pulses and pulse trains in an aquarium. They reported that the mussels responded to the sounds by partially closing their valves and that the response waned with repeated exposures. They could not determine whether the decay in response was due to habituation or a sensory adaptation. There was no difference in recovery time between exposures to single pulses or a pulse trains. Hubert et al. (2022b) noted that the sound-induced valve closure varied with pulse train speed − mussels exposed to faster pulse trains returned to baseline conditions faster than those exposed to slower pulse trains; phytoplankton clearance rates were not impacted.

Jézéquel et al. (2023) reported that sound sensitivity in the giant scallop (*Placopecten magelanicus*) depends on the life stage and intensity and frequency of the sound it is exposed to. 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 $\mu\text{Pa}^2 \cdot \text{s}$ 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 rock 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 SEL_{cum} source levels were 189–199 dB re 1 $\mu\text{Pa}^2 \cdot \text{s}$. 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). Day et al. (2019, 2021, 2022) exposed rock lobster to the equivalent of a full-scale commercial seismic survey passing within 500 m, adult and juvenile lobsters exhibited impaired righting and damage to the sensory hairs of the statocyst. Lobsters that were exposed at a more distance range showed recovery, whereas those exposed at closer range had persistent impairment (Day et al. 2019, 2021, 2022). Day et al. (2021, 2022) noted that there was indication for slowed growth and physiological stress in juvenile lobsters after exposure. Adult lobsters that were collected from areas with high anthropogenic noise were shown to have pre-existing damage to the statocysts which were not damaged further upon exposure to airgun sounds (Day et al. 2020). However, lobsters from noisy environments appeared to be better able to cope with the damage than noise naïve lobsters; they did not show any disruption to the righting reflex (Day et al. 2020).

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 haemolymph 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 (*Cancer magister*) larvae or snow crab (*Chionoecetes opilio*) embryos to seismic sounds (Pearson et al. 1994; DFO 2004; Morris et al. 2018). However, when Borland (2023) examined the behavior of Dungeness crab during a seismic survey (6600 in^3 discharge volume) off southern Oregon in 2021, she found slight differences in the movement and spatial use of crabs when the airguns were active; however, the results were inconclusive.

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.

Cote et al. (2020) conducted a study using the multi-year Before-After/Control-Impact (BACI) approach in the Carson and Lilly Canyons to evaluate the potential of industry-scale seismic exposure to modify movement behavior of free-ranging adult male snow crab. The crabs were exposed to a commercial seismic array, with a total volume of 4880 in^3, horizontal $SPL_{0\text{-}p}$ of 251 dB re 1 µPa, and SEL of 229 dB re 1 $\mu Pa^2 \cdot s$ (the same seismic source as used by Morris et al. 2018, noted below). The movements of the snow crabs were tracked using a hyperbolic acoustic positioning array. In total, 201 and 115 snow crabs were tagged in Carson and Lilly canyons, respectively. Before, during, and after exposure periods to a single seismic surveying line of 5−8 hours in duration, were matched in time across control and test sites—each site monitored an area 4 km^2. There were no obvious effects of seismic exposure on the movement ecology of adult male snow crab; variation in snow crab movement was primarily attributable to individual variation and factors like handling, water temperature, and time of day. The authors concluded that seismic exposure did not have any important effects on snow crab movement direction, and any variance in the results were shown to be individual-specific. Snow crabs are known to display highly variable movement behavior and individual-specific tendencies can explain experimental variance (Cote et al. 2020). Snow crab have also been considered to be less vulnerable to physiological damages from noise due to their absence of gas filled organs such as swim bladders that are sensitive to seismic exposures (Cote et al. 2020). There was also no evidence of physical damage to internal organs based on histological examinations (Morris et al. 2021).

In total, 201 and 115 snow crabs were tagged in Carson and Lilly canyons, respectively. Before, During, and After exposure periods to a single 2D seismic surveying line (5−8 hours duration) were matched in time across Control and Test sites—each site monitored an area 4 km^2. There were no obvious effects of seismic exposure on the movement ecology of adult male snow crab; variation in snow crab movement was primarily attributable to individual variation and factors like handling, water temperature and time of day. The authors concluded that the effects of seismic exposure on the behavior of adult male snow crab, are at most subtle and are "not likely to be a prominent threat to the fishery." There was also no evidence of physical damage to internal organs based on histological examinations (Morris et al. 2021). The study concluded that seismic exposure did not have any important effects on snow crab movement direction, and any variance in the results were shown to be individual-specific. Snow crab have also been considered to be less vulnerable to physiological damages from noise due to their absence of gas filled organs such as swim bladders that are sensitive to seismic exposures (Cote et al. 2020).

Hall et al. (2021) collected tissue samples to investigate the potential impact of seismic surveying on the transcriptome responses of snow crab hepatopancreas. The hepatopancreas is an organ that aids in the absorption and storage of nutrients and produces important digestive enzymes and is therefore assumed to be an indicator suitable for determining the effect of sound exposure effects on crab physiology and health. Snow crabs were subjected to 2-D seismic noise in 2016 for 2 h and sampled before, and 18 h and three weeks after exposure. In 2017, 2-D seismic exposure was repeated, and samples were collected prior to seismic testing, and 1 day, 2 days, and 6 weeks after exposure. Additionally, in 2017 snow crabs were subjected 3-D seismic noises for 2 months and were sampled 6 weeks after exposure. Hall et al. (2021) identified nine transcripts with significantly higher expression after 2-D seismic exposure, and 14 transcripts with significant differential expression between the test and control sites. These included transcripts with functional annotations related to oxidation-reduction, immunity, and metabolism. Significant changes for these transcripts were not observed during the 2017. Thus, although transcript expression changes were detected in snow crab in response to seismic survey sound, the response was variable across years. Hall et al. (2021) concluded that although candidate molecular biomarkers identified in one field season (2016), they were not reliable indicators in the next year (2017), and further study is warranted.

Roberts and Laidre (2019) studied the effect of an impulsive sound source on the chemically mediated shell searching behavior of the hermit crab (*Pagarus acadianus*). Although the sound source was not seismic airgun-related, it was impulsive. An underwater slide hammer was used to create vibration within the seabed, allowing the production of a fully controllable manually operated stimulus. Exposures consisted of repetitive low-frequency pulses, with most energy within the 500−700 Hz range. The average peak particle velocity ranges at 1-m and 5-m were 0.00001−0.0005 m/s and 0.00002−0.00009 m/s, respectively. Results of this study indicated the sound source used can act cross-modally and affect chemically guided search behavior. The broad conclusion was that anthropogenic noise and seabed vibration may have effects on other behaviors mediated by other sensory modalities.

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$_{\mathrm{rms}}$ 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 $_{\text{0-pk}}$ were 204 dB re 1 µPa^2·s and 226 dB re 1 µPa. No macroscopic effects on soft tissues or the skeleton were noted days or months after the survey.

Buscaino et al. (2019) exposed caged sea urchins (*Arbacia lixula*) and sea cucumbers (*Holothuria tubulosa*) to sounds from an airgun with a peak pressure level of 122 dB re 1 µPa^2/Hz at 850 Hz and a peak particle speed of 207 dB re (1 nm/s)^2 at 550 Hz. When the coelemic fluid was extracted from each animal (40 individuals of each species), there was evidence of stress as indicated by differences in esterase and peroxidase in sea urchins and total hemocyte count and total protein for the sea cucumbers.

Spiga (2022) reported behavioral responses of snapping shrimp in the field to playbacks of impulses with frequencies of 50−600 Hz when exposed to sound pressure levels at or above to 130 re 1 µPa and particle motion of 2.06×10^{-06} m/s. Bigger shrimp snapped more for longer durations and moved away from the sound source; peak frequency of snaps decreased during exposure compared with before and after sound exposure.

4.1.2.2 Effects of Sound on Fish

Popper et al. (2019a) and Popper and Hawkins (2021) 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), Slabbekoorn et al. (2019), and Hawkins (2022a,b), and Lessa et al. (2024); they include pathological, physiological, and behavioral effects. Radford et al. (2014), Putland et al. (2017), de Jong et al. (2020), Pine et al. (2020), and Jones et al. (2024) noted that masking of key environmental sounds or social signals could also be a potential negative effect from sound. Mauro et al. (2020) concluded that noise exposure may have significant effects on fish behavior which may subsequently affect fitness and survival.

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) and Hawkins et al. (2020) cautioned that particle motion as well as sound pressure should be considered when assessing the effects of underwater sound on fishes.

Waddell and Širović (2023) examined the effects of seismic survey on larval fish behavior. They exposed presettlement-sized red drum (*Sciaenops ocellatus*), southern flounder (*Paralichthys lethostigma*), spotted seatrout (*Cynoscion nebulosus*), and Florida blenny (*Chasmodes saburrae*) larvae to these sounds and found initial significant avoidance of airgun sounds in three of the four species (except Florida blenny); however, habituation occurred as the experiment carried on. All four species also avoided vessel sounds. The results indicate that these larval fish could habituate relatively quickly (<10 min) to anthropogenic noise.

Borland (2023) and Borland et al. (2024) examined the behavior of rockfish and lingcod during a seismic survey off southern Oregon in 2021. They found slight differences in the movement and spatial use of these fish when the airguns (total discharge value of 6600 in^3) were active; however, differences diminished after several days. Sample sizes for lingcod were small ($n = 5$). 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 $\mu Pa^2 \cdot s$). Meekan et al. (2021) also reported that a commercial seismic source had no short- or long-term effects on the tropical demersal fish community on the North west Shelf of Western Australia, as no changes on species composition, abundance, size structure, behavior, or movement were reported. The source level of the airgun array was estimated as 228 dB SEL and 247 dB re 1 µPa m peak-to-peak pressure.

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 SEL_{cum} had reached 190 dB re 1 $\mu Pa^2 \cdot s$. Wei and McCauley (2022) determined that the angle of sound energy arrival at the otolith (a pathway for sound transmittance between a sound source and the inner ear) affects the extent of potential injury from noise. de Jong et al. (2020) conducted a study on the predicted effects of anthropogenic noise on fish reproduction and found that continuous sounds with irregular amplitudes and/or frequency-content such as heavy ship traffic were likely to induce masking or hearing loss. The vulnerability of a species to noise-induced stressors was dependent on its ability to reallocate reproduction to a quieter location or time, and whether or not their reproductive strategy relied on sound communication. Although TTS has been demonstrated in some fish species, it is unlikely to occur in free-swimming fish (Smith and Popper 2024).

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 µPa^2·s. Although cod had a reduced hear rate in response to the sound exposure, there was no behavioral startle response. However, 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. Davidsen et al. (2019) concluded that the sound exposures over a 3-day period were unlikely to lead to long-term alterations in physiology or behavior.

van der Knaap et al. (2021) investigated the effects of a seismic survey on the movement behavior of free-swimming Atlantic cod in the southern North Sea. A total of 51 Atlantic cod were caught and tagged with acoustic transmitters and released in the southern North Sea where they were exposed to a towed airgun array 2.5 km from the tagged location over 3.5 days. The airgun array consisted of 36 airguns with a total volume of 2950 in^3, which fired every 10 s during operation in continuous loops, with parallel tracks of 25 km. The SEL_{cum} over the 3.5-day survey period at the receiver position was 186.3 dB re 1 µPa^2s in the 40−400 Hz band. During sound exposure, cod became less locally active (moving small distances, showing high body acceleration) and more inactive (moving small distances, showing low body acceleration) at dawn and dusk which interrupted their diurnal activity cycle. The authors concluded that seismic surveying has the potential to affect energy budgets for a commercial fish species, which may have population-level consequences.

Hubert et al. (2020) exposed Atlantic cod in an aquaculture net pen to playback of seismic airgun sounds to determine the effect on swimming patterns and behavioral states. The fish were exposed to sound recordings of a downscaled airgun with a volume of (10 in^3) and a pressure of 800 kPa. During the experimental trials, the fish were exposed to mean zero-to-peak sound pressure levels ($SPL_{0\text{-}p}$) of 174, 169, and 152 dB re 1 µPa (0-pk) (100−600 Hz bandpass filter) with the speaker at 2, 7.8, and 20 m from the net pen, respectively. They found that individual cod within the net pen did not immediately change their swimming patterns during sound exposure; however, several individuals did change the amount of time they spent in three different behavioral states (transit, locally active, inactive) during the 1 h exposure; they exhibited more transiting behavior (i.e., swimming at high speed with a low turning angle) during and after exposure. Similar results were obtained during an experiment that exposed wild-caught Atlantic cod to airgun playbacks in an experimental tank with an SPL of 150 dB re 1 µ$Pa_{0\text{-}p}$; although the cod did not change the time spent foraging, they did increase the time spent swimming during exposure (Hubert et al. 2019; Hubert 2021).

When McQueen et al. (2022, 2023) exposed Atlantic cod on their spawning grounds to airgun sounds with received exposure levels of 115 to 145 dB re 1 µPa^2s, the fish showed weak responses by swimming slightly deeper during sound exposure; however, they did not change their swimming acceleration nor were they displaced from the exposed area. According to McQueen et al. (2023), the results suggest that distant seismic surveys 5 to >40 km away would not significantly change cod behavior (McQueen et al. 2023).

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 µPa^2 · 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.

Neo et al. (2014, 2015, 2016, 2018) reported changes in fish (primarily European seabass) behavior (e.g., dive depth, group cohesion, swim speed) upon exposure to impulsive sounds and noted that temporal structure of sound plays a large role in the potential response of fish to noise exposure. Neo et al. (2014) also postulated that intermittent sounds, such as from airguns, may elicit a stronger response by fish than continuous sounds, regardless of the SEL_{cum}.

Waddell and Širović (2023) examined larval fish behaviour in a linear acoustic chamber when exposed to airgun sounds. They found that larvae of drum (*Sciaenops ocellatus*), southern flounder (*Paralichthys lethostigma*), and spotted seatrout (*Cynoscion nebulosus*) actively avoided airguns sounds, as well as vessel passage sounds, but habituated to the noise within 10 min.

Sivle et al. (2017) examined the behavioural responses of wild captured mackerel in a net pen to sounds from a 90 in^3 airgun towed behind a vessel; SELs ranged from 146 to 171 re 1 μPa_{0-p}. No overt responses (e.g., changes in swimming dynamics, swim speed, etc.) were recorded during sound exposure. When fish were exposed to airgun sounds at close range (90 m) at received SPLs of 184 dB re 1 μPa_{0-p}, they swam rapidly. This suggests that the threshold between subtle reactions and avoidance responses occurs between 178 and 184 dB re 1 μPa_{0-p}, and that ramp up of sound may be effective at minimizing initial responses to sound.

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 231 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.

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 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 fish.

Kok et al. (2021) examined the behavior of pelagic fish to seismic surveys using echosounders; the received SPLs at the echosounder ranged from 123 to 195 dB re 1 μPa_{0-p}. They found that there were fewer schools of fish during the seismic surveys, but the schools were more cohesive than before the sound exposure.

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 and no post-seismic evaluation was possible, it contributes evidence that normal fish use of reef ecosystems is reduced when they are impacted by seismic sounds.

4.1.2.3 Conclusions for Fish and Marine Invertebrates

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. 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 fish (Table 12). In decades of seismic surveys carried out by R/V *Langseth* and its predecessor, R/V *Maurice Ewing*, PSOs and other crew members have not observed any seismic sound-related fish or invertebrate injuries or mortality.

TABLE 12. ESA determination for marine fish species that could potentially be encountered during the proposed surveys in the ETP.

Species	ESA Determination		
	No Effect	May Affect – Not Likely to Adversely Affect	May Affect – Likely to Adversely Affect
Scalloped Hammerhead Shark		√	
Oceanic Whitetip Shark		√	
Giant Manta Ray		√	

4.1.3 Direct Effects on Seabirds and Their Significance

The underwater hearing of seabirds (including loons, scaups, gannets, and ducks) has been investigated by Crowell (2016), and the peak hearing sensitivity was found to be between 1500 and 3000 Hz. The best sensitivity of underwater hearing for great cormorants was found to be at 2 kHz, with a hearing threshold of 71 dB re 1 μPa_{rms} (Hansen et al. 2017). Gentoo penguins, black ducks, and great cormorants have been found to be able to detect underwater sounds (e.g., Hansen et al. 2017, 2020, 2023;

Larsen et al. 2020; Sørensen et al. 2020; McGrew et al. 2022; Rasmussen et al. 2022). Great cormorants may have special adaptations for hearing underwater (Johansen et al. 2016; Hansen et al. 2017).

Common murres (*Uria aalge*) were found to respond negatively to pulsed sound (Hansen et al. 2020). 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 shut down in the unlikely event an ESA-listed seabird was observed diving or foraging within the designated EZ. However, ESA-listed seabirds that could be present forage at the ocean surface rather than diving and would not be affected by the airgun operations below the water surface. Given the proposed activities, avoidance measures and unlikelihood of encounter, no effects to ESA-listed seabirds would be anticipated from the proposed action (Table 13). In decades of seismic surveys carried out by R/V *Langseth* and its predecessor, the R/V *Maurice Ewing*, PSOs and other crew members have seen no seismic sound-related seabird injuries or mortality.

TABLE 13. ESA determination for seabird species that could be encountered during the proposed surveys in the ETP.

	ESA Determination		
Species	**No Effect**	**May Affect – Not Likely to Adversely Affect**	**May Affect – Likely to Adversely Affect**
Galápagos 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, fish, or marine invertebrates 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 Reasonably Foreseeable Effects

Reasonably foreseeable effects refer to the impacts on the environment that result from a combination of the proposed action and other projects and human activities that could occur within the proposed study area. These 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 proposed study area. However, understanding these 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.

Here we focus on activities (e.g., research, vessel traffic, and fisheries) that could impact animals specifically in the proposed study area. However, the combination of the proposed activities with the existing operations in the region would be expected to produce only a negligible increase in overall disturbance effects on marine mammals. For these reasons, significant impacts to marine resources are not anticipated from the proposed surveys.

4.1.6.1 Past and Future Research Activities

The SWFSC has been conducting systematic marine mammal surveys in the wider ETP region since 1986. Ferguson and Barlow (2001) reported on data collected from 1986−1996, and Forney et al. (2012) used SWFSC data collected during 1986−2006 to develop species-habitat models for the ETP. Initial systematic studies of cetaceans in the ETP were prompted by the incidental killing of dolphins in the purse-seine fishery for yellowfin tuna in the area (Smith 1983). As it is currently unknown whether the dolphin populations have recovered, Oedekoven et al. (2021) conducted a trial survey for ETP dolphins off the west coast of Mexico in November 2019. A second trial survey using drones was conducted in November 2023, but the results are not available yet (IATTC 2024).

Other research activities may have been conducted in the past or may be conducted in the study area in the future. As mentioned earlier, seismic data were collected in the area during 2008. More recently, the study area was visited during NSF-funded expedition AT50-33 in January-February 2025 and again in April 2025, where RV *Atlantis* and HOV *Alvin* and AUV *Sentry* were used to survey and sample deep-sea vents. In fact, there was an underwater volcanic eruption within the proposed study area at the Tica vent, in April 2025. There may be an expedition using ROV Jason to the study site in 2026.

4.1.6.2 Vessel Traffic

Vessel traffic in the proposed study area would consist mainly of commercial fishing vessels, cargo vessels, and tankers. Based on the data available through the Automated Mutual-Assistance Vessel Rescue (AMVER) system managed by the U.S. Coast Guard (USCG), the monthly density plot totals for the shipping lanes that intersect the study area had 4 or fewer vessels within 60' latitude by 60' longitude cells during January and February 2025 (USCG 2025). When live vessel traffic information for the area was accessed during April 2025, there were two cargo vessels, one tug/special craft, and one pleasure craft within the proposed study area (MarineTraffic 2025). The total transit time by R/V *Langseth* (~5 days) would be significant relative to the number of other vessels operating in the proposed study area. Thus, the combination of R/V *Langseth*'s operations with the existing shipping operations is expected to produce a significant increase in overall ship disturbance effects on marine mammals.

4.1.6.3 Fisheries

The proposed study area is located in the eastern Central Pacific Ocean. In 2019, nearly 900,000 tons of fish were harvested in this region (Sea Around Us 2024). Most of the catch (44%) consisted of skipjack tuna, followed by yellowfin tuna (20%), big eye tuna (14%), and blue shark (6%); other species landed included albacore tuna, swordfish, striped marlin, common dolphinfish, and mackerels (Sea Around Us 2024). Most catches were taken by purse seine by fishing vessels based out of Ecuador, followed by Taiwan, and the U.S. (Sea Around Us 2024).

The primary contributions of fishing to potential reasonably foreseeable impacts on marine mammals and sea turtles involve direct removal of prey items and noise (Reeves et al. 2003).

Marine Mammals.—Entanglement in fishing gear can lead to serious injury or mortality of some marine mammals and high numbers of bycatch. Hundreds of thousands of dolphins used to be killed in the tuna fishery annually in the ETP (Ballance et al. 2021). The main cetacean species that were affected by the fishery include pantropical spotted and spinner dolphins (Smith 1983; Ballance et al. 2021). Short-beaked common, striped, bottlenose, Fraser's, and rough-toothed dolphins, as well as short-finned pilot whales, have also been killed in the fishery (e.g., Hall and Boyer 1989). Dolphin mortality was high at the onset of the fishery (Allen 1985), but has since dropped considerably (Ballance et al. 2021). During the 1960s, it was estimated that 200,000−500,000 dolphins per year were killed by the fishery (Wade 1995). Since 2000, ~1000 dolphins are killed in the ETP tuna purse-seine fishery annually (Ballance et al. 2021).

In 1992, the La Jolla Agreement provided a framework to reduce the mortality by setting dolphin mortality limits (DML) for fishing vessels (AIDCP 2024). The Agreement on the International Dolphin Conservation Program (AIDCP) formalized the provisions of the La Jolla Agreement and entered into force in 1999. The Parties to the AIDCP "committed to ensure the sustainability of tuna stocks in the eastern Pacific Ocean and to progressively reduce the incidental dolphin mortalities in the tuna fishery of the eastern Pacific Ocean to levels approaching zero and to avoid, reduce and minimize the incidental catch and the discard of juvenile tuna and the incidental catch of non-target species, taking into consideration the interrelationship among species in the ecosystem".

The total DML was 5000 animals for 2023 and 2020 (AIDCP 2024). The bycatch was reported as 828 animals in 2023 and has been <1000 since 2011 (AIDCP 2024). Populations of offshore spotted dolphins and eastern spinner dolphins had not recovered by the early 2000s (Gerrodette and Forcada 2005; Wade et al. 2007). It is currently unknown whether these populations have recovered, as current population estimates are unknown (Leslie and Morin 2016; Ballance et al. 2021); no systematic surveys have taken place since 2006 (Scott et al. 2018; Ballance et al. 2021). However, Oedekoven et al. (2021) conducted a trial survey for ETP dolphins off the west coast of Mexico in November 2019, and a second trial survey was conducted in November 2023 (IATTC 2024). The goal of a future main survey is to estimate the current abundance of dolphins in the ETP. The trial surveys mainly tested the use of a drone to assess whether they can be used to detect dolphin schools ahead of the vessel and whether they can be used to determine school size and species composition.

Sea Turtles.—Lewison et al. (2004) estimated that 30,000−75,000 loggerheads are taken as bycatch in longlines in 2000 in the Pacific; the estimate for leatherbacks was lower (20,000−40,000). Although Lewison et al. (2014) reported relatively high bycatch of sea turtles during longlining operations in the ETP 1990−2008. Roe et al. (2014) reported limited bycatch risk for leatherbacks in the proposed study area. Sea turtles are also occasionally caught in the tropical purse-seine fishery. A mean of 85 sea turtles per year are caught in the eastern Pacific, of which most (86%) are olive ridleys, followed by green, loggerhead, and hawksbill turtles (Hall and Roman 2013). Montero et al. (2016) indicated some bycatch risk for olive ridleys in the purse-seine fishery within the proposed study area, and Lopez et al. (2024) indicated limited bycatch vulnerability for leatherbacks from all fishery types within the proposed study area. 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. 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. In the fisheries in the ETP, Huang et al. (2011) reported a bycatch of 22 to 109 white-chinned petrels (*Procellaria* *aequinoctialis*) annually whereas Hall and Roman (2013), Lewison et al. (2014), and Wang et al. (2021) reported no bycatch.

4.1.6 Unavoidable Impacts

Unavoidable impacts to the species of marine mammals and sea turtles occurring in the proposed study 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 sea turtles, or on the populations to which they belong; NMFS, however, requires NSF to request Level A takes. Effects on recruitment or survival would be expected to be (at most) negligible.

4.1.7 Coordination with Other Agencies and Processes

This Final EA has been prepared by LGL Limited on behalf of L-DEO and NSF pursuant to Executive Order 12114. Potential impacts to marine mammals and endangered species have also been assessed in the document. The Draft EA was used to support the ESA Section 7 consultation processes with NMFS and other U.S. and international regulatory processes as appropriate. The Draft EA was also used as supporting documentation for an IHA application submitted by L-DEO, on behalf of itself, NSF, UCSD, and WHOI, to NMFS, under the U.S. MMPA, for "taking by harassment" (disturbance) of small numbers of marine mammals, for the proposed seismic surveys.

NSF coordinated with NMFS to complete the Final EA prior to issuance of the IHA and Biological Opinion/ITS to facilitate NMFS' issuance of the authorizations. NSF had enhanced coordination with NMFS throughout the IHA and ESA consultation processes to facilitate this streamlined approach.

(a) Endangered Species Act (ESA)

The Draft EA was used during the ESA Section 7 consultation process with NMFS. On 24 June 2025, NSF submitted a formal ESA Section 7 consultation request, including the Draft EA, to NMFS for the proposed activity. On 09 February 2026, NMFS transmitted a Biological Opinion and ITS, signed 06 February 2026 (Appendix D). As part of its decision-making process for the Proposed Action, NSF has taken 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 16 June 2025 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. On 18 December 2025, NMFS issued in the Federal Register a notice of intent to issue an IHA for the survey and a 30-day public comment period. NMFS issued an IHA for the proposed activity on 11 February 2026 (Appendix E). As part of its decision-making process for the Proposed Action, NSF has taken into consideration the IHA issued by NMFS, and the results of the entire environmental review process.

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 species attributable to the proposed activity; however, valuable data about the marine environment would be lost. Geological data of scientific value, with the aim to examine a timelapse of crustal mantle body changes within or between volcanic cycles, would not be collected, and 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. 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

APPENDIX A: DETERMINATION OF MITIGATION ZONES

During the planning phase, mitigation zones for the proposed marine seismic surveys were calculated based on modeling by L-DEO for Level A and Level B (160 dB re 1µPa$_{\mathrm{rms}}$) thresholds. 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 18-airgun array at a 7.5 m tow depth. The 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). Propagation measurements of pulses from the 36-airgun array at a tow depth of 6 m have also 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 America 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 the sites in the Gulf of America, the calibration hydrophone was located at a roughly constant depth of 350–500 m, which may not intersect all the sound pressure level (SPL) isopleths at their widest point from the sea surface down to the maximum relevant water depth for marine mammals of ~2000 m (Costa and Williams 1999). Figures 2 and 3 in Appendix H of the PEIS show how the values along the maximum SPL line that connects the points where the isopleths attain their maximum width (providing the maximum distance associated with each sound level) may differ from values obtained along a constant depth line. At short ranges, where the direct arrivals dominate and the effects of seafloor interactions are minimal, the data recorded at the deep and slope sites are suitable for comparison with modeled levels at the depth of the calibration hydrophone. At longer ranges, the comparison with the mitigation model—constructed from the maximum SPL through the entire water column at varying distances from the airgun array—is the most relevant. The results are summarized below.

In deep and intermediate-water depths, comparisons at short ranges between sound levels for direct arrivals recorded by the calibration hydrophone and model results for the same array tow depth are in good agreement (Fig. 12 and 14 in Appendix H of the PEIS). Consequently, isopleths falling within this domain can be predicted reliably by the L-DEO model, although they may be imperfectly sampled by measurements recorded at a single depth. At greater distances, the calibration data show that seafloor-reflected and sub-seafloor-refracted arrivals dominate, whereas the direct arrivals become weak and/or incoherent (Fig. 11, 12, and 16 in Appendix H of the PEIS). Aside from local topography effects, the region around the critical distance (~5 km in Fig. 11 and 12, and ~4 km in Fig. 16 in Appendix H of the PEIS) is where the observed levels rise closest to the mitigation model curve. However, the observed sound levels are found to fall almost entirely below the mitigation model curve (Fig. 11, 12, and 16 in Appendix H of the PEIS). Thus, analysis of the Gulf of America 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 Gulf of America calibration survey was appropriate to sample the maximum sound level in the water column, and the field measurements reported in Table 1 of Tolstoy et al. (2009) for the 36-airgun array at a tow depth of 6 m can be used to derive mitigation radii.

The proposed surveys would acquire data with the 18-airgun array at a maximum tow depth of 7.5 m in deep water. 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 shows the distances at which the 160-dB and 175-dB re 1µPa$_{\mathrm{rms}}$ sound levels are expected to be received for the 18-airgun array. The 160-dB level is the behavioral disturbance criteria (Level B) that is used by NMFS to estimate anticipated takes for marine mammal. The 175-dB level is used by NMFS, based on data from the DoN (2017), to determine behavioral disturbance for turtles. A retrospective analysis of acoustic propagation of R/V *Langseth* sources in a coastal/shelf environment from the Cascadia Margin off Washington suggests that predicted (modeled) radii (using an approach similar to that used here) for R/V *Langseth* sources were 2–3 times larger than measured in shallow water, so in fact, as expected, were very conservative (Crone et al. 2014). Similarly, data collected by Crone et al. (2017) during a survey off New Jersey in 2014 and 2015 confirmed that *in situ* measurements and estimates of the 160- and 180-dB distances collected by R/V *Langseth* hydrophone streamer were 2–3 times smaller than the predicted operational mitigation radii. In fact, five separate comparisons conducted of the L-DEO model with *in situ* received levels[3] have confirmed that the L-DEO model generated conservative exclusion zones (EZs), resulting in significantly larger EZs than required by National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS).

In July 2016, NMFS released technical guidance for assessing the effects of anthropogenic sound on marine mammal hearing (NMFS 2016, 2018). The guidance established thresholds for permanent threshold shift (PTS) onset or Level A Harassment (injury), for marine mammal species. The noise exposure criteria for marine mammals accounted 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. Southall et al. (2019) provided updated scientific recommendations regarding noise exposure criteria which are similar to those presented by NMFS (2016, 2018), but included all marine mammals (including sirenians), and a re-classification of hearing groups. NMFS (2024) incorporated Southall et al. (2019) recommendations into updated guidance regarding noise exposure criteria. The new guidance incorporates marine mammal auditory weighting functions (Fig. A-2) 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), high-frequency (HF) cetaceans (e.g., most delphinids), very high-frequency (VHF) cetaceans (e.g., porpoise and *Kogia* spp.), phocid pinnipeds underwater (PW), and otariid pinnipeds 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 new NMFS guidance did not alter the current threshold, 160 dB re $1\mu Pa_{rms}$, for Level B harassment (behavior). It should be recognized that there are a number of limitations and uncertainties associated with these injury criteria (Southall et al. 2007). Lucke et al. (2020) caution that some thresholds may not be able to accurately predict hearing impairment and other injury to marine mammals due to noise. Tougaard et al. (2024) noted that TTS-onset thresholds are likely impacted by the experimental methods used (e.g., behavioral vs. brain stem recordings, and stationary vs. free-swimming animals), in particular for noise exposure >10 kHz.

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

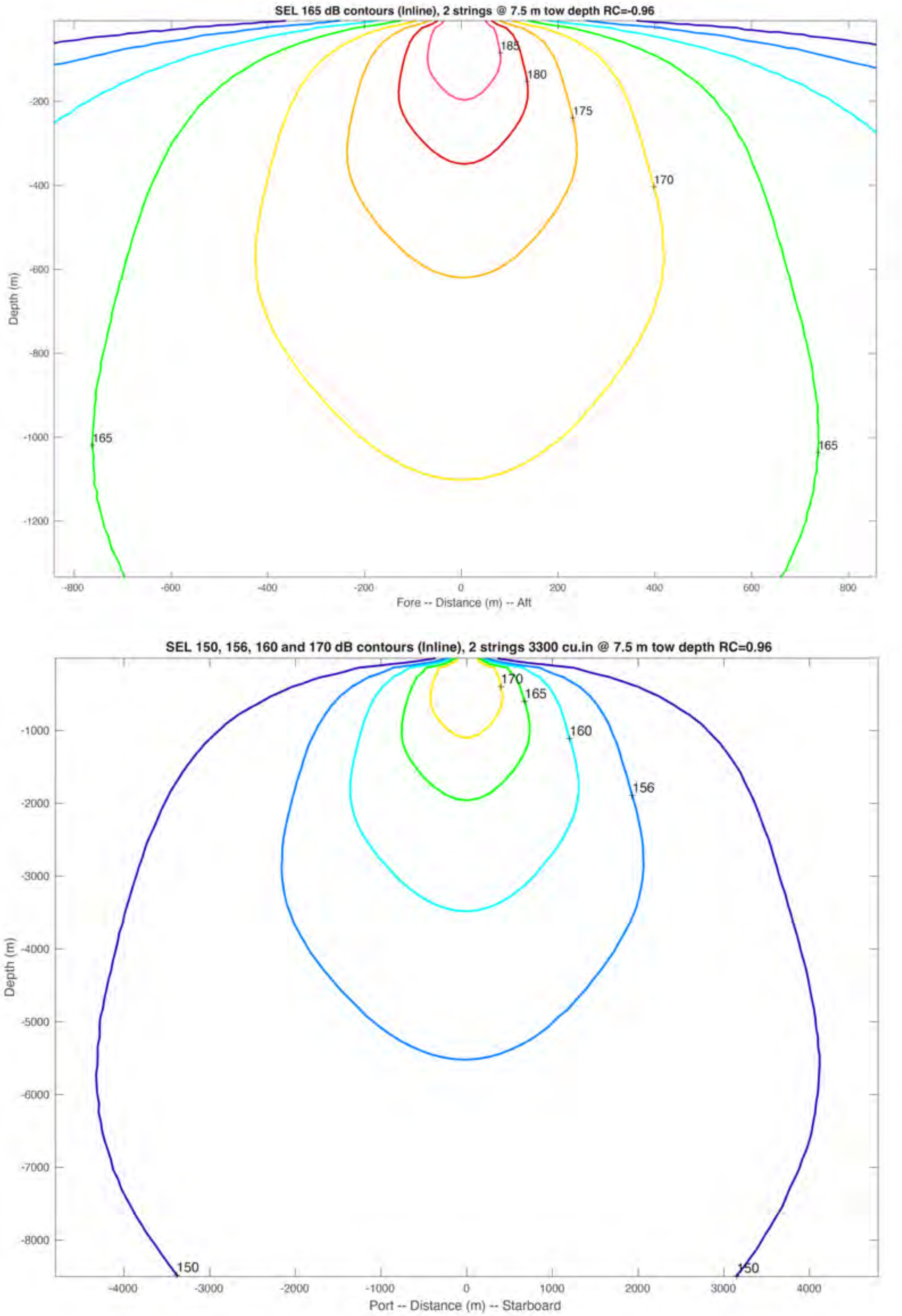


FIGURE A-1. Modeled deep-water received sound exposure levels (SELs) from the 18-airgun array at a 7.5-m tow depth planned for use during the proposed surveys. Received rms levels (SPLs) are expected to be ~10 dB higher. For example, the radius to the 150-dB SEL isopleth is a proxy for the 160-dB rms isopleth. The upper plot is a zoomed-in version of the lower plot.

TABLE A-14. Predicted distances to behavioral disturbance sound levels ≥160-dB re 1 µPa$_{rms}$ and ≥175-dB re 1 µPa$_{rms}$ that could be received during the proposed surveys with the 18-airgun array in the Eastern Tropical Pacific. The 160-dB criterion applies to all hearing groups of marine mammals (Level B harassment), 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[1]	Predicted distances (in m) to the 175-dB Received Sound Level[1]
2 strings, 18 airguns, 3300 in^3	7.5	>1000 m	3,526	763

[1] Distance is based on L-DEO model results.

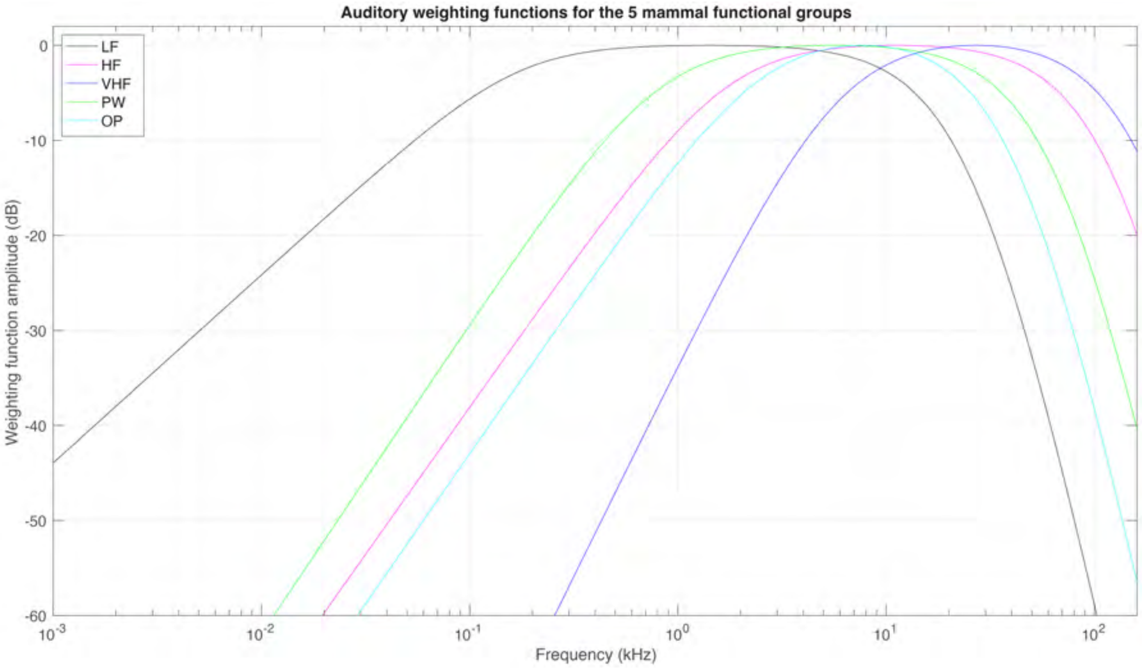


FIGURE A-2. Auditory weighting functions for five marine mammal hearing groups from the NMFS Technical Guidance Spreadsheet. LF = low frequency cetaceans, HF = high frequency cetaceans, VHF = very high frequency cetaceans, PW = phocid pinnipeds underwater, OP = otariid pinnipeds underwater.

The SEL$_{cum}$ for R/V *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). 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 $\mathrm{SEL}_{\mathrm{cum}}$ 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 $\mathrm{SEL}_{\mathrm{cum}}$ isopleths and account for the accumulation (Safe Distance Methodology) using the source characteristics (source velocity and duty) after Sivle et al. (2014).

For LF cetaceans during operations with the 18-airgun array, we estimated a new adjustment value by computing the distance from the geometrical center of the source to where the 183 dB $\mathrm{SEL}_{\mathrm{cum}}$ 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 assuming a propagation of $20\log_{10}$(Radial distance) (Table A-2).

However, for MF and HF cetaceans (and OW and PW pinnipeds, if applicable), 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, if applicable), 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 18-airgun array, the results for single shot SEL source level modeling are shown in Table A-2. The weighting function calculations, thresholds for $\mathrm{SEL}_{\mathrm{cum}}$, and the distances to the PTS thresholds for the 18-airgun array are shown in Table A-3. Figure A-3 shows the impact of weighting functions by hearing group. Figures A-4–A-6 show the modeled received sound levels for single shot SEL without applying auditory weighting functions for various hearing groups. Figure A-7 shows the modeled received sound levels for single shot SEL with weighting for LF cetaceans.

The thresholds for Peak $\mathrm{SPL}_{\mathrm{flat}}$ for the 36-airgun array, as well as the distances to the PTS thresholds, are shown in Table A-4. Figures A-8–A-10 show the modeled received sound levels to the Peak $\mathrm{SPL}_{\mathrm{flat}}$ thresholds, for a single shot. A summary of the Level A threshold distances are shown in Table A-5.

TABLE A-2. Results for modified farfield SEL source level modeling for the 18-airgun array with and without applying weighting functions to 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**	**193**	**159**	**183**	**185**	**184***
Radial Distance (m) (no weighting function)	162.78	38.25	2602	162.78	126.42	141.92
Modified Farfield SEL	227.23	224.65	227.31	227.23	126.42	227.04
Radial Distance (m) (with weighting function)	43.36	N.A.	N.A.	N.A.	N.A.	N.A.
Adjustment (dB)	-11.26	N.A.	N.A.	N.A.	N.A.	N.A.

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

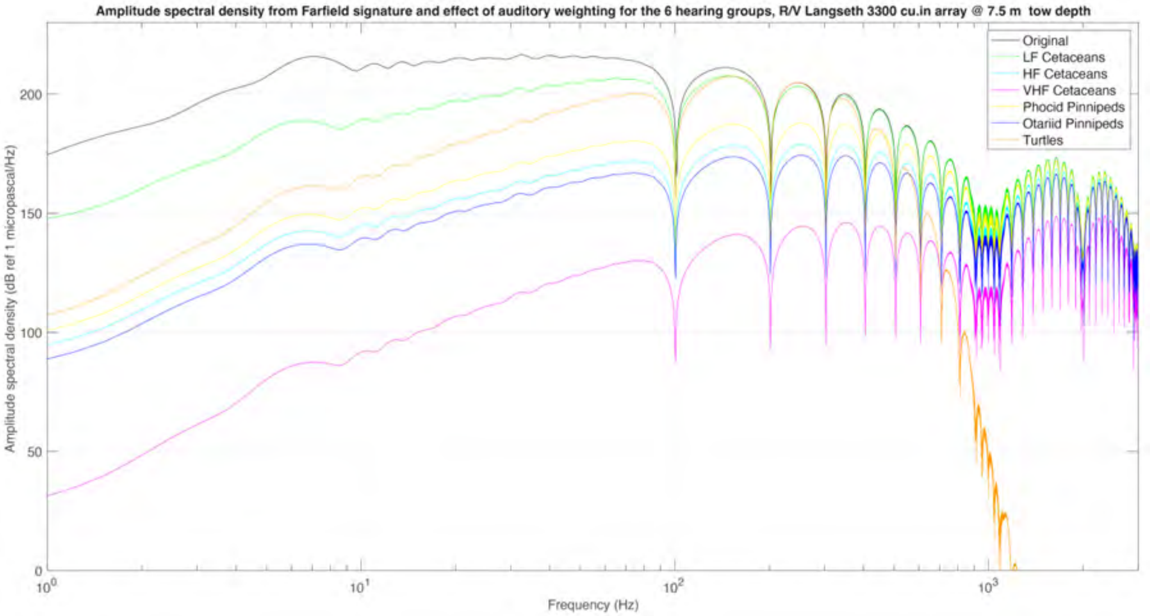
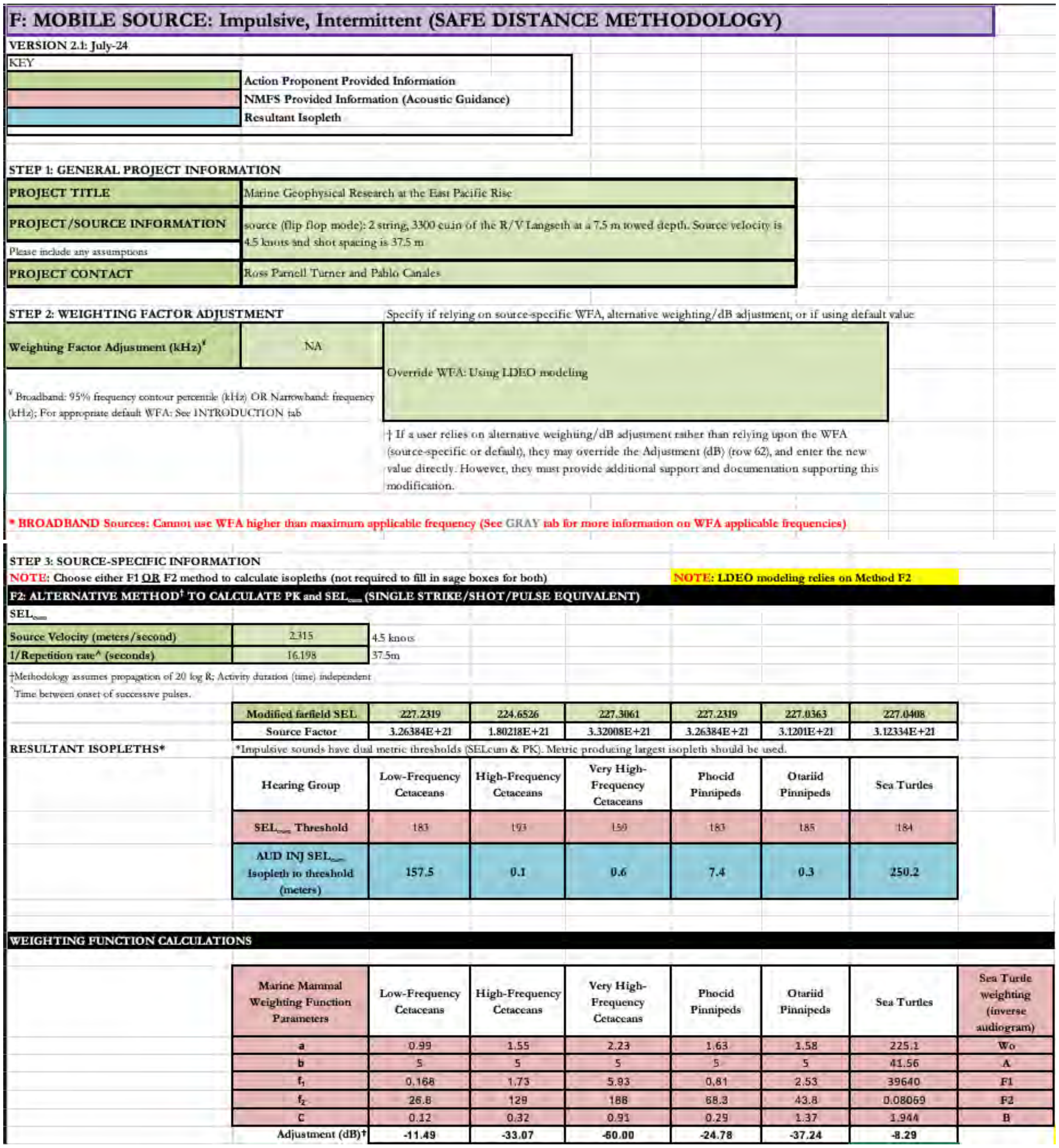


FIGURE A-3. Modeled amplitude spectral density of the 18-airgun array farfield signature. Amplitude spectral density before (black) and after (colors) applying the auditory weighting functions for LF, HF, and VHF cetaceans, Phocid Pinnipeds (PP), and Otariid Pinnipeds (OP). Modeled spectral levels are 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-3. Results for single shot SEL source level modeling for the 18-airgun array, at a speed of 4.5 kt and shot spacing of 37.5 m, with weighting function calculations for the SEL$_{\text{cum}}$ criteria, as well as resulting isopleths to thresholds for various hearing groups.



F: MOBILE SOURCE: Impulsive, Intermittent (SAFE DISTANCE METHODOLOGY)

VERSION 2.1: July-24

KEY

🟩	**Action Proponent Provided Information**
🟥	**NMFS Provided Information (Acoustic Guidance)**
🟦	**Resultant Isopleth**

STEP 1: GENERAL PROJECT INFORMATION

PROJECT TITLE	Marine Geophysical Research at the East Pacific Rise
PROJECT/SOURCE INFORMATION Please include any assumptions	source (flip flop mode): 2 string, 3300 cuin of the R/V Langseth at a 7.5 m towed depth. Source velocity is 4.5 knots and shot spacing is 37.5 m
PROJECT CONTACT	Ross Parnell Turner and Pablo Canales

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$_{\text{cum}}$ (SINGLE STRIKE/SHOT/PULSE EQUIVALENT)

SEL$_{\text{cum}}$

Source Velocity (meters/second)	2.315	4.5 knots
1/Repetition rate^ (seconds)	16.198	37.5m

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

^Time between onset of successive pulses.

Modified farfield SEL	227.2319	224.6526	227.3061	227.2319	227.0363	227.0408
Source Factor	3.26384E+21	1.80218E+21	3.32008E+21	3.26384E+21	3.1201E+21	3.12334E+21

RESULTANT ISOPLETHS*

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

Hearing Group	Low-Frequency Cetaceans	High-Frequency Cetaceans	Very High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds	Sea Turtles
SEL$_{\text{cum}}$ Threshold	183	193	159	183	185	184
AUD INJ SEL$_{\text{cum}}$ Isopleth to threshold (meters)	157.5	0.1	0.6	7.4	0.3	250.2

WEIGHTING FUNCTION CALCULATIONS

Marine Mammal Weighting Function Parameters	Low-Frequency Cetaceans	High-Frequency Cetaceans	Very High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds	Sea Turtles	Sea Turtle weighting (inverse audiogram)
a	0.99	1.55	2.23	1.63	1.58	225.1	Wo
b	5	5	5	5	5	41.56	A
f_1	0.168	1.73	5.93	0.81	2.53	39640	F1
f_2	26.8	129	188	68.3	43.8	0.08069	F2
C	0.12	0.32	0.91	0.29	1.37	1.944	B
Adjustment (dB)†	-11.49	-33.07	-60.00	-24.78	-37.24	-8.29	

†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-3).

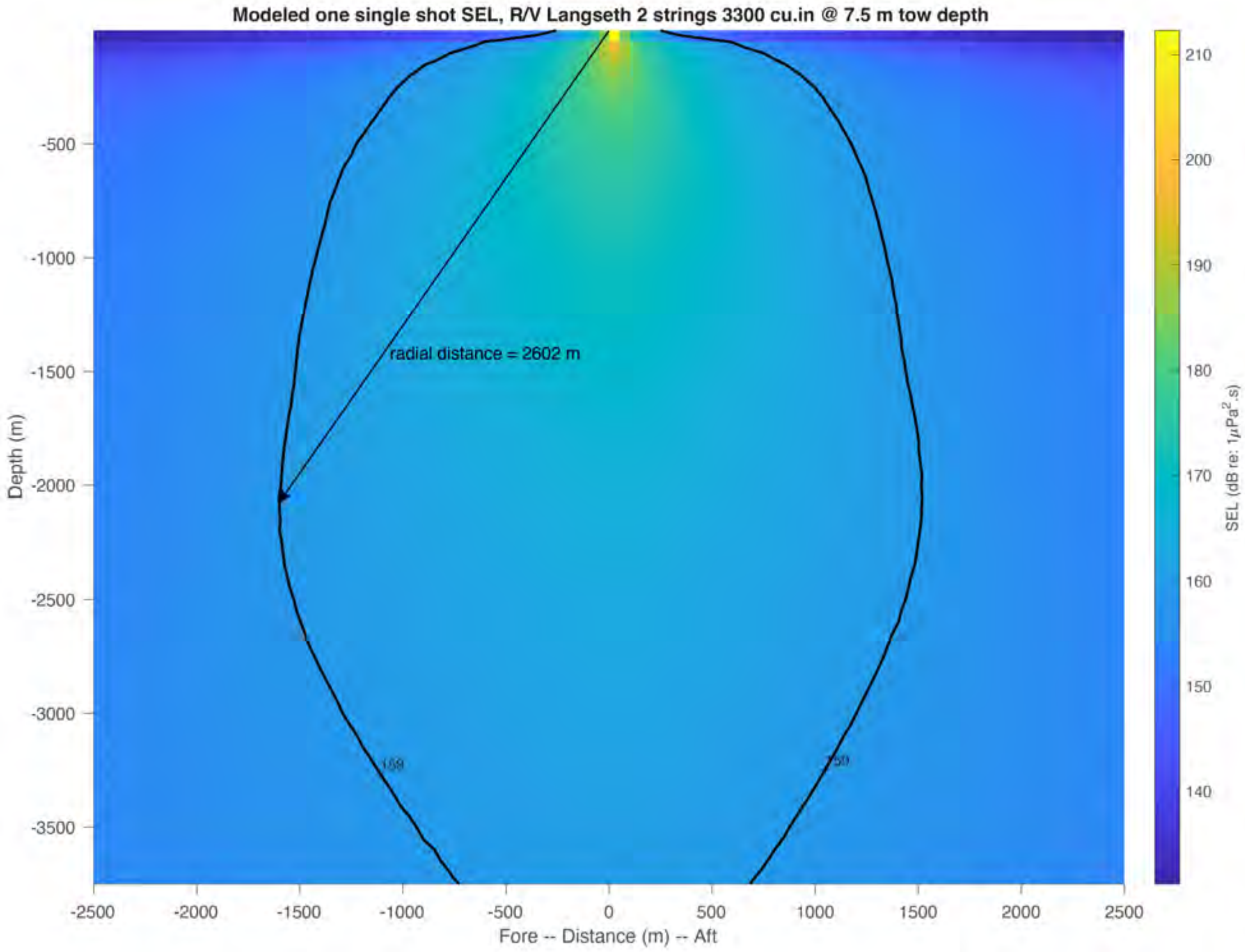


FIGURE A-4. Modeled received sound levels (SELs) in deep water from the 18-airgun array. The plot provides the radial distance from the geometrical center of the source array to the 159-dB SEL isopleth. Radial distance allows us to determine the modified farfield SEL using a propagation of 20log10(radial distance).

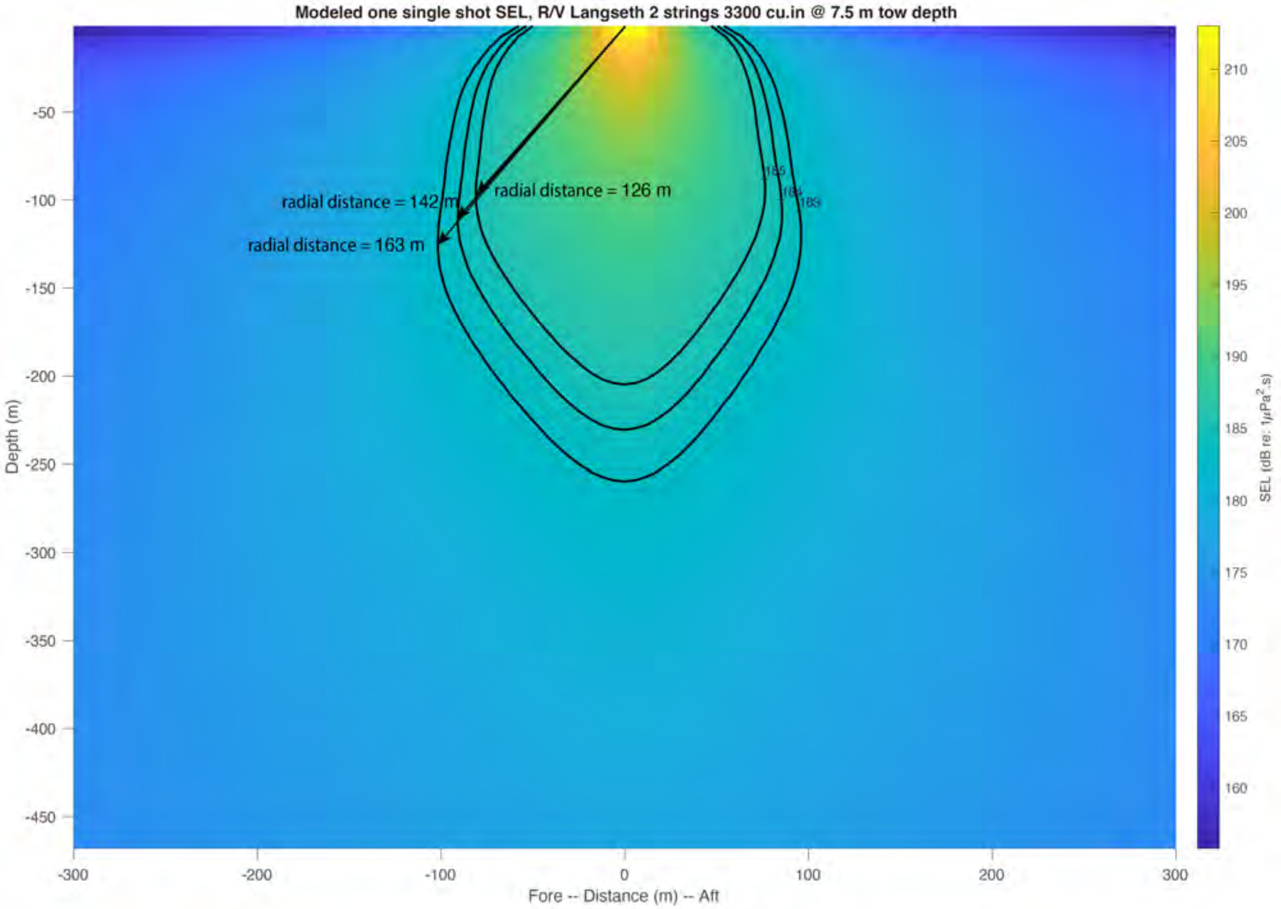


FIGURE A-5. Modeled received sound levels (SELs) in deep water from the 18-airgun array. The plot provides the radial distance from the geometrical center of the source array to the 183–185-dB SEL isopleths.

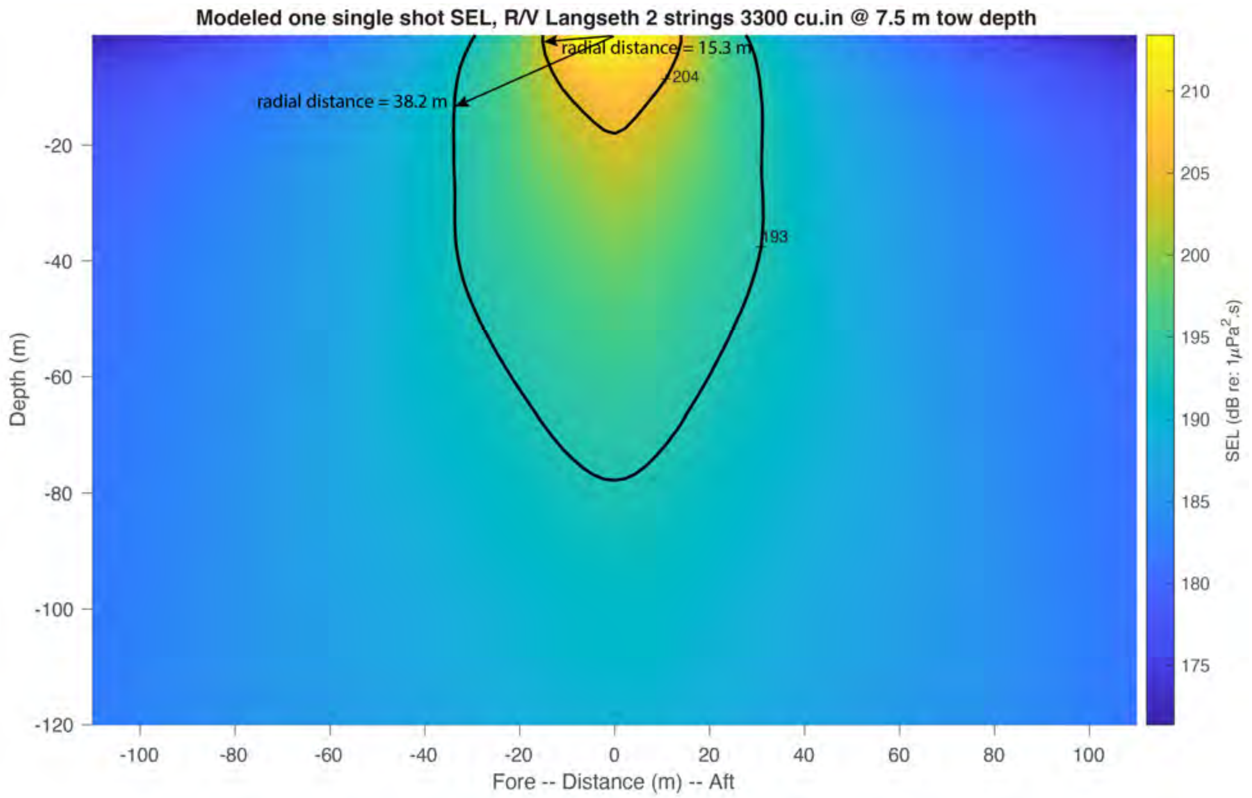


FIGURE A-6. Modeled received sound levels (SELs) in deep water from the 18-airgun array. The plot provides the radial distance from the geometrical center of the source array to the 193-dB SEL isopleth.

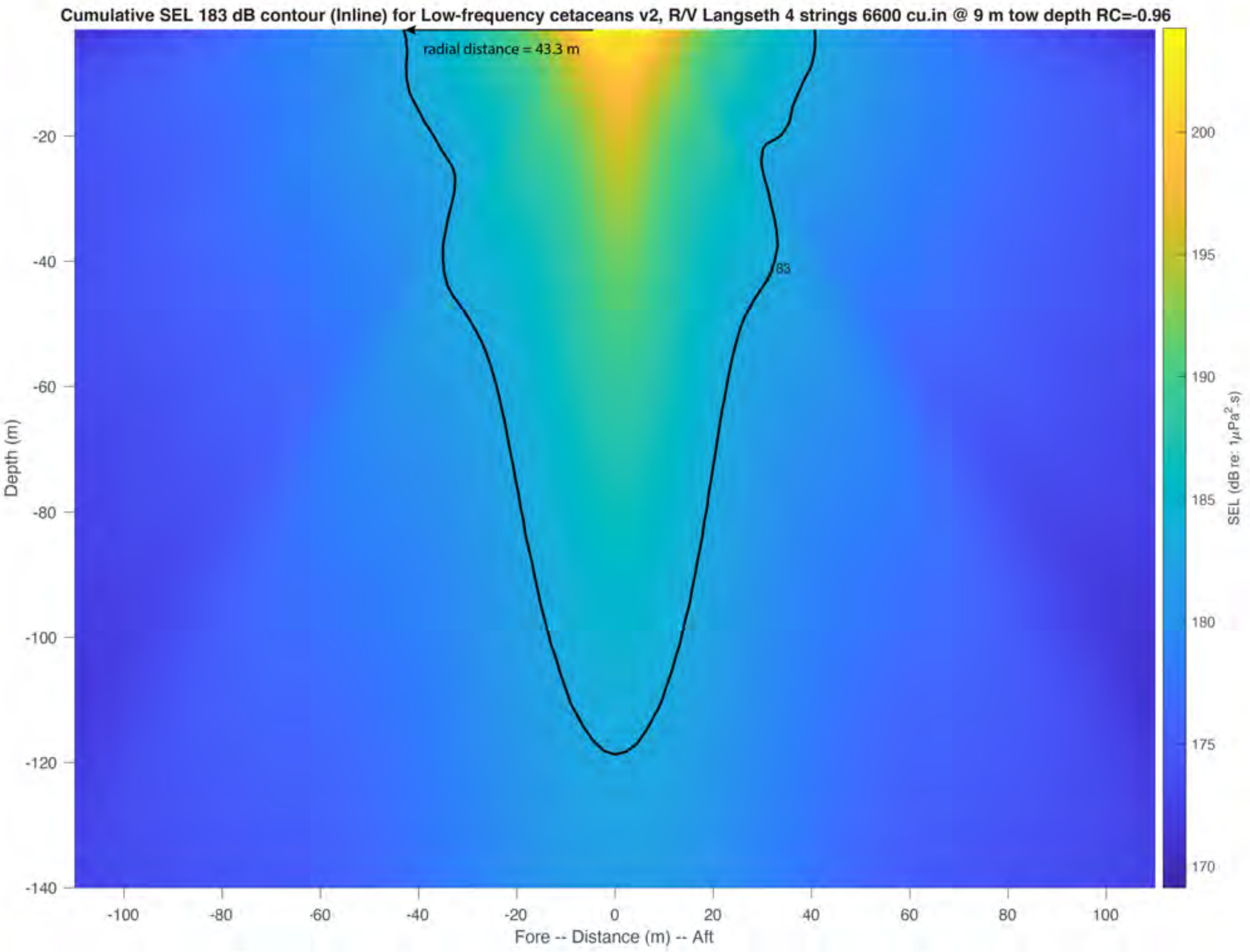


FIGURE A-7. Modeled received sound exposure levels (SELs) from the 18-airgun array at a 7.5-m tow depth, after applying the auditory weighting function for the LF cetaceans hearing group following the NMFS Technical Guidance. The plot provides the radial distance to the 183-dB SEL_{cum} isopleth for one shot. The difference in radial distances between Fig. A-5 and this figure allows us to estimate the adjustment in dB.

TABLE A-4. NMFS Level A acoustic thresholds (Peak SPL_{flat}) for impulsive sources for marine mammals and sea turtles and predicted distances to Level A thresholds for various hearing groups that could be received from the 18-airgun array during the proposed surveys.

Peak Threshold	**222**	**230**	**202**	**223**	**230**	**232**
Radial Distance to Threshold (m)	23.4	13.4	166.5	21.6	13.4	11.9
PTS Peak Isopleth (Radius) to Threshold (m)	23.4	13.4	164.6	21.6	13.4	11.9

N.A. means not applicable or not available.

TABLE A-5. Level A (PTS) threshold distances for different marine mammal hearing groups for the 18-airgun array in the Eastern Tropical Pacific. Consistent with NMFS (2024), 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. PTS threshold distances for sea turtles are also shown.

	Level A Threshold Distances (m) for Various Hearing Groups					
	Low-Frequency Cetaceans	High-Frequency Cetaceans	Very High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds	Sea Turtles
PTS SEL_{cum}	**157.5**	0.1	0.6	7.4	0.3	**250.2**
PTS Peak	23.4	**13.4**	**164.6**	**21.6**	**13.4**	11.9

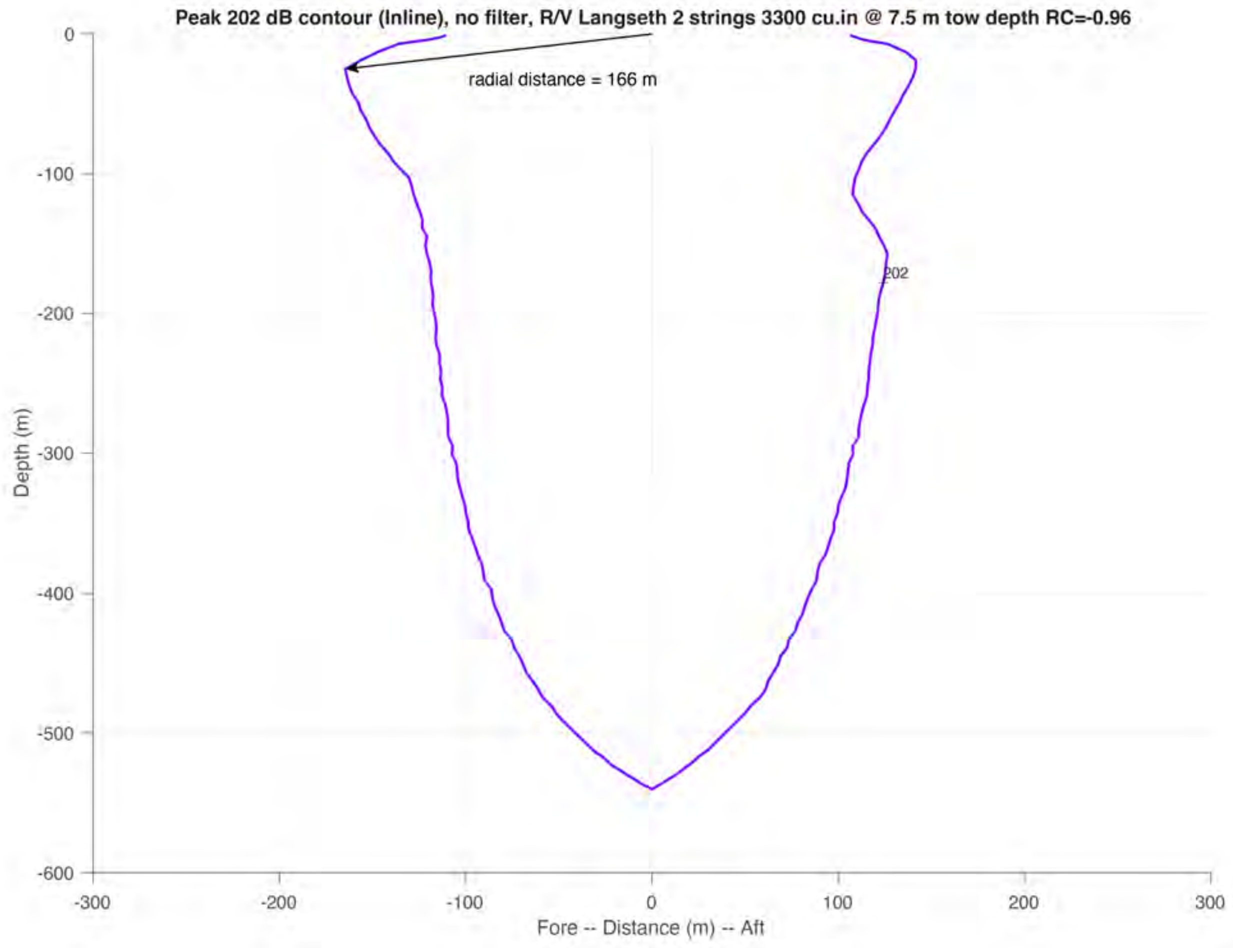


FIGURE A-8. Modeled deep-water received Peak SPL from the 18-airgun array at a 7.5-m tow depth. The plot provides the distance to the 202-dB Peak isopleth.

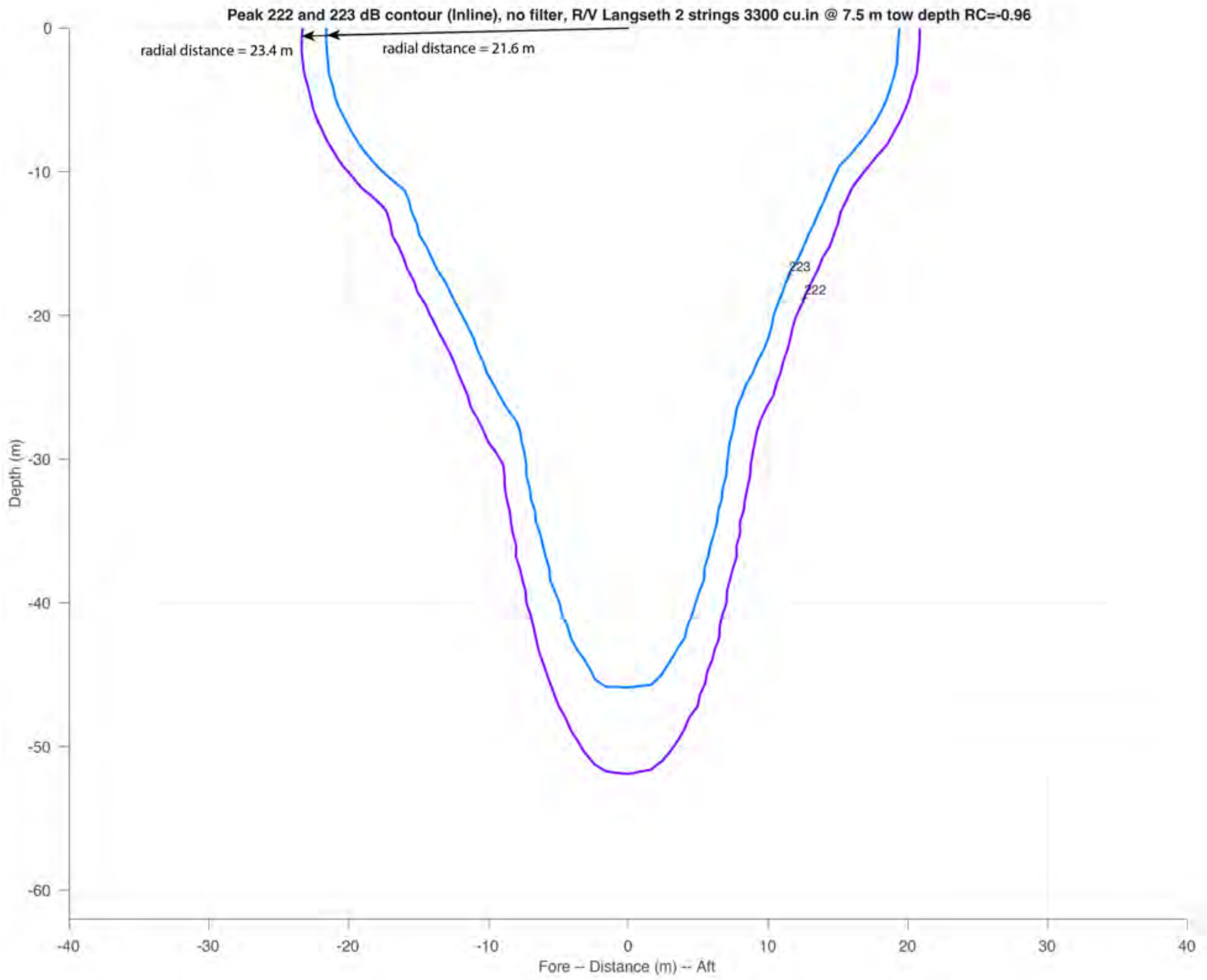


FIGURE A-9. Modeled deep-water received Peak SPL from the 18-airgun array at a 7.5 m tow depth. The plot provides the distances to the 222- and 223-dB Peak isopleths.

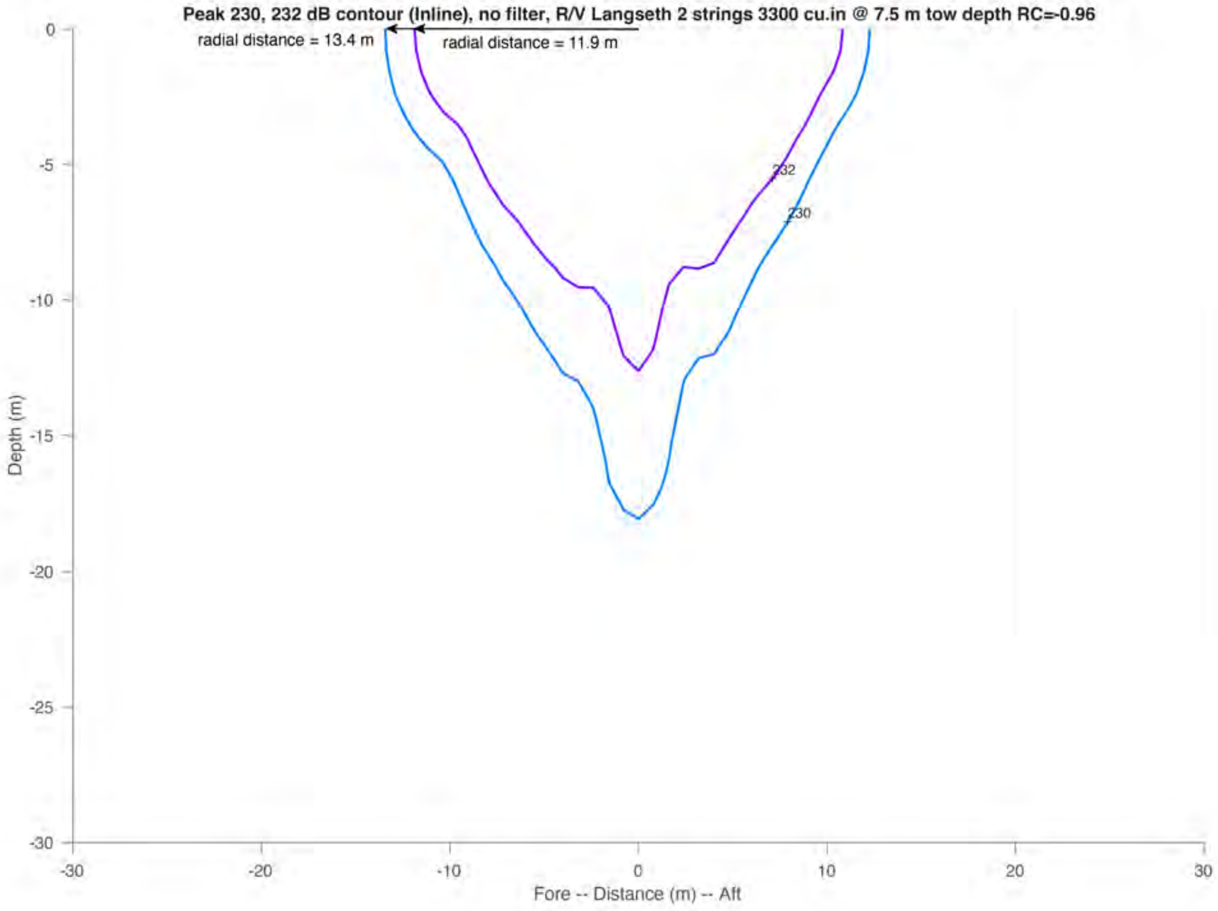


FIGURE A-10. Modeled deep-water received Peak SPL from the 18-airgun array at a 7.5 m tow depth. The plot provides the distances to the 230- and 232-dB Peak isopleths.

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APPENDIX B: MARINE MAMMAL TAKE CALCULATIONS

APPENDIX B: MARINE MAMMAL TAKE CALCULATIONS

Level A and Level B takes were determined for the seismic surveys; the detailed take calculations are shown in Table B-1. The ensonified areas that were used to calculate Level A and B takes are provided in Appendix C.

TABLE B-1. Take estimates for the proposed surveys in the ETP.

Species	Estimated Density (#/km^2)	Population Size in ETP[1]	Level B Ensonified Area (km^2)	Level A Ensonified Area (km^2)	Level B Takes[1]	Level A Takes[2]	% of Pop. in ETP (Total Takes)[3]	Requested Level A+B Take Authorization[4]
LF Cetaceans								
Humpback whale[5]	0.00013	2,566	14,558	1,122	2	0	0.07	2
Minke whale	0.00001	115	14,558	1,122	0	0	0.87	***1***
Bryde's whale	0.00051	10,411	14,558	1,122	5	1	0.06	6
Fin whale	0.00003	574	14,558	1,122	0	0	0.17	***1***
Sei whale	0.00005	*29,600*	14,558	1,122	1	0	<0.01	1
Blue whale	0.00008	1,415	14,558	1,122	1	0	0.14	**2**
HF Cetaceans								
Sperm whale	0.00019	4,145	14,558	97	3	0	0.19	**8**
Cuvier's beaked whale	0.00084	20,000	14,558	97	12	0	0.06	12
Longman's beaked whale	0.00004	1,007	14,558	97	1	0	1.99	**20**
Mesoplodon spp.	0.00031	25,300	14,558	97	5	0	N.A.	N.A.
Blaineville's beaked whale	N.A.	25,300	14,558	97	N.A.	N.A.	0.01	**3**
Ginkgo-toothed beaked whale	N.A.	25,300	14,558	97	N.A.	N.A.	0.01	**3**
Deraniyagala's beaked whale	N.A.	25,300	14,558	97	N.A.	N.A.	0.01	**3**
Pygmy beaked whale	N.A.	25,300	14,558	97	N.A.	N.A.	0.01	**3**
Risso's dolphin	0.00455	110,457	14,558	97	66	0	0.06	66
Rough-toothed dolphin	0.00620	107,663	14,558	97	69	1	0.07	70
Common bottlenose dolphin	0.01308	335,834	14,558	97	148	1	0.04	149
Pantropical spotted dolphin	0.07258	857,884	14,558	97	1,050	7	0.12	1,057
Spinner dolphin (whitebelly)	0.00889	734,837	14,558	97	129	1	0.02	**135**
Spinner dolphin (eastern)	0.08000	1,062,879	14,558	97	1,157	8	0.11	1,165
Striped dolphin	0.08099	964,362	14,558	97	1,171	8	0.12	1,179
Common dolphin	0.03980	3,127,203	14,558	97	576	4	0.02	580
Fraser's dolphin	0.01355	289,300	14,558	97	196	1	0.14	**395**
Short-finned pilot whale	0.00867	589,315	14,558	97	125	1	0.02	126
Killer whale	0.00040	8,500	14,558	97	6	0	0.07	6
False killer whale	0.00186	39,800	14,558	97	27	0	0.07	27
Pygmy killer whale	0.00183	38,900	14,558	97	26	0	0.07	**28**
Melon-headed whale	0.00213	45,400	14,558	97	31	0	0.44	**200**
VHF Cetaceans								
Dwarf and pygmy sperm whales	0.00003	11,200	14,558	1,147	0	0	0.02	**2**

N.A. means not available.

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

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

[3] Requested take authorization is expressed as % of population for the EPT (see Table 4).

[4] Requested take authorization is Level A plus Level B calculated takes; numbers in bold are based on mean group sizes from Oliveira and DeAngelis (2024), except for those in italics which are from Wade and Gerrodette (1993). *For Longman's beaked whale, the upper end of the average group size range from NMFS (2025d) was used..

APPENDIX C: ENSONIFIED AREA CALCULATIONS

APPENDIX C: ENSONIFIED AREA CALCULATIONS

The ensonified areas that were used to calculate takes for sea turtles and Level A and Level B takes for marine mammals for the proposed surveys in the ETP.

TABLE C-1. Areas expected to ensonified during the proposed surveys.

	Criterion	Daily Ensonified Area (km^2)	Total Survey Days	25% Increase	Total Ensonified Area (km^2)	Relevant Isopleth (m)
Marine Mammals						
Racetrack Survey	160 dB	478.1	18	1.25	10757.9	3,526
Long Transect Line	160 dB	1520.0	2	1.25	3799.9	3,526
Total					**14557.8**	
Sea Turtles						
Racetrack Survey	175 dB	110.4	18	1.25	2483.5	763
Long Transect Line	175 dB	322.3	2	1.25	805.7	763
Total					**3289.2**	
PTS						
Racetrack Survey	**LF**	42.5	18	1.25	956.1	157.5
Long Transect Line	**LF**	66.2	2	1.25	165.6	157.5
Total	**LF**	**108.7**			**1121.7**	
Racetrack Survey	**HF**	3.7	18	1.25	83.0	13.0
Long Transect Line	**HF**	5.6	2	1.25	14.1	13.0
Total	**HF**	**9.3**			**97.1**	
Racetrack Survey	**VHF**	43.3	18	1.25	973.5	164.6
Long Transect Line	**VHF**	69.2	2	1.25	173.0	164.6
Total	**VHF**	**112.5**			**1146.6**	
Racetrack Survey	**Sea turtles**	3.3	18	1.25	73.7	11.9
Long Transect Line	**Sea turtles**	105.3	2	1.25	263.2	11.9
Total	**Sea turtles**	**108.6**			**336.9**	

APPENDIX D: BIOLOGICAL OPINION AND INCIDENTAL TAKE STATEMENT

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
1315 East-West Highway
Silver Spring, Maryland 20910

February 9, 2026

Refer to NMFS No.: OPR-2025-02269

Ms. Kristen Hamilton
Environmental Policy Specialist
National Science Foundation
2415 Eisenhower Avenue
Alexandria, Virginia 22314

RE: Biological Opinion on the National Science Foundation's Marine Geophysical Surveys by the Research Vessel *Marcus G. Langseth* of the East Pacific Rise in the Eastern Tropical Pacific Ocean and National Marine Fisheries Service Permits and Conservation Division's Issuance and Possible Renewal of an Incidental Harassment Authorization Pursuant to Section 101(a)(5)(D) of the Marine Mammal Protection Act Pursuant to Section 7 of the Endangered Species Act of 1973

Dear Ms. Hamilton:

Enclosed is the National Marine Fisheries Service's (NMFS) Endangered Species Act (ESA) Interagency Cooperation Division's biological opinion on the effects of the National Science Foundation's proposed funding and Lamont Doherty Earth Observatory of Columbia University's conduct of a marine geophysical survey by the Research Vessel *Marcus G. Langseth* East Pacific Rise in the Eastern Tropical Pacific Ocean in February and March 2026 on listed threatened and endangered species under NMFS's jurisdiction in the action area. This consultation also considers the NMFS Permits and Conservation Division's proposed issuance and possible renewal of an incidental harassment authorization pursuant to the Marine Mammal Protection Act (16 U.S.C. 1371(a)(5)(D)) for the National Science Foundation and Lamont Doherty Earth Observatory of Columbia University to "take" marine mammals incidental to their action. We prepared the biological opinion pursuant to section 7(a)(2) of the ESA, as amended (16 U.S.C. 1536(a)(2)).

Based on our assessment, we concluded that the proposed action is likely to adversely affect, but not likely to jeopardize the continued existence of the blue whale (*Balaenoptera musculus*), fin whale (*Balaenoptera physalus*), Central America distinct population segment humpback whale (*Megaptera novaeangliae*), sei whale (*Balaenoptera borealis*), sperm whale (*Physeter macrocephalus*), East Pacific DPS green sea turtle (*Chelonia mydas*), hawksbill sea turtle (*Eretmochelys imbricata)* olive ridley sea turtle *(Lepidochelys olivacea)* Mexico's Pacific Coast breeding colonies, leatherback sea turtle (*Dermochelys coriacea*), and North Pacific Ocean DPS loggerhead sea turtle (*Caretta caretta*). We also concluded that the proposed action may affect, but is not likely to adversely affect giant manta ray (*Manta birostris*), oceanic whitetip shark (*Carcharhinus longimanus*), and Eastern Pacific DPS scalloped hammerhead shark (*Sphyrna lewini*).

This concludes ESA section 7 consultation on this action. Reinitiation of consultation is required and shall be requested by the Federal agency where discretionary Federal involvement or control over the action has been retained or is authorized by law and: (1) if the amount or extent of taking specified in the incidental take statement is exceeded; (2) if new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered; (3) if the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this consultation; or (4) if a new species is listed or critical habitat designated that may be affected by the identified action (50 C.F.R. §402.16).

If you have any questions regarding this biological opinion, please contact Colette Cairns, Consultation Biologist, at (301) 427-8414 or colette.cairns@noaa.gov, or me at (240) 723-6321 or tanya.dobrzynski@noaa.gov.

Sincerely,

Tanya Dobrzynski
Chief, ESA Interagency Cooperation Division
Office of Protected Resources

National Marine Fisheries Service

Endangered Species Act Section 7

Biological Opinion

Title:	Biological Opinion on a High-Energy Marine Geophysical Survey in the Eastern Tropical Pacific Ocean and the Issuance of an Incidental Harassment Authorization Pursuant to Section 101(a)(5)(D) of the Marine Mammal Protection Act
Action Agency:	National Science Foundation and Permits and Conservation Division, Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U. S. Department of Commerce
In Consultation With:	Endangered Species Act Interagency Cooperation Division, Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce
Publisher:	Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce
Approved:	DAMON RANDALL.KIMBERL Y.BETH.1365821093 [illegible] Kimberly Damon-Randall Director, Office of Protected Resources
Date:	February 6, 2026
ECO Number:	OPR-2025-02269
Digital Object Identifier:	https://doi.org/10.25923/dje5-am39

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1 INTRODUCTION

The Endangered Species Act of 1973, as amended (ESA; 16 U.S.C. §1531 et seq.), establishes a mandate for conserving and recovering threatened and endangered species of fish, wildlife, plants, and the habitats on which they depend. Section 7(a)(2) of the Act and its implementing regulations require every Federal agency, in consultation with and with the assistance of the Secretary (16 U.S.C. §1532(15)), to insure that any action it authorizes, funds, or carries out, in whole or in part, in the United States or upon the high seas, is not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of designated critical habitat.

Section 7(b)(3) of the ESA requires that, at the conclusion of consultation, the National Marine Fisheries Service (NMFS) provide an opinion stating whether the Federal agency's action is likely to jeopardize ESA-listed species or destroy or adversely modify their critical habitat. If NMFS determines that the action is likely to jeopardize ESA-listed species or destroy or adversely modify designated critical habitat, NMFS provides a reasonable and prudent alternative that allows the action to proceed in compliance with section 7(a)(2) of the ESA. If the action (or reasonable and prudent alternative) is expected to cause incidental take without violating section 7(a)(2), section 7(b)(4), as implemented by 50 CFR §402.14(i), requires NMFS to provide an incidental take statement (ITS) that specifies the amount or extent of incidental taking.

The marine mammal species in this consultation are regulated under the Marine Mammal Protection Act (MMPA) and the ESA. Each statute has defined the meaning of take independently. The MMPA defines take as to harass, hunt, capture, collect, or kill, or attempt to harass, hunt, capture, collect, or kill any marine mammal. Take in the ESA is to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct (16 U.S.C. §1532(19)). Actions considered 'take' under one statute do not necessarily rise to the level of take under the other statute. The ITS includes reasonable and prudent measures, which are actions necessary or appropriate to minimize impacts of incidental taking and terms and conditions to implement the reasonable and prudent measures.

The action agencies for this consultation are the National Science Foundation (NSF) and the NMFS, Office of Protected Resources, Permits and Conservation Division (Permits Division). Two Federal actions are considered in this biological opinion (Opinion). The first is the NSF's proposal to fund a high-energy seismic survey in the Eastern Tropical Pacific Ocean to take place in February and March 2026, in support of a NSF-funded collaborative research project led by Columbia University's Lamont-Doherty Earth Observatory (L-DEO). The second is the Permits Division's proposal to issue an incidental harassment authorization (IHA) authorizing nonlethal "takes" by Level B harassment (as defined by the MMPA) of marine mammals incidental to the planned seismic survey, pursuant to section 101(a)(5)(D) of the MMPA, 16 U.S.C. § 1371(a)(5)(D).

Updates to the regulations governing interagency consultation (50 CFR Part 402) were effective on May 6, 2024 (89 Fed. Reg. 24268). NMFS is applying the updated regulations to this consultation. The 2024 regulatory changes, like those from 2019, were intended to improve and clarify the consultation process, and, with one exception from 2024 (offsetting reasonable and prudent measures), were not intended to result in changes to the Services' existing practice in implementing section 7(a)(2) of the Act (89 Fed. Reg. 24268; 84 Fed. Reg. 45015). NMFS has considered the prior rules and affirms that the substantive analysis and conclusions articulated in this Opinion and incidental take statement would not have been any different under the 2019 regulations or pre-2019 regulations.

Consultation in accordance with section 7(a)(2) of the statute (16 U.S.C. §1536(a)(2)), associated implementing regulations (50 CFR Part 402), and agency policy and guidance (USFWS and NMFS 1998) was conducted by the NMFS Office of Protected Resources (OPR) ESA Interagency Cooperation Division (hereafter referred to as 'we' or 'us'). We prepared this Opinion and ITS in accordance with section 7(b) of the ESA and implementing regulations at 50 CFR Part 402. This document represents NMFS's opinion on the effects of these actions on threatened and endangered blue whale (*Balaenoptera musculus*), fin whale (*Balaenoptera physalus*), Central America distinct population segment humpback whale (*Megaptera novaeangliae*), sei whale (*Balaenoptera borealis*), sperm whale (*Physeter macrocephalus*), East Pacific DPS green sea turtle (*Chelonia mydas*), hawksbill sea turtle (*Eretmochelys imbricata)* olive ridley sea turtle *(Lepidochelys olivacea)* Mexico's Pacific Coast breeding colonies, leatherback sea turtle (*Dermochelys coriacea*), North Pacific Ocean DPS loggerhead sea turtle (*Caretta caretta*), giant manta ray (*Manta birostris*), oceanic whitetip shark (*Carcharhinus longimanus*), and Eastern Pacific DPS scalloped hammerhead shark (*Sphyrna lewini*) in the action area.

We completed pre-dissemination review of this document using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (DQA; section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). A complete record of this consultation is on file electronically with the NMFS OPR in Silver Spring, Maryland, and available in the NOAA Library Institutional Repository https://repository.library.noaa.gov/welcome.

1.1 Background

The NSF, as the research funding and action agency, has a mission to promote the progress of science, advance the national health, prosperity, and welfare, and secure the national defense. The NSF is proposing to fund a seismic survey in the Eastern Tropical Pacific Ocean over the East Pacific Rise (Proposed Action). In this action, researchers from the University of California, San Diego and the Woods Hole Oceanographic Institution, in collaboration with the Institut de Physique du Globe de Paris, will collect data in support of a research proposal that has been reviewed under the NSF merit review process and identified as a priority program by the NSF.

The proposed seismic research survey will be conducted from the research vessel (R/V) *Marcus G. Langseth* (*Langseth*) that is owned and operated by the L-DEO. In conjunction with this action, the Permits Division proposes to issue an IHA to the L-DEO, pursuant to the MMPA requirements for incidental takes of marine mammals that could occur during the NSF funded seismic survey. This document represents our opinion on the effects of the two proposed Federal actions on threatened and endangered species, and has been prepared in accordance with section 7(a)(2) of the ESA.

1.1.1 Consultation History

This Opinion is based on information provided in the NSF draft environmental analysis (EA) prepared pursuant to Executive Order 12114 and the Permits Division's notice of a proposed IHA prepared pursuant to the MMPA. Our communication with the NSF and Permits Division regarding this consultation is summarized as follows:

- **June 24, 2025**: We received a draft initiation package from the NSF.
- **July 30, 2025**: We provided comments and questions on the draft EA to the NSF. The NSF responded with answers on July 30, 2025. We informed NSF that the initiation package was complete and initiated consultation on June 24, 2025.
- **December 17, 2025**: The Permits Division submitted an initiation package with the draft proposed IHA.
- **January 20, 2026**: The public comment period for the proposed IHA closed.
- **January 27, 2026**: We notified the Permits Division that the initiation package was complete as of December 17, 2025, and initiated consultation.

1.1.2 Analytical Approach

This Opinion includes a jeopardy analysis. We use the following approach to determine whether an action agency is able to insure its proposed action is not likely to jeopardize listed species or destroy or adversely modify critical habitat:

- Identify all aspects of the proposed action (as defined in 50 CFR §402.02), including activities that are a consequence of the action but are not part of the proposed action.
- Identify the physical, chemical, and biological modifications to land, water, and air (stressors) that result from those actions and subsequent activities.
- Establish the spatial extent of those stressors, which is the action area (50 CFR §402.02).
- Identify the listed species (as defined at 16 U.S.C. §1532(16)) that may be affected by the action.
- Identify any species that are not likely to be adversely affected by the action.

- Evaluate the range-wide status of the species expected to be adversely affected by the proposed action.
- Evaluate the environmental baseline (as defined in 50 CFR §402.02) as it pertains to the species.
- Evaluate the effects of the proposed action on listed species using a stressor-exposure-response approach. When complete, this section anticipates the amount or extent, as well as the forms (harass, harm, etc.), of take of listed species (or a surrogate) that is reasonably certain to occur as a result of the action. Because take is categorized differently under ESA and MMPA, the initiation documents provided by the NMFS Permits and Conservation Division, and the analysis in this Opinion may discuss take differently and identify different numbers of takes as the reasonably certain outcomes of this action (see guidance at https://www.fisheries.noaa.gov/s3/2023-05/02-110-19-renewal-kdr.pdf).
- Evaluate cumulative effects (as defined at 50 CFR §402.02).
- Produce an integration and synthesis, where we add the effects of the action and cumulative effects to the environmental baseline, and, in light of the status of the species and critical habitat, analyze whether the proposed action is likely to jeopardize the continued existence of listed species or destroy or adversely modify critical habitat.
- Complete a jeopardy and destruction or adverse modification analysis, relying on the justification in the integration and synthesis.
- If the Opinion determines the action agency failed to insure their action is not likely to jeopardize the continued existence of listed species, we suggest a reasonable and prudent alternative to the proposed action and assess the effects of that alternative action.
- Provide an incidental take statement that specifies the amount or extent of impact of the take on listed species, reasonable and prudent measures, and terms and the conditions to implement those measures for actions that do not violate section 7(a)(2) of the ESA, for an alternative action that does not violate section 7(a)(2) of the ESA, and when take of marine mammals is reasonably certain to occur, it is permitted under section 101(a)(5) of the MMPA.

In each of the steps above, NMFS relies on the best scientific and commercial data available to ensure we reach supportable conclusions. This Opinion is based on our review and analysis of various information sources, including:

- Information submitted by the NSF and NMFS Permits Division;
- Government reports (including NMFS's biological opinions and stock assessment reports);
- National Oceanic and Atmospheric Administration (NOAA) technical memorandums;

- Monitoring reports; and
- Peer-reviewed scientific literature.

2 PROPOSED FEDERAL ACTION

Action means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies in the United States or on the high seas. Examples include, but are not limited to: 1) actions intended to conserve listed species or their habitat; 2) the promulgation of regulations; 3) the granting of licenses, contracts, leases, easements, rights-of-way, permits, or grants in aid; or 4) actions directly or indirectly causing modifications to the land, water, or air (50 CFR §402.02).

2.1 Description of the Action

Two proposed Federal actions are evaluated in this consultation. The first is the NSF's proposal to fund the Principal Investigators, Drs. R. Parnell-Turner (University of California San Diego) and J.P. Canales (Woods Hole Oceanographic Institute), with international collaboration from Dr. M. Marjanović (Institut de Physique du Globe de Paris and University of California San Diego), to conduct marine geophysical research in the Eastern Tropical Pacific Ocean over the East Pacific Rise during February and March 2026 using the seismic surveying capability of the *Langseth*. The second Federal action is the Permits Division's issuance of an IHA authorizing nonlethal MMPA "takes" by Level B harassment, pursuant to section 101(a)(5)(D) of the MMPA, incidental to the high-energy marine seismic survey to the L-DEO, owner and operator of the *Langseth*.

The overview of the proposed action that follows here is based primarily on the initiation packages from NSF and the Permits Division, that included a draft EA, the draft proposed IHA, and the related *Federal Register* notice (90 Fed. Reg. 59330, see Appendix A; Section 14).

2.1.1 National Science Foundation: Geophysical Research Survey Overview

The main goal of NSF's proposed high-energy seismic research is to collect seismic reflection data of volcanic cycles and to examine the active magmatic system at the East Pacific Rise. The proposed project would consist of 3-D multi-channel seismic surveys at the 9°50'N segment of the East Pacific Rise, thereby repeating the same experiment conducted in 2008 on board the *Langseth*. The two datasets would be processed together using the latest elastic full waveform inversion techniques, to obtain high-resolution imagery that would be used to investigate how the magmatic and hydrothermal plumbing systems beneath this submarine volcanic ridge have changed since 2008, thereby allowing for a unique four-dimensional time-lapse study. The time-lapse imagery would allow the investigators to test long-debated hypotheses about the eruption cycle for the first time, by distinguishing characteristic changes in the shape and melt content of the magmatic system.

2.1.1.1 Vessel Specifications

The survey will be conducted from one vessel, the U.S.-flagged *Langseth*. The research vessel will be self-contained, and the scientific party and crew will live aboard the vessel for the entire seismic survey. The *Langseth* has a length of 72 meters (m), a beam of 17 m, maximum draft of 5.9 m, and a gross tonnage of 3,834 tons. Its propulsion system consists of two diesel Bergen BRG-6 engines, each producing 3,550 horsepower, and an 800 horsepower bow thruster. The *Langseth* is designed for seismic research, to run quietly compared to similarly sized and powered vessels. This avoids interference with the seismic signal data collection. The vessel speed during seismic survey operations would be ~8.3–9.3 kilometers per hour (km/h; ~4.5–5 knots [kt]). Maneuverability is limited while towing all the equipment because the turning rate of the vessel would be no more than five degrees per minute. When not towing seismic survey gear, the *Langseth* typically cruises at 18.5 km/h (10 kt).

2.1.1.2 Airguns and Acoustic Receiver

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

During the proposed high-energy survey the *Langseth* will tow two 18-airgun arrays with a discharge volume of ~3,300 cubic inches (in^3) each, at a depth of 7.5 m. The two linear airgun arrays would fire in an alternate “flip-flop” mode every 37.5 m (~16 seconds). The airgun array sound source specifications are in Table 1. During operations, the generator-injector (GI) airguns will be operated continuously unless maintenance or mitigation measures, such as shutdowns, are warranted (see Conservation Measures, Section 2.2).

Table 1. Eighteen airgun array sound source specifications

Source output:	0-peak is 42 bar-m (252 dB re 1 µPa·m); peak-peak is 87 bar-m (259 dB re 1 µPa·m)
Dominant frequency components:	0–188 Hz

dB re 1 µPa·m=decibels referenced to a pressure of one microPascal at one meter; Hz=Hertz

During the seismic surveys, the *Langseth* would tow four strings (each ~16 m long) with 36 airguns (plus four spares); however, only 18 airguns in two strings would be firing at one time.

The two strings in each 18-airgun array would be separated by 8 m, and the two "flip-flop" arrays would be spaced 75 m apart. The airgun strings would be towed ~265 m behind R/V *Langseth*.

The main receiving system would consist of four 5,850 m long solid-state hydrophone streamers, separated by 150 m (solid flexible polymer – not gel nor oil filled). As the airgun arrays are towed along the survey lines, the hydrophone streamers will receive the returning acoustic signals and transfer the data to the on-board processing system.

2.1.1.3 Additional Acoustic Data Systems

During the seismic survey a multibeam echosounder (MBES), sub-bottom profiler (SBP), and an acoustic Doppler current profiler (ADCP) will be operated continuously. The ocean floor will be mapped with the Kongsberg EM 122 MBES and a Knudsen Chirp 3260 SBP. A Teledyne RDI 75 kiloHertz (kHz) Ocean Surveyor ADCP will be used to measure water current velocities. It will operate at a frequency of 35–1,200 kHz, with a maximum source level of 224 decibels referenced to a pressure of one microPascal at one meter (dB re 1 µPa-m) over a conically-shaped 30° beam and a ping rate of 0.7 Hz.

The Kongsberg EM122 is a hull-mounted system operating at 10.5–13 (usually 12) kHz. The transmitting beamwidth is one or two degrees fore-aft and 150° (maximum) athwartship (i.e., perpendicular to the ship's line of travel). The maximum sound source level is 242 decibels referenced to 1 dB re 1 µPa-m. Each ping consists of eight (in water greater than 1,000 m) or four (in water less than 1,000 m) successive fan-shaped transmissions, each ensonifying a sector that extends one degree fore-aft. Continuous-wave signals increase from 2-15 milliseconds long in water depths up to 2,600 m and frequency modulated chirp signals up to 100 milliseconds long are used in water greater than 2,600 m. The successive transmissions span an overall cross-track angular extent of about 150°, with two millisecond gaps between the pings for successive sectors.

The Knudsen 3260 is normally operated to provide information about the near sea floor sedimentary features and the bottom topography that is mapped simultaneously by the MBES. The beam is transmitted as a 27° cone, which is directed downward by a 3.5 kHz transducer in the hull of the *Langseth*. The nominal power output is 10 kilowatts, but the actual maximum radiated power is three kilowatts or 222 dB re 1 µPa-m root-mean-square (rms). The ping duration is up to 64 milliseconds, and the ping interval is one second. A common mode of operation is to broadcast five pulses at one second intervals followed by a five second pause. The SBP is capable of reaching depths of 10,000 m.

2.1.2 NMFS Permits and Conservation Division: Incidental Harassment Authorization Issuance

The OPR Permits and Conservation Division proposes to issue the L-DEO an IHA for the incidental taking of marine mammals during the conduct of this action.

The Permits and Conservation Division proposes to issue an IHA pursuant to the MMPA, as amended (16 U.S.C. 1361 et seq.) for the L-DEO to "take" marine mammals incidental to conducting a high-energy marine seismic survey in the Eastern Tropical Pacific Ocean. Issuance of an IHA by the Permits and Conservation Division is dependent in part on a determination that the total taking of the affected species or stocks of marine mammals from the proposed action as a whole would have a negligible impact on the affected species or stocks. NMFS has defined negligible impact in 50 CFR §216.103 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."

The Permits and Conservation Division's proposed IHA, which also include[*s*] proposed mitigation, monitoring, and reporting requirements, is available on the following website: https://www.fisheries.noaa.gov/action/incidental-take-authorization-lamont-doherty-earth-observatorys-marine-geophysical-survey-2

On June 16, 2025, the Permits Division received a request from the L-DEO for an IHA under the MMPA to take marine mammals incidental to conducting a high-energy marine seismic survey of the East Pacific Rise in the Eastern Tropical Pacific Ocean. On September 10, 2025, the Permits Division deemed the L-DEO's application for an IHA to be adequate and complete. The IHA request is for take of a small number of 28 species of marine mammals by MMPA Level B harassment only. Neither the L-DEO nor the Permits Division expects serious injury or mortality to result from the proposed activities; therefore, an IHA is considered appropriate. The IHA would be valid for a period of one year from the date of issuance.

The Permits Division is proposing to authorize takes of marine mammals incidental to the planned seismic survey by MMPA Level B harassment which is comparable to harassment under ESA. The proposed IHA authorizes the incidental harassment of the following threatened and endangered marine mammal species: fin whale (*Balaenoptera physalus*), Central America distinct population segment (DPS) of humpback whale (*Megaptera novaeangliae*), sei whale (*Balaenoptera borealis*), blue whale (*Balaenoptera musculus*), and sperm whale (*Physeter macrocephalus*). The proposed IHA identifies requirements that the survey activities must comply with as part of its authorization to L-DEO, which were discussed in the previous sections.

On December 18, 2025, the Permits Division published a notice of proposed IHA and request for comments on the proposed IHA and possible renewal in the *Federal Register* (90 Fed. Reg. 19090). The public comment period closed on January 20, 2026. The Permits Division received one substantive comment during the public comment period. The public comment did not result in any changes to the proposed IHA.

2.2 Conservation Measures

The L-DEO is obligated to enact mitigation measures to have its action result in the least practicable adverse impact on marine mammal species or stocks under the MMPA, which may also reduce the likelihood of adverse effects to ESA-listed marine species. Monitoring for protected species (ESA-listed or MMPA-protected species), via protected species observers (PSOs), during the conduct of the proposed action triggers certain mitigation measures, such as a shutdown. Monitoring also helps evaluate the effectiveness of the mitigation over time and ensures that any measures implemented to reduce or avoid adverse effects on protected species are successful.

When a final IHA is issued, the Permits Division will require that L-DEO implement the mitigation and monitoring measures listed below. The NSF proposed action applies these measures to sea turtles as well. These measures are required during the seismic survey to reduce the potential for injury to or harassment of marine mammals and sea turtles. The following mitigation and monitoring measures are described in subsequent sections of this Opinion:

- Proposed exclusion and buffer zones;
- Shutdown procedures;
- Ramp-up procedures;
- Visual monitoring by NMFS-approved PSOs;
- Vessel strike avoidance measures.

Other proposed MMPA mitigation and monitoring measures (e.g., shutdown and ramp-up procedures) are described in the Permits Division's *Federal Register* notice of proposed IHA and request for comments on proposed IHA and possible renewal (90 Fed. Reg. 59330) and Appendix A (Section 14).

While we consider all of these measures important and expect them to be effective in minimizing the effects of potential stressors, they are not anticipated to completely eliminate the potential for adverse effects.

2.2.1 Exclusion and Buffer Zones

The NSF proposed action includes measures for implementing exclusion zones (EZs) and the IHA will require them to minimize any potential adverse effects of the sound from the airgun array on protected species. EZs are monitored areas within which occurrence of a marine mammal or sea turtle triggers a shutdown of the airgun array, to reduce exposure of marine mammals or sea turtles to sound levels expected to have adverse effects on the species. These EZs are based upon the distance over which sound levels from the seismic sound source array are expected to meet or exceed acoustic thresholds used by NMFS[1] to identify intensities potentially

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[1] For example see https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-acoustic-technical-guidance-other-acoustic-tools

affecting a species group, such as the onset of hearing threshold shifts and behavioral disturbance in low frequency cetaceans (i.e., baleen whales). Acoustic thresholds are discussed in more detail in the Effects of the Action section (see Section 6.1.1).

The intent in prescribing a standard distance for the EZ is to: (1) encompass zones within which auditory injury can occur on the basis of instantaneous exposure; (2) provide additional protection from the potential for more severe behavioral responses for marine mammals and sea turtles at relatively close range to the sound source; (3) provide consistency for PSOs, who need to monitor and implement the EZ; and (4) define a distance within which detection probabilities (using binoculars and the naked eye) are reasonably high for most marine mammal and sea turtle species under typical conditions.

Visual monitoring of the buffer zone is intended to: (1) provide additional protection to marine mammals that may be in the area during pre-clearance; and (2) during use of the airgun array, aid in establishing and maintaining the EZ by alerting the visual PSO and crew of marine mammals and sea turtles that are outside of, but may approach and enter, the EZ.

For other recent high-energy seismic surveys conducted by L-DEO, NMFS required PSOs to establish and monitor a 500 m EZ for shutdowns for marine mammals, monitor an additional 500-m buffer zone beyond the EZ for marine mammals prior to ramp up, and implement a 150-m EZ for sea turtles. The buffer zone means an area beyond the EZ to be monitored for the presence of marine mammals that may enter the EZ. If marine mammals are detected in or about to enter the 500-m EZ, or sea turtles are detected in or about to enter the 150-m EZ, the GI airguns would be shut down. The NSF proposes to use the same approach for the 18 GI airguns with a total discharge volume of 3,300 in^3 used in this proposed action. The IHA will also require an extended 1,500-m EZ for any beaked whale or a large whale (sperm whale or any baleen whale) with a calf and for groups of six or more large whales. This provides additional protective measures for particularly sensitive species and situations. See the subsections that follow for more details on shutdowns and buffer zones.

2.2.2 Shutdown Procedures

A shutdown requires the deactivation of all individual airguns. PSOs will be required to call for shutdown of the airgun array if a marine mammal is seen approaching or is detected within the 500-m EZ. The airgun array would be shut down if ESA-listed sea turtles were observed within a 150-m designated EZ. Clear lines of communication are needed between the PSOs on duty and the crew controlling the airgun array to ensure that shutdown commands are conveyed swiftly while allowing PSOs to maintain watch. When shutdown is called for by a PSO, the airgun array will be immediately deactivated and any dispute resolved only following deactivation.

Following a shutdown, the airgun array activity will not resume until the animal is visually observed to have departed the EZ, or after 30 minutes in the case of mysticetes and large odontocetes, including sperm whales. A shutdown triggered by a marine mammal will require a ramp-up (see section 2.2.3) when the airgun array activity resumes. A shutdown triggered by a sea turtle will not require a ramp-up, but the airgun array activity may not resume until all sea turtles are visually observed to have departed the 150-m EZ or none have been seen in the EZ for 15 minutes.

2.2.3 Pre-clearance and Ramp-up

Ramp-up (sometimes referred to as “soft-start”) means the gradual and systematic increase of emitted sound levels from an airgun array. A ramp-up typically begins by first activating a single airgun of the smallest volume, followed by doubling the number of active elements in stages until the full complement of an airgun array are active. Since this survey will only use two GI airguns, the ramp-up would begin by activating a single GI airgun and adding the second GI airgun after five minutes.

A pre-clearance observation (30 minutes) is to ensure that no marine mammals or sea turtles are observed within the EZ, and no marine mammals are in the buffer zone, prior to the beginning of ramp-up. During pre-clearance, observations of marine mammals in the buffer zone are the only time operations will be prevented (i.e., at the beginning of ramp-up). The intent of ramp-up is to alert protected species of the pending seismic survey activities and to allow time for those animals to move away from the immediate vicinity. A ramp-up procedure is required as part of the activation of the airgun array.

Operators must adhere to the following pre-clearance and ramp-up requirements:

- The operator must notify a designated PSO of the planned start of ramp-up as agreed upon with the lead PSO; the notification time will not be less than 60 minutes prior to the planned ramp-up in order to allow the PSO time to monitor the exclusion and buffer zones for 30 minutes prior to the initiation of ramp-up (pre-clearance);
- Ramp-ups will be scheduled so as to minimize the time spent with the airgun array activated prior to reaching the designated run-in;
- One of the PSOs conducting pre-clearance observations must be notified again immediately prior to initiating ramp-up procedures and the operator must receive confirmation from the PSO to proceed;
- Ramp-up may not be initiated if any marine mammals or sea turtles are within the EZ or any marine mammals are within the buffer zone. If a marine mammal or sea turtle is observed within the applicable zone during the 30 minute pre-clearance period, ramp-up may not begin until the animal(s) has been observed exiting the zones or until an additional time period has elapsed with no further sightings (15 minutes for small odontocetes and sea turtles) and 30 minutes for all other species (e.g., marine mammals).
- PSOs must monitor the exclusion and buffer zones during ramp-up, and ramp-up must cease and the airgun array must be shut down upon observation of a marine mammal or

sea turtle within the applicable zone. Once ramp-up has begun, observations of marine mammals within the buffer zone do not require shutdown, but such observation will be communicated to the operator to prepare for the potential shutdown;

- If the airgun array is shut down for brief periods (i.e., less than 30 minutes) for reasons other than that described for a shutdown (e.g., mechanical difficulty), it may be activated again without ramp-up if PSOs have maintained constant observations and detections of marine mammals or sea turtles have occurred within the exclusion zone. For any longer shutdown, pre-clearance observation and ramp-ups are required. For any shutdown at night or in periods of poor visibility (e.g., Beaufort Sea State 4 or greater), ramp-up is required, but if the shutdown period was brief and constant observation was achieved, pre-clearance watch of 30 minutes is not required. Airgun array activation may only occur at times of poor visibility where operational planning cannot reasonably avoid such circumstances; and
- Testing of the airgun array involving all elements requires ramp-up. Testing an individual element of the airgun array does not require ramp-up but does require pre-clearance of 30 minutes.

2.2.4 Visual Monitoring for Mitigation

Independently contracted and NMFS-approved PSOs will be on board the survey vessel to scan the ocean surface visually for the presence of marine mammals or sea turtles. The EZ is the primary focus for visual observations and as previously described, the buffer zone will be monitored for the presence of marine mammals and sea turtles that may enter the EZ. During use of the airgun array (i.e., anytime the airgun array is active, including ramp-up), occurrences of marine mammals and sea turtles within the buffer zone (but outside the EZ) will be communicated to the operator to prepare for the potential shutdown.

During pre-clearance monitoring, described above, the buffer zone also acts as an extension of the EZ in that observations of marine mammals and sea turtles would delay airgun operations. Visual monitoring of the EZ and adjacent waters is intended to maintain enough distance around the sound source to reduce or eliminate the potential for injury and minimize the potential for behavioral reactions of marine mammals and sea turtles that become more severe when closer to active airguns.

During seismic survey activities (e.g., any day on which use of the airgun array is planned to occur, and whenever the airgun array is in the water, whether activated or not), a minimum of two visual PSOs must be on duty and conducting visual observations at all times during daylight hours (i.e., from 30 minutes prior to sunrise through 30 minutes following sunset) and 30 minutes prior to and during nighttime ramp-ups of the airgun array. When there is sufficient light, the PSOs will scan the area around the vessel systematically with reticle binoculars (e.g., 7×50 Fujinon), Big-eye (25×150) binoculars, and with the naked eye. During darkness, night vision devices will be available to aid observations (ITT F500 Series Generation 3 binocular image intensifier or equivalent).

The PSOs must have no tasks other than to conduct observational effort, record observational data, instruct vessel crew with regard to mitigation requirements, and communicate to the crew the presence of marine mammals and sea turtles. Any observations of marine mammals and sea turtles by crewmembers will be relayed to the PSO team.

Visual PSOs shall coordinate to ensure 360° visual coverage around the vessel from the most appropriate observation posts, and shall conduct visual observations using binoculars and the naked eye while free from distractions and in a consistent, systematic, and diligent manner. Visual monitoring of the EZ and buffer zones must begin no less than 30 minutes before ramp-up and must continue until one hour after use of the airgun array ceases or until 30 minutes past sunset. A PSO may be on watch for a maximum of four consecutive hours, followed by a break of at least one hour between watches, and may conduct a maximum of 12 hours of observation per 24-hour period.

The designated lead for the PSO team aboard the vessel must have a minimum of 90 days at-sea experience working as a visual monitoring PSO during a shallow penetration (i.e., low-energy) seismic survey, with no more than 18 months elapsed since the conclusion of the at-sea experience. The lead PSO shall serve as the primary point of contact for the vessel operator and ensure all PSO requirements are met, per the MMPA IHA and the ITS. To the maximum extent practicable, any PSO with appropriate training but not enough relevant at-sea experience will be scheduled to be on duty with an experienced PSO.

During good conditions (e.g., daylight hours, Beaufort Sea State 3 or less), visual PSOs will conduct observations when the airguns are not operating for comparison of sighting rates and behavior with and without use of the airguns and between acquisition periods, to the maximum extent practicable.

2.2.5 Vessel Strike Avoidance

Vessel strike avoidance measures are intended to minimize the potential for collisions with marine mammals and sea turtles. The requirements below will not apply in situations where compliance would create an imminent and serious threat to a person or vessel or to the extent that a vessel is restricted in its ability to maneuver and, because of the restriction, cannot comply. These measures include the following:

- The *Langseth* operator and crew will maintain a vigilant watch during daylight hours for all marine mammals and sea turtles and slow down, stop, or alter the course of the vessel, as appropriate, to avoid striking any marine mammal and sea turtle during seismic survey activities as well as transits. A single marine mammal at the surface may indicate the presence of submerged animals in the vicinity of the vessel; therefore, avoidance and minimization measures should be exercised when an animal is observed. A visual observer aboard the vessel will monitor a vessel strike avoidance zone around the vessel, to ensure the potential for vessel strike is minimized, according to the parameters stated below. Visual observers monitoring the vessel strike avoidance zone can be either third-party PSOs or crew members, but crew members responsible for these duties will be provided sufficient training to distinguish marine mammals and sea turtles from other phenomena and to identify marine mammals and sea turtles to a broad taxonomic group (e.g., a large whale pinniped, hard shell turtle).

- Vessel speeds must be reduced to 18.5 km/h (10 kt) or less when mother/calf pairs, pods, or large assemblages of marine mammals are observed near the vessel.
- The R/V (*Langseth*) will maintain a minimum separation distance of 100 m from large whales (i.e., all baleen whales and sperm whales).
- The vessel will maintain a minimum separation distance of 50 m from all other marine mammals and sea turtles, with an exception made for mammals that approach the vessel, such as certain delphinids.

When marine mammals are sighted while a vessel is underway, the vessel must take action as necessary to avoid violating the relevant separation distance. If marine mammals or sea turtles are sighted within the relevant separation distance, the vessel must reduce speed and shift the engine to neutral, not engaging the engines until animals are clear of the area. This requirement does not apply to any vessel that is towing gear and restricted in its ability to maneuver.

2.3 Stressors Resulting from the Components of the Proposed Action

In this section, the direct or indirect modifications to the land, water, or air caused by an action are identified as stressors. This section identifies all of the stressors resulting from the proposed action, as well as the sources of those stressors. Some stressors may have multiple sources. Likewise, multiple sources may combine to create a stressor that would not exist if only one of the sources were present. The following is a summary of stressors and their sources that are reasonably certain to be caused by this action.

Stressors produced by components or the action are categorized as pollution (e.g., vessel discharges of fuel, oil, exhaust, and trash), physical strikes (e.g., vessels, survey equipment deployment or retrieval), noise and visual disturbance (e.g., research vessel, airguns, and other active acoustic equipment), and entanglement (e.g., in vessel debris or deployed survey equipment). The following subsections provide more detailed summaries of these stressors. Section 2.3.1 through Section 2.3.3 summarize the potential effects of stressors on ESA-listed species, while also identifying the components of the action producing those stressors.

2.3.1 Pollution

Exhaust, fuel, oil, trash, and other debris produced during operation of the *Langseth* may pollute water and air. Air and water quality determine the health of the environment for all species. Exhaust emissions could be harmful to air-breathing organisms and could partition into water, polluting it (Duce et al. 1991; Chance et al. 2015). Marine species may ingest and be sickened or internally injured by marine debris (e.g., paper, plastic, wood, glass, and metal) associated with vessel operations (Gall and Thompson 2015), while marine habitat may be degraded by the pollutants in gray water and wastewater discharged from vessels.

2.3.2 Physical Strikes

ESA-listed species may be struck and injured by vessels during transit or by gear while in use or during deployment or retrieval. An animal struck by a vessel or equipment may experience minor, nonlethal injuries, serious injuries, or death. Vessel strikes adversely affect ESA-listed marine mammals, sea turtles, and fishes (Laist et al. 2001; NMFS and USFWS 2008; Brown and Murphy 2010; Work et al. 2010a). The probability of a collision depends on the number, size, and speed of vessels or nature of equipment deployment/retrieval, as well as the distribution, abundance, and behavior of the species at the time of transit or deployment/retrieval (Laist et al. 2001; Jensen and Silber 2004; Hazel et al. 2007; Vanderlaan and Taggart 2007; Conn and Silber 2013b). Among sources of equipment strikes, the deployment of the ocean bottom seismometers is more likely to result in injury because they will be lowered into the water from the vessel by a boom, are weighted down with an 80-kilogram steel anchor, then dropped to the ocean floor.

2.3.3 Noise and Visual Disturbance

Sound and visual disturbance resulting from the operation of vessels and equipment, including the airguns, MBES, SBP, and ADCP may cause ESA-listed species and their prey to avoid or leave an area with otherwise suitable habitat. The sound produced during the action may also harm the hearing of ESA-listed species.

2.3.4 Entanglement

ESA-listed species may become entangled in vessel debris, towed seismic equipment (e.g., airgun array and hydrophones), or the cable for the heat probe that will be deployed to the seafloor. Entanglement can result in death or injury of marine mammals, sea turtles, and fishes (Moore et al. 2009a; Moore et al. 2009b; Deakos and H. 2011; Van Der Hoop et al. 2013a; Van der Hoop et al. 2013b; Duncan et al. 2017). Entangled marine mammals and sea turtles may drown or starve due to being restricted by the entangling material, suffer physical trauma and systemic infections, and/or be hit by vessels due to an inability to avoid them.

3 ACTION AREA

Action area means "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action" (50 CFR §402.02). The action area is defined by the extent of the environmental changes the stressors cause on the physical environment (e.g., land, air, or water, detailed in the previous section).

The proposed marine seismic surveys would occur within the survey area depicted in Figure 1, in International Waters within the study area depicted in Figure 1, bounded by the following coordinates: 10.2°N, 104.5°W; 10.2°N, 104.1°W; 8.3°N, 104.1°W; and 8.3°N, 104.5°W. The water depths in the survey area range from 2,500-3,200 m. Representative seismic survey tracklines are shown in Figure 1. Tracklines in Figure 1 are considered representative because tracklines will be influenced by mechanical issues, poor data quality, weather, etc. An additional seismic survey may be necessary because equipment failure or shutdowns and ramp-ups for protected species may result in data quality that is considered sub-standard by the project scientists.

The action area includes the survey tracklines, the transit for turns, and ensonified (filled with sound) area above ambient background level by the airgun array during the seismic survey. The airguns that will be used are low frequency, with a dominant signal frequency of 0–188 Hz, which allows for long-range propagation in water (Hildebrand 2009a). The ambient background levels for the area of the Eastern Tropical Pacific Ocean will be variable, depending upon local conditions and several factors, both from natural (e.g., rain, wind) and anthropogenic sources (e.g., vessel traffic) in the region. We are not able to determine the ambient background noise levels and therefore do not know the distance over which the sound from the airguns will be above that level. The modeled estimates (see Ensonified Area, Section 6.1.2) of total area ensonified above the acoustic threshold for marine mammal harassment (160 dB re 1 μPa_{rms}) for the proposed seismic survey is approximately 14,557.8 square kilometers (km^2). The total area ensonified above the acoustic threshold for sea turtle harassment (175 dB re 1 μPa_{rms}) for the proposed seismic survey is approximately 3,289.2 km^2 (see Ensonified Area, Section 6.1.2).

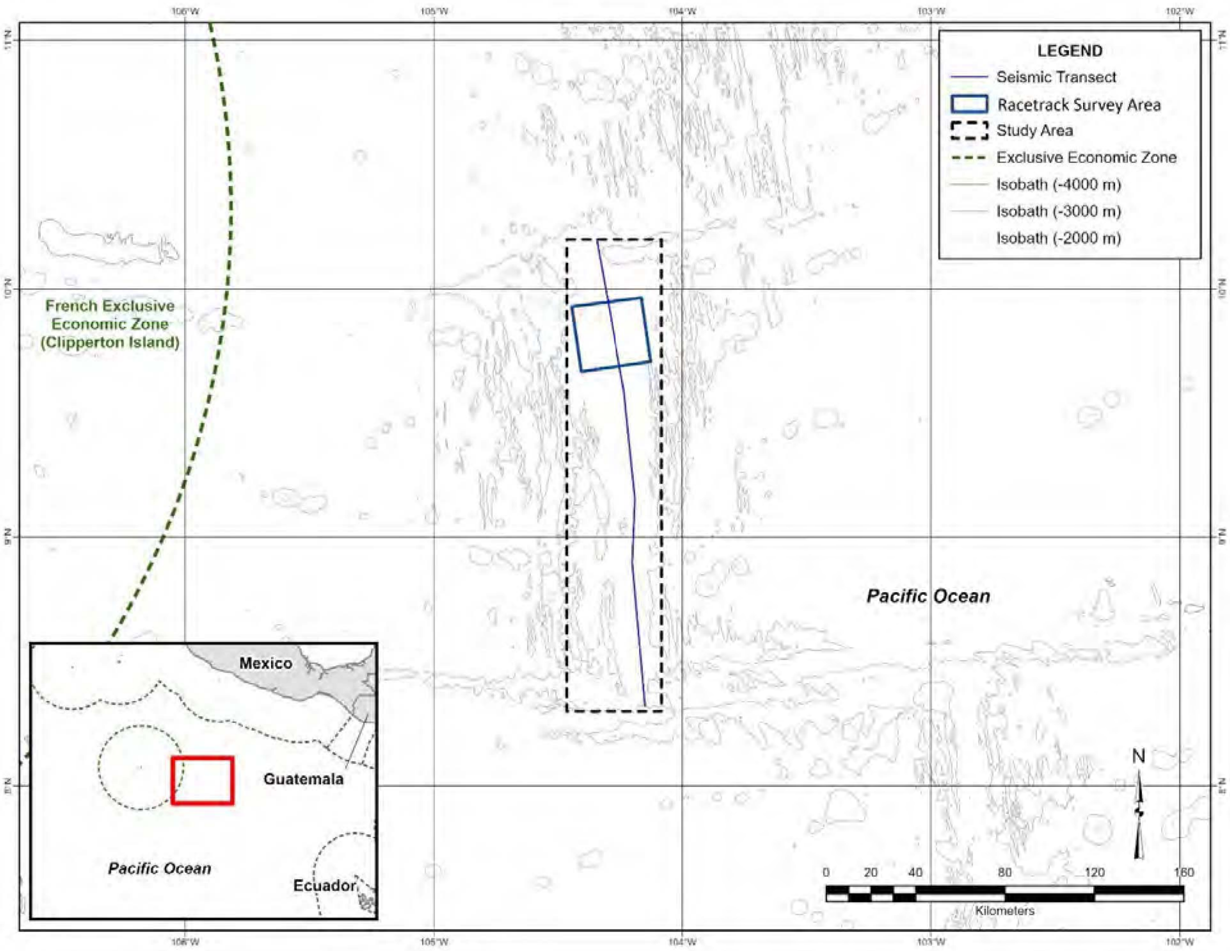

Figure 1. Location of the proposed geophysical survey in the Eastern Tropical Pacific Ocean

The action area will also include the route covered by the *Langseth* while transiting from the port of Manzanillo, Mexico, to the survey area and its return at the conclusion of the survey.

4 SPECIES THAT MAY BE AFFECTED BY THE PROPOSED ACTION

Implementing regulations for the ESA (50 CFR Part 402) allow for three general determinations when analyzing the effects of an action on listed species: 1) no effect, 2) may affect (formal consultation), and 3) may affect, not likely to adversely affect (NLAA). Action agencies, prior to requesting ESA consultation, determine whether their proposed action may affect ESA-listed species. Generally, a "no effect" determination means there is no plausible exposure or response to stressors generated by the proposed action for any ESA-listed species. A "no effect" determination does not require consultation. Any scenario where there is a plausible exposure to stressors generated by the action is considered "may affect." For any action that "may affect" an ESA-listed species, the action agency shall consult with the Services under section 7(a)(2) of the ESA.

This section identifies the ESA-listed species that occur in the action area (Table 2) and thus may be affected by the stressors introduced to the action area by the proposed action. There is no critical habitat in the action area, and thus, none will be considered.

Table 2. Species Present in the Action Area

Species	ESA Status	Recovery Plan
Blue Whale (*Balaenoptera musculus)*	**E – 35 Fed. Reg. 18319**	07/1998 11/2020 – First Revision
Fin Whale (*Balaenoptera physalus)*	**E – 35 Fed. Reg. 18319**	75 Fed. Reg. 47538 07/2010
Humpback Whale (*Megaptera novaeangliae*) – Central America DPS	**E – 81 Fed. Reg. 62259**	11/1991
Sei Whale (*Balaenoptera borealis*)	**E – 35 Fed. Reg. 18319**	12/2011
Sperm Whale (*Physeter macrocephalus*)	**E – 35 Fed. Reg. 18319**	75 Fed. Reg. 81584 12/2010
Green Turtle (*Chelonia mydas*) – East Pacific DPS	**T – 81 Fed. Reg. 20057**	63 Fed. Reg. 28359 01/1998
Hawksbill Turtle (*Eretmochelys imbricata)*	**E – 35 Fed. Reg. 8491**	57 Fed. Reg. 38818 63 Fed. Reg. 28359 05/1998 – U.S. Pacific
Olive Ridley Turtle (*Lepidochelys olivacea*) Mexico's Pacific Coast Breeding Colonies	**E – 43 Fed. Reg. 32800**	63 Fed. Reg. 28359
Leatherback Turtle (*Dermochelys coriacea*)	**E – 35 Fed. Reg. 8491**	63 Fed. Reg. 28359 05/1998 – U.S. Pacific
Loggerhead Turtle (*Caretta caretta*) – North Pacific Ocean DPS	**E – 76 Fed. Reg. 58868**	63 Fed. Reg. 28359
Giant Manta Ray (*Manta birostris*)	**T – 83 Fed. Reg. 2916**	-- --
Oceanic Whitetip Shark (*Carcharhinus longimanus*)	**T – 83 Fed. Reg. 4153**	9/2018 – Outline
Scalloped Hammerhead Shark (*Sphyrna lewini*) – Eastern Pacific DPS	**E – 79 Fed. Reg. 38213**	-- --

4.1 May Affect, Not Likely to Adversely Affect

Once we have determined the action may affect ESA-listed species, the next step analytical filter in this Opinion is to consider whether the action is NLAA for each listed species in the action area. We accomplish this by evaluating individual stressors in the proposed action for each listed species. An action warrants a NLAA finding when its effects are completely beneficial, discountable, or insignificant. Completely beneficial effects have an immediate positive effect without any adverse effects to the species or habitat. Completely beneficial effects are usually discussed when the project has a clear link to the ESA-listed species or its specific habitat needs and consultation is required because the species may be affected, albeit positively. Discountable effects are those that could occur while an ESA-listed species is in the action area but, because of the intensity, magnitude, frequency, duration, or timing of the stressor, exposure to the stressor is extremely unlikely to occur. Insignificant effects relate to the response of exposed individuals where the response, in terms of an individual's growth, survival, or reproduction, would be too small to be measured. For stressors that meet the criteria for completely beneficial, discountable, or insignificant, the appropriate conclusion is NLAA.

To assist in reaching an NLAA determination, if appropriate, we perform a two-step assessment that considers all of the stressors identified in Section 2.3 of this Opinion and all of the species identified in Table 2 to understand the likelihood of the stressors having an effect on the ESA-listed species. We consider whether it is likely that a listed species is exposed to a stressor or there is a reasonable expectation of the stressor and an individual or habitat co-occurring. If we conclude that exposure of a species to a stressor caused by the proposed action or activity is discountable, we must also conclude it is NLAA. However, if exposure is probable, the second step is to evaluate the probability of a response to the stressor. Where the negative effects to any species or from any stressor to those species are found to exceed the standards of insignificant or discountable, we must analyze those consequences in the Analysis of Effects.

If all stressors of an action are found to be NLAA for a listed species, we conclude informal consultation for that particular species. Likewise, if a stressor associated with this action is found to be NLAA for all listed species, there is no need to continue analyzing the consequences of that stressor in the Analysis of Effects.

4.1.1 Stressors Not Likely to Adversely Affect Species

The following subsections examine the potential stressors identified in Section 2.3 that may affect ESA-listed species in the action area and for which we determined are NLAA. We will not need to continue analyzing these stressors for consequences to ESA-listed species in the Analysis of Effects (Section 6).

4.1.1.1 Pollution

Pollution in the form of vessel exhaust, fuel or oil spills or leaks, and trash or other debris resulting from the proposed use of the research vessel could result in impacts to ESA-listed marine mammals, sea turtles, and fishes.

Exhaust (i.e., air pollution) from the research vessel would occur during the entirety of the proposed action, during all vessel transit and operations, and could affect air-breathing ESA-listed species such as marine mammals and sea turtles. Emissions would not exceed Federal Clean Air standards and to reduce impacts on air quality, the *Langseth* uses Ultra-Low Sulfur fuel (<15 parts per million sulfur) and employs a Ship Energy Efficiency Management Plan to reduce and minimize fuel consumption resulting in overall lower emissions. The *Langseth* also complies with the Act to Prevent Pollution from Ships (33 U.S.C. §1901–1905). It is unlikely that vessel exhaust resulting from the operation of the *Langseth* would have a measurable impact on ESA-listed marine mammals or sea turtles given the relatively short duration of the proposed action (~24 days) and the brief amount of time that whales and sea turtles spend at the surface. The likelihood of a whale or sea turtle being co-located with and surfacing while the vessel is operating is low. For these reasons, the effects that may result from vessel exhaust on ESA-listed marine mammals and sea turtles are considered insignificant.

Discharges of fuel and oil incidental to the operation of the *Langseth* are possible, though effects of any spills to ESA-listed marine mammals, sea turtles, and fishes considered in this Opinion will be minimal, if they occur at all. The *Langseth* is a University-National Oceanographic Laboratory System (UNOLS)-designated vessel, meaning that it must adhere to UNOLS Research Vessel Safety Standards, which include requirements for pollution prevention (UNOLS 2021). The *Langseth* has a spill-prevention plan, which would allow a rapid response to a spill in the event one occurs. An oil or fuel leak would likely pose a significant risk to the research vessel and its crew and actions to correct a leak should occur immediately to the fullest extent possible. There are no reports of a fuel or oil spill over many years of conducting similar NSF-funded seismic survey activities. In the unlikely event that a leak should occur, the amount of fuel or oil onboard the *Langseth* is not expected to cause widespread, high-dose contamination (excluding the remote possibility of severe damage to the research vessel) that would impact ESA-listed species directly or pose hazards to their food sources. Because fuel or oil leakage is extremely unlikely to occur, we find that the risk from this potential stressor on proposed and ESA-listed marine mammals, sea turtles, and fishes is discountable.

Wastewater from the *Langseth* would be treated in accordance with U.S. Coast Guard standards (33 CFR Parts 151 and 159). In addition, given the large size of the action area, the dilution of discharged wastewater, and oceanographic conditions that promote mixing, proposed and ESA-listed marine mammals, sea turtles, fishes, and marine invertebrates are not likely to be exposed to concentrations of contaminants from wastewater that could lead to adverse responses. The potential for fuel or oil leakages is extremely unlikely. The lack of potential exposure makes the risk from this potential stressor on ESA-listed marine mammals, sea turtles, and fishes discountable.

Trash or other debris resulting from the proposed action may affect ESA-listed marine mammals, sea turtles, and fishes. Any marine debris (e.g., plastic, paper, wood, metal, glass) that might be released would be accidental. The *Langseth* follows standard, established guidance on the handling and disposal of marine trash and debris during the seismic survey (UNOLS 2021). Because the potential for accidental release of trash is extremely unlikely to occur, we find that the effects from this potential stressor on ESA-listed marine mammals, sea turtles, and fishes are discountable.

We conclude that pollution by vessel exhaust, wastewater, fuel or oil spills or leaks, and trash or other debris may affect, but is not likely to adversely affect ESA-listed species and will not be analyzed further in this Opinion.

4.1.1.2 Vessel and Equipment Strikes

Vessel operations and transit associated with the proposed action carries the risk of vessel strike of ESA-listed marine mammals, sea turtles, and fishes. In general, the probability of a vessel collision and the associated response depends, in part, on size and speed of the vessel. The *Langseth* has a length of 72 m and the operating speed during seismic data acquisition is approximately 8.3–9.3 km/h (~4.5–5 kt). When not towing seismic survey gear, the *Langseth* typically transits at 18.5 km/h (10 kt). The majority of vessel strikes of large whales occur when vessels are traveling at speeds greater than approximately 18.5 km/h (10 kt); large vessels in particular (80 m or greater), are more likely to cause serious injury or death (Laist et al. 2001; Jensen and Silber 2004; Vanderlaan and Taggart 2007; Conn and Silber 2013b).

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

The ESA-listed fish species considered in this Opinion (giant manta ray, oceanic whitetip, and scalloped hammerhead shark) are generally thought to spend considerable time at the water’s surface, although likely use the upper portion of the water column for at least some portion of their life history. Despite these species’ possibly occurring in the upper water column where they may be susceptible to vessel strike, in most cases, the ESA-listed fishes considered in this Opinion would be able to detect and avoid vessels or other in-water devices. Fish are able to use a combination of sensory cues, such as sight, hearing, and their lateral line to detect nearby movement of the water (i.e., particle motion) caused by approaching vessels. A study on fish behavioral responses to vessels showed that most adults exhibit avoidance responses to engine noise, sonar, depth finders, and fish finders (Jørgensen et al. 2004), reducing the potential for vessel strikes. Misund (1997) found that fish ahead of a ship showed avoidance reactions at ranges of 50–350 m. When the vessel passed over them, some fish exhibited sudden escape responses that included movement away from the vessel laterally or through downward compression of the school. In an early study conducted by Chapman and Hawkins (1973), the authors observed avoidance responses of herring from the low-frequency sounds of large vessels or accelerating small vessels. Avoidance responses quickly ended within ten seconds after the vessel departed. Conversely, Rostad (2006) observed that some fish (likely schools of herring) are attracted to different types of drifting and stationary vessels (e.g., research vessels) of varying sizes, noise levels, and habitat locations, as well as moving commercial vessels.

While vessel strikes of marine mammals, sea turtles, and fishes during seismic survey activities are possible, we are not aware of any definitive case of a marine mammal, sea turtle, or fish being struck by a research vessel associated with seismic surveys. The *Langseth* would be traveling at generally low speeds, reducing the amount of noise produced by the propulsion system and the probability of a vessel strike (Kite-Powell et al. 2007; Vanderlaan and Taggart 2007). The *Langseth* has traveled hundreds of thousands of kilometers without a reported vessel strike.

Several conservation measures proposed by the Permits Division and/or NSF and L-DEO would minimize the risk of vessel strike to marine mammals and sea turtles, such as the use of PSOs, and ship crew keeping watch while in transit. In addition, the overall level of vessel activity associated with the proposed action is low relative to the large size of the action area, further reducing the likelihood of a vessel strike of an ESA-listed species.

Our expectation of vessel strike being extremely unlikely to occur is due to general expected movement of marine mammals and sea turtles away from or parallel to the *Langseth*, as well as the generally slow movement of the *Langseth* during most of its travels (Holst and Smultea 2008b; Hauser and Holst 2009; Holst 2010). In addition, adherence to observation and avoidance procedures during survey activities is also expected to avoid vessel strikes of marine mammals and sea turtles. All factors considered, we have concluded vessel strike of ESA-listed species by the *Langseth* is extremely unlikely to occur, and therefore, discountable. We conclude that vessel strike may affect, but is not likely to adversely affect, ESA-listed species and will not be analyzed further in this Opinion.

4.1.1.3 Noise and Visual Disturbance

The *Langseth* may cause visual or auditory disturbances to ESA-listed species that spend time near the surface or in the upper parts of the water column and this may disrupt their behavior. Assessing whether these sounds may adversely affect ESA-listed species involves understanding the characteristics of the acoustic sources, the species that may be present in the vicinity of the sound, and the effects that sound may have on the physiology and behavior of those species.

Sounds emitted by large vessels can be characterized as low frequency, continuous, or tonal and sound pressure levels at a source will vary according to speed, burden, capacity, and length (Richardson et al. 1995a; Kipple and Gabriele 2007; McKenna et al. 2012). Source levels for 593 container ship transits were estimated from long-term acoustic recording received levels in the Santa Barbara shipping channel, and a simple transmission loss model using Automatic Identification System data for source-receiver range (McKenna et al. 2013a). Vessel noise levels could vary 5–10 dB depending on transit conditions. Given the sound propagation of low frequency sounds, a large vessel in this sound range can be heard 139–463 km (75.1–250 NM) away (Polefka 2004). Hatch et al. (2008) measured commercial ship underwater noise levels and reported average source level estimates (71–141 Hz, dB re 1 μPa_{rms} ± standard error) for individual vessels ranged from 158 ± 2 dB (research vessel) to 186 ± 2 dB (oil tanker). McKenna et al. (2012), in a study off southern California, documented different acoustic levels and spectral shapes observed from different modern vessel-types, illustrating the variety of possible noise levels created by the diversity of vessels that may be present.

Although it is known that sound is important for marine mammal communication, navigation, and foraging (NRC 2003a; NRC 2005a), there are many unknowns in assessing impacts of sound, such as the potential interaction of different effects and the significance of responses by marine mammals to sound exposures (Nowacek et al. 2007; Southall et al. 2007a). Other ESA-listed species such as sea turtles and fishes are often considered less sensitive to anthropogenic sound and the impacts are difficult to assess considering we know less about how they use sound (Popper et al. 2014b; Nelms et al. 2016).

Studies have shown that vessel operations can result in changes in the behavior of marine mammals, sea turtles, and fishes (Patenaude et al. 2002; Richter et al. 2003; Hazel et al. 2007; Smultea et al. 2008; Holt et al. 2009; Luksenburg and Parsons 2009; Noren et al. 2009). In many cases, particularly when responses are observed at great distances, it is thought that animals are likely responding to sound more than the visual presence of vessels (Evans et al. 1992; Blane and Jaakson 1994; Evans et al. 1994). At close distances, animals may not even differentiate between visual and acoustic disturbances created by vessels and simply respond to the combined disturbance. Nonetheless, it is generally not possible to distinguish between responses to the visual presence of vessels and the sounds associated with those vessels. The effects to marine mammals, sea turtles, and fishes from the visual presence of research vessels is expected to be minor and immeasurable, and therefore insignificant.

Research on sea turtle responses to vessel noise disturbance is limited, especially on quantifying the response. There is a study examining vessel strike risk to green sea turtles that suggests sea turtles may habituate to vessel sound and may be more likely to respond to the sight of a vessel rather than the sound of a vessel, although both may play a role in prompting reactions (Hazel et al. 2007). Regardless of which vessel associated stimulus that turtles are responding to, they only appear to show responses (i.e., avoidance behavior) at approximately 10 m or closer (Hazel et al. 2007). Therefore, noise from vessels is not likely to affect sea turtles from further distances.

Fishes can detect vessel noise due to its low-frequency components and their hearing capabilities. Data for elasmobranch fishes suggest they are capable of detecting sounds from approximately 20 Hz–1 kHz, with the highest sensitivity to sounds at lower ranges (Myrberg 2001; Casper et al. 2003; Casper and Mann 2006; Casper and Mann 2009; Casper et al. 2012; Ladich and Fay 2013). Therefore, ESA-listed fishes could be exposed to a range of vessel noises, depending on the source and context of the exposure. In the near field, fish are able to detect particle motion as well as visually locate an oncoming vessel. Fishes located in close proximity may detect the vessel either visually or via sound pressure and particle motion, and would be capable of moving away from the affected area. Thus, fish are more likely to respond to vessel noise at close range than to vessel noise emanating from greater distances.

The contribution of vessel noise by the *Langseth* is likely small in the overall regional sound field. Brief interruptions in communication via masking are possible, but unlikely given the habits of marine mammals and fish to move away from vessels, either as a result of engine noise, the physical presence of the vessel, or both (Mitson and Knudsen 2003; Lusseau 2006). As noted, sea turtles have shown to be less effected by vessel noise at distances greater than 10 m (Hazel et al. 2007). Also, during survey operations, the *Langseth* will be traveling at slow speeds, reducing the amount of noise produced by the propulsions system (Kite-Powell et al. 2007; Vanderlaan and Taggart 2007). Avoidance protocols that maintain distance between the *Langseth* and observed marine mammals and sea turtles, will also minimize the potential for acoustic disturbance from engine noise. Because the expected interference from engine noise will be undetectable or so minor that it cannot be meaningfully measured, we find that the risk posed by vessel noise is insignificant, and therefore, will not be analyzed further.

4.1.1.3.1 Noise from Acoustic Data Systems

The proposed survey will use equipment intended for controlled active sound production and data collection: MBES, SBP, ADCP, and airguns. A description of those devices and their acoustic signals is in Sections 2.1.1.2 and 2.1.1.3.

The generalized hearing range for low-frequency cetaceans (baleen whales) is 7 Hz–36 kHz, and for high frequency cetaceans (includes sperm whales) is 150 Hz–160 kHz (NMFS 2024). The operating frequencies for the MBES (10.5–13 kHz), SBP (3.5 kHz), ADCP (35–1,200 kHz), heat probe pinger (12 kHz) and fail-safe release pinger (19–34 kHz) overlap those composite marine mammal hearing ranges. It is worth noting the baleen whale hearing range ends (36 kHz) near where the ADCP frequency range starts (35 kHz) and goes to much higher frequencies. In general, hearing is not well understood for ESA-listed baleen whales, but it is assumed that they are most sensitive to frequencies over which they vocalize, which are typically lower than frequencies emitted by the acoustic devices considered here (Richardson et al. 1995c; Ketten 1997).

Goldbogen et al. (2013) observed responses in blue whales to 3.5–4 kHz mid-frequency sonar that included cessation of foraging, increased swimming speed, and directed travel away from the source. Maybaum (1990a; 1993) observed Hawaiian humpback whales moving away and/or increasing swimming speed upon exposure to 3.1–3.6 kHz sonar. Sperm whales have stopped vocalizing in response to 6–13 kHz pingers, but did not respond to 12 kHz echosounders (Backus and Schevill 1966; Watkins and Schevill 1975a; Watkins 1977). Sperm whales exhibited a startle response to 10 kHz pulses upon exposure while resting and feeding, but not while traveling (Andre 1997; André 1997). Hastie et al. (2014) reported behavioral responses by gray seals to echosounders with frequencies of 200 and 375 kHz.

Investigations stemming from a 2008 stranding event in Madagascar indicated a 12 kHz MBES, similar in operating characteristics as that proposed for use aboard the *Langseth*, may have played a significant role in the mass stranding of a large group of melon-headed whales (*Peponocephala electra*; (Southall 2013). Although pathological data suggest a direct physical effect was lacking and the authors acknowledge that, and while the use of this type of sonar is widespread and commonplace globally without noted incidents (like the Madagascar stranding), all other possibilities were either ruled out or believed to be of much lower likelihood as a cause or contributor to stranding compared to the use of the MBES (Southall 2013). This incident highlights the caution needed when interpreting effects that may or may not stem from anthropogenic sound sources, such as the *Langseth's* use of the MBES, SBP, ADCP, and pingers. Although effects such as the stranding in Madagascar have not been documented for ESA-listed species, the combination of exposure to this stressor with other factors, such as behavioral and reproductive state, oceanographic and bathymetric conditions, movement of the source, previous experience of individuals with the stressor, and other factors may combine to produce a response that is greater than would otherwise be anticipated or has been documented to date (Ellison et al. 2012; Francis 2013).

It is important to note that navigational sonars are operated routinely by thousands of vessels around the world and strandings have not been correlated to their use. Stranding cases associated with the operation of naval sonar suggest that mid-frequency sonar sounds may have the capacity to cause serious impacts to marine mammals. The sonars proposed for use by the *Langseth* differ from sonars used during naval operations, which generally have a longer pulse duration and more horizontal orientation than the downward-directed MBES. The sound energy received by any individuals exposed to the MBES, SBP, ADCP, and pinger sound sources during the proposed activities is lower relative to naval sonars, as is the duration of exposure. The area of possible influence for those proposed devices is also much smaller, consisting of a narrow zone close to and below the source vessel. Because of these differences, we do not expect these systems to contribute to inciting a stranding response by ESA-listed marine mammals. A more recent study used group vocal periods (GVP) as proxies to assess foraging behavior and use of habitat by goose-beaked whales (*Ziphius cavirostris*; also known as Cuvier's beaked whale) during multibeam mapping with a 12 kHz MBES in southern California (Kates Varghese et al. 2021). The study found that there was no significant difference between GVP when the MBES was in use and not being used, suggesting a lack of behavioral response.

These MBES, SBP, ADCP, and pinger acoustic devices will be used when the airguns are active and also at times when the airguns are not active. The airguns will generate acoustic signals substantially greater than these other devices and therefore all other transducer signals are unlikely to be detectable to ESA-listed species in the action area. When the airguns are not in use, the signals from these other devices have characteristics that limit the potential for exposure and detection by ESA-listed species in the action area.

Burkhardt et al. (2013) assessed the risk of injury from MBES caused by behavioral responses and determined them unlikely given the characteristics of the acoustic signals, such as short duration and high downward directivity. Boebel et al. (2006) and Lurton and DeRuiter (2011) also concluded that SBPs, MBESs, and ADCPs similar to those to be used during the seismic survey activities presented a low risk for auditory damage or any other injury. Kremser et al. (2005) concluded the probability of a marine mammal swimming through the area of exposure when such sources emit a pulse is small. Ruppel et al. (2022) also found that MBESs, SBPs, sidescan sonars, ADCPs, and pingers are unlikely to result in take of marine mammals as these sources typically operate at frequencies inaudible to marine mammals, have low source and received levels, narrow beams, downward directed transmission, and/or have low exposure (e.g., short pulse lengths, intermittency of pulses). In order for there to be a measurable response from exposure to these sound sources, the animal would have to pass the transducers at close range and match the research vessel’s speed and direction in order to receive multiple pulses. This behavior is extremely unlikely, therefore exposure to sound levels sufficient to cause a response is also extremely unlikely to occur.

Several studies indicate that sea turtles are capable of hearing low frequencies and they lose sensitivity, i.e. stop responding to stimuli, when sounds approach and go above 1 kHz (Muirhead et al. 2025). The MBES, SBP, ADCP, and pingers all have acoustic signals that operate at much higher frequencies, therefore sea turtles are not expected to detect these sounds or respond to them, even if they were to be exposed.

Fishes have an inner ear capable of detecting sound and a lateral line capable of detecting water motion caused by sound (Hastings and Popper 2005; Popper and Schilt 2009). Data for elasmobranch fishes (e.g., sharks and rays) suggest they are capable of detecting sounds from approximately 20 Hz–1 kHz with greater sensitivity to sounds in the lower frequencies (Myrberg 2001; Casper et al. 2003; Casper and Mann 2006; Casper and Mann 2009; Casper et al. 2012; Ladich and Fay 2013). The proposed MBES, SBP, ADCP, and pingers operate at much higher acoustic signal frequencies, and similar to sea turtles, the ESA-listed elasmobranchs that could occur in the action area (giant manta ray, and oceanic whitetip and scalloped hammerhead sharks) are not expected to detect these sounds or respond to them, even if they were to be exposed.

Exposure of ESA-listed marine mammals to levels sufficient to cause a measurable response is extremely unlikely to occur and therefore is discountable. The sea turtles and ESA-listed elasmobranchs are not expected to detect acoustic signals from those devices and therefore a response is discountable. In conclusion, sound from the MBES, SBP, ADCP, and pingers are not likely to adversely affect ESA-listed species in the action area and therefore will not be analyzed further in this Opinion. Sound from the airguns is analyzed in the Analysis of Effects, Section 6, because we determine it is likely to adversely affect ESA-listed species in the action area.

4.1.1.4 Entanglement

Some of the survey gear proposed for use could pose a risk of entanglement, strike, or otherwise interact with ESA-listed species in the action area. Towed seismic equipment (e.g., airgun array and hydrophone streamer) associated with the seismic survey activities may pose a risk of interaction and entanglement to ESA-listed species, although the overall lack of instances this has occurred suggests it is extremely unlikely. There is one known case of an NSF-funded seismic survey off the coast of Costa Rica during 2011 that recovered a dead olive ridley turtle in the foil of towed seismic equipment; it is unclear whether the sea turtle became lodged in the foil pre- or post-mortem (Spring 2011).

The towed hydrophone streamer design makes entanglement highly unlikely and there are observations of sea turtles investigating the towed hydrophone streamer and not becoming entangled, as well as operations in regions of high sea turtle density and entanglements not occurring (Holst et al. 2005b; Holst et al. 2005a; Hauser 2008; Holst and Smultea 2008a). The towed hydrophone streamer is rigid and as such will not encircle, wrap around, or in any other way entangle any of the ESA listed species considered during this consultation. Similarly, any cables used to tow gear, including heat probe operations, will be taut and therefore prevent entanglement. Additionally, the airgun operations will likely be an aversive stimulus to some degree and animals will tend to move away and temporarily avoid areas where the airgun array is actively being used, meaning they will also avoid towed gear. Furthermore, the slow speed of the vessel while towing gear provides greater opportunity to move away.

Based upon the gear design and operational conditions cited, and the extensive deployment of this type of equipment without entanglement cases, we find the probability of adverse impacts to ESA-listed species to be extremely unlikely and therefore discountable. Gear interaction will not be analyzed further in this Opinion.

4.1.2 Species Not Likely to be Adversely Affected: ESA-listed Elasmobranchs

ESA-listed elasmobranchs (giant manta rays, oceanic whitetip sharks, and Eastern Pacific DPS scalloped hammerhead sharks) may occur in the action area and be affected by sound fields generated by the airguns. Noise from airguns is only remaining stressor to be considered, so the impacts of this stressor on ESA listed species is addressed in this section. As discussed in Section 4.1.1.3.1, Noise from Acoustic Data Systems, elasmobranchs are capable of detecting low frequency sounds from approximately 20 Hz–1 kHz (Myrberg 2001; Casper et al. 2003; Casper and Mann 2006; Casper and Mann 2009; Casper et al. 2012; Ladich and Fay 2013).

Unlike most teleost fish, elasmobranchs do not have swim bladders or other air-filled cavities that would be affected by sound pressure (Casper et al. 2012). Particle motion is presumably the only sound stimulus that may be detectable by elasmobranchs (Casper et al. 2012). Given their assumed hearing range, elasmobranchs are expected to detect the low frequency (10–500 Hz; (Hildebrand 2009a) sound from an airgun array if exposed. However, the duration and intensity of low-frequency acoustic stressors and the implementation of conservation measures will likely minimize the effect this stressor has on elasmobranchs. Furthermore, although some elasmobranchs have been known to respond to anthropogenic sound, in general elasmobranchs are not considered particularly sensitive to sound (Casper et al. 2012).

There have been no studies examining the direct effects of exposure to specific anthropogenic sound sources in any species of elasmobranchs (Casper et al. 2012). However, several elasmobranch species, including the oceanic silky shark (*Carcharhinus falciformis*) and coastal lemon shark (*Negaprion brevirostris*), have been observed withdrawing from pulsed low-frequency sounds played from an underwater speaker (Myrberg et al. 1978; Klimley and Myrberg 1979). Lemon sharks exhibited withdrawal responses to pulsed low to mid-frequency sounds (500 Hz–4 kHz) raised 18 dB re 1 µPa at an onset rate of 96 dB re 1 µPa per second to a peak amplitude of 123 dB re 1 µPa received level from a continuous level, just masking broadband ambient sound (Klimley and Myrberg 1979). In the same study, lemon sharks withdrew from artificial sounds that included 10 pulses per second and 15–7.5 decreasing pulses per second.

In contrast, other elasmobranch species are attracted to pulsing low frequency sounds. Myrberg (2001) stated that sharks have demonstrated highest sensitivity to low frequency sound (40–800 Hz). Free-ranging sharks are attracted to sounds possessing specific characteristics including irregular pulsed, broadband frequencies below 80 Hz and transmitted suddenly without an increase in intensity, thus resembling struggling fish.

These signals, some “pulsed,” are not substantially different from the airgun array signals. Myrberg et al. (1978) reported that silky shark withdrew 10 m from a speaker broadcasting a 150–600 Hz sound with a sudden onset and peak source level of 154 dB re 1 µPa. These sharks avoided a pulsed low frequency attractive sound when its sound level was abruptly increased by more than 20 dB re 1 µPa. Other factors enhancing withdrawal were sudden changes in the spectral or temporal qualities of the transmitted sound. The pelagic oceanic whitetip shark also showed a withdrawal response during limited tests, but less so than other species (Myrberg et al. 1978). These results do not rule out that such sounds may have been harmful to the fish after habituation; the tests were not designed to examine that point.

Popper et al. (2014b) concluded that the relative risk of fishes with no swim bladders exhibiting a behavioral response to low-frequency active sonar was low, regardless of the distance from the sound source. The authors did not find any data on masking by sonar in fishes, but concluded that if it were to occur, masking will result in a narrow range of frequencies being masked

(Popper et al. 2014b). Popper et al. (2014b) also concluded that injury for fish with no swim bladders exposed to low frequency active sonar is unlikely because no damage was found after exposure to higher intensity impulsive signals.

A recent study on the behavioral responses of sharks to sensory deterrent devices tested the sharks' attraction to bait while being exposed to auditory and visual stimuli. Ryan et al. (2017) used a strobe light and sound sources within a range thought to be audible to sharks (20–2,000 Hz) on captive Port Jackson (*Heterodontus portusjacksoni*) and epaulette (*Hemiscyllium ocelltum*) sharks, and wild great white sharks (*Carcharodon carcharius*). The strobe lights alone (and the lights with sound) reduced the number of times bait was taken by Port Jackson and epaulette sharks. The strobe lights alone did not change white shark behavior, but the sound and the strobe light together led to great white sharks spending less time near bait. Sound alone did not have an effect on great white shark behavior (Ryan et al. 2017). The sound sources used in this study are different than the airguns used in the proposed action, but are still somewhat similar as they are both fairly low frequency sounds.

The precise expected response of ESA-listed elasmobranchs to low-frequency acoustic energy is not completely understood due to a lack of sufficient experimental and observational data for these species. However, given the signal type and level of exposure to the low frequency signals used in seismic survey activities, we do not expect adverse effects (including significant behavioral adjustments, temporary threshold shifts [TTS], permanent threshold shifts [PTS], injury, or mortality). The most likely response of ESA-listed elasmobranchs exposed to seismic survey activities, if any, will be minor temporary changes in their behavior including increased swimming rate, avoidance of the sound source, or changes in orientation to the sound source, none of which rise to the level of take. Therefore, the potential effect of seismic survey activities on the ESA-listed elasmobranch species (giant manta ray, oceanic whitetip shark, and Eastern Pacific DPS scalloped hammerhead shark) is insignificant. We conclude that the proposed seismic survey activities in the action area are not likely to adversely affect these elasmobranch species and they will not be considered further in this Opinion.

4.2 Status of the Species for Further Analysis

The remainder of this Opinion examines the status of each species with effects caused by the proposed seismic survey that were not discountable or insignificant. The status section establishes the current demography of the species by assessing the abundance, recent trends in abundance, survival rates, life stages present, limiting factors, and sub-lethal or indirect changes in population trends such as inter-breeding period, shifts in distribution or habitat use, and shifts in predator distribution that contribute to the extinction risk that the listed species face. The status of each species below is described in terms of life history, threats, population dynamics, and recovery planning.

The information used in each of these sections is based on parameters considered in documents such as status reviews, recovery plans, and listing decisions and based on the best available scientific and commercial information. This section establishes a reference to the condition of the species' likelihood of both survival and recovery in terms of their "reproduction, numbers, or distribution" as described in 50 CFR §402.02 and informs the environmental baseline (Section 5 below) to put the effects of the action in context. More detailed information on the status and trends of these ESA-listed species, and their biology and ecology can be found in the listing regulations and critical habitat designations published in the Federal Register, status reviews, recovery plans, and on the NMFS OPR web site (https://www.fisheries.noaa.gov/species-directory/threatened-endangered).

4.2.1 Blue Whale

The blue whale is a widely distributed baleen whale found in all major oceans. There are currently four accepted subspecies of blue whale, *B. m. musculus*, which occurs in the Northern Hemisphere, and whose range includes the action area. The blue whale was originally listed as endangered on December 2, 1970 (35 Fed. Reg. 18319). Information available from the recovery plan (NMFS 1998a; NMFS 2020a), recent stock assessment reports (Carretta 2019; Carretta 2020), and recent scientific publications were used to summarize the life history, population dynamics, and status of the species as follows.

Life History

The average life span of blue whales is 80-90 years. They have a gestation period of 10-12 months, and calves nurse for six to seven months. Blue whales reach sexual maturity between 5 and 15 years of age with an average calving interval of two to three years. They winter at low latitudes, where they mate, calve and nurse, and summer at high latitudes, where they feed. In the northeast Pacific, blue whales overwinter along the Pacific Coast of Baja California, and the upwelling area known as the Costa Rica Thermal Dome (Forney et al. 2012), but they may use other areas as well (Nichol 2011). Blue whales forage almost exclusively on krill and can eat approximately 3,600 kilograms (7,936.6 pounds) daily. Feeding aggregations are often found at the continental shelf edge, where upwelling produces concentrations of krill at depths of 90-120 m.

Threats

The blue whale was listed as endangered as a result of past commercial whaling. Commercial whaling no longer occurs, and populations appear to be increasing in size, however, the species has not recovered enough to be down-listed to threatened and therefore is still at risk of extinction.

Population Dynamics

The global, pre-exploitation estimate for blue whales is approximately 181,200 (IWC 2007b). Current estimates indicate approximately 5,000-12,000 blue whales globally (IWC 2007b). Blue whales are separated into populations by ocean basin in the North Atlantic Ocean, North Pacific Ocean, and Southern Hemisphere. There are three stocks of blue whales designated in United

States waters: the Eastern North Pacific Ocean, Central North Pacific Ocean, and Western North Atlantic Ocean. Due to the location of the action, the Eastern North Pacific stock of blue whales is most likely to be in the action area. Blue whales satellite-tagged off California in summer have traveled to the eastern tropical Pacific and the Costa Rica Dome in winter. The minimum population size for eastern North Pacific Ocean blue whales is 1,050; the more recent abundance estimate is 1,496 whales (Carretta 2020). Based on survey data from 1986-1990 in the Eastern Tropical Pacific, Wade and Gerrodette (1993) estimated an abundance of 1,415 blue whales. Current estimates indicate a growth rate of just under three percent per year for the eastern North Pacific stock (Calambokidis 2009).

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

In general, distribution is driven largely by food requirements; blue whales are more likely to occur in waters with dense concentrations of their primary food source, krill. While they can be found in coastal waters, they are thought to prefer waters further offshore. Off California, they are associated with areas of upwelling off the continental slope, likely due to high concentrations of zooplankton there (Nichol 2011). Data from satellite telemetry research indicate that blue whales in U.S. West Coast waters spend about five months outside the U.S. EEZ, from November to March (Hazen et al. 2017). There is a known wintering area for blue whales in the Gulf of California (Ortega-Ortiz et al. 2018).

Vocalizations and Hearing

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

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

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

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

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

Direct studies of blue whale hearing have not been conducted, but it is assumed that blue whales can hear the same frequencies that they produce (low frequency) and are likely most sensitive to this frequency range (Richardson et al. 1995b; Ketten 1997). Based on vocalizations and anatomy, blue whales are assumed to predominantly hear low frequency sounds below 400 Hz (Croll et al. 2001; Stafford and Moore 2005; Oleson et al. 2007c). In terms of functional hearing capability, blue whales belong to the low frequency group, which have a hearing range of 7 Hz to 35 kHz (NOAA 2018).

Recovery Planning

See the 1998 Final Recovery Plan for the Blue Whale for complete downlisting/delisting criteria for each of the following recovery goals:

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

4.2.2 Fin Whale

The fin whale is a large, widely distributed baleen whale found in all major oceans and is currently comprised of three recognized subspecies (recognized by the Society for Marine Mammalogy's Committee on Taxonomy): *B. p. physalus* in the North Atlantic Ocean, *B. p. velifera* in the North Pacific Ocean, and *B. p. quoyi* in the Southern Hemisphere. Previously, another subspecies, *B. p. patachonica* (a pygmy form), was identified in the Southern Hemisphere but a recent genetic study found no support for this differentiation of fin whales in the Southern Hemisphere (further discussed below in "Population Dynamics").

Near the action area, fin whales occur year round in the Sea of Cortez (Bérubé et al. 2002). The fin whale was originally listed as endangered on December 2, 1970.

Information available from the recovery plan (NMFS 2010c), recent stock assessment reports (Carretta et al. 2024), and status review (NMFS 2019) were used to summarize the life history, population dynamics and status of the species as follows.

Life History

Fin whales can live, on average, 80–90 years. They have a gestation period of less than one year, and calves nurse for six to seven months. Sexual maturity is reached between six and 10 years of age with an average calving interval of two to three years. They mostly inhabit deep, offshore waters of all major oceans. They winter at low latitudes, where they calve and nurse, and summer at high latitudes, where they feed, although some fin whales appear to be residential to certain areas (e.g., potentially in the Mediterranean Sea, East China Sea/Sea of Japan, and Gulf of California; (Bérubé et al. 2002; Mizroch et al. 2009; Geijer et al. 2016; Rivera-León et al. 2019). Fin whales eat pelagic crustaceans (mainly euphausiids or krill) and schooling fish such as capelin, herring, and sand lance (NMFS 2010a).

Threats

The fin whale is endangered as a result of past commercial whaling. Prior to commercial whaling, hundreds of thousands of fin whales existed. Fin whales may be killed under "aboriginal subsistence whaling" in Greenland, and Iceland's formal objection to the International Whaling Commission's ban on commercial whaling, or commercial whaling by Japan.[2] Additional threats include ship strikes, reduced prey availability due to overfishing or changing environmental conditions, and noise.

Population Dynamics

The pre-exploitation estimate for the fin whale population in the North Pacific Ocean was 42,000–45,000 individuals (Ohsumi and Wada 1974). There are three MMPA stocks for fin whales in United States Pacific Ocean waters and the following are their best current abundance

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[2] https://iwc.int/management-and-conservation/whaling/total-catches

estimates: Northeast Pacific minimum (N_{min}) of 2,554 individuals (Young et al. 2024), Hawaii approximately 203 individuals (N_{min}=101 individuals; (Bradford et al. 2021), and California/Oregon/Washington approximately 11,065 individuals (N_{min}=7,970 individuals; (Becker et al. 2020). Estimates for fin whales in the Eastern Tropical Pacific range from 574 individuals (NMFS 2015b), to 2,842 individuals (Barlow 2003), to 3,388 individuals (Forney et al. 2012).

An overall fin whale population trend in the U.S. Pacific has not been established, but there is evidence that there has been increasing rates in the recent past in different parts of the region. Based on movement data from fin whales tagged in the Southern California Bight (Falcone and Schorr 2013), individuals from the California/Oregon/Washington stock are most likely to be in the action area. From 1991–2014, the estimated average rate of fin whale population increase for the California Current area (California, Oregon, and Washington waters) was 7.5% (Nadeem et al. 2016). How much of that rate could be attributed to immigration rather than birth and death processes is not known (Carretta et al. 2024).

The availability of prey, such as sand lance or krill, is thought to have had a strong influence on the distribution and movements of fin whales. Some fin whales tagged off southern California made seasonal movements from Central California to Baja California peninsula (Falcone and Schorr 2013).

Archer et al. (2013) examined the genetic structure and diversity of fin whales globally. Full sequencing of the mitochondrial DNA (mtDNA) genome for 154 fin whales sampled in the North Atlantic Ocean, North Pacific Ocean, and Southern Hemisphere, resulted in 136 haplotypes, none of which were shared among ocean basins suggesting differentiation at least at this geographic scale. However, North Atlantic Ocean fin whales appear to be more closely related to the Southern Hemisphere population, as compared to fin whales in the North Pacific Ocean. Results of a later single-nucleotide polymorphism analysis indicate that distinct mitogenome matrilines in the North Pacific are interbreeding (Archer et al. 2019). Pygmy fin whales were thought to be a separate subspecies occurring in the low- to mid-latitudes of the Southern Hemisphere since 2004 based on morphological features (Clarke 2004). However, in 2021 researchers determined that there was an absence of genetic structure within the Southern Hemisphere, suggesting that all fin whales in the Southern Hemisphere are of the *B. p. quoyi* subspecies (Pérez-Alvarez et al. 2021).

Generally speaking, haplotype diversity was found to be high both within oceans basins, and across, with the greatest diversity found in North Pacific fin whales (Archer et al. 2019). Such high genetic diversity and lack of differentiation within ocean basins may indicate that despite some populations having small abundance estimates, the species may persist long-term and be somewhat protected from substantial environmental variance and catastrophes. There is evidence that there is a genetically distinct, isolated, and small (~400 individuals) population of fin whales that reside in the Gulf of California year-round (Bérubé et al. 2002) which is further supported by satellite telemetry data (Jiménez López et al. 2019).

Vocalizations and Hearing

Fin whales produce a variety of low frequency sounds in the 10–200 Hz range (Watkins 1981; Watkins et al. 1987; Edds 1988; Thompson et al. 1992). Typical vocalizations are long, patterned pulses of short duration (0.5 to two seconds) in the 18–35 Hz range, but only males are known to produce these (Patterson and Hamilton 1964; Clark et al. 2002). The most typically recorded call is a 20-Hz pulse lasting about one second, and reaching source levels of 189 ± 4 dB re 1 µPa-m (Watkins 1981; Watkins et al. 1987; Edds 1988; Richardson et al. 1995b; Charif et al. 2002; Clark et al. 2002; Sirovic et al. 2007). These pulses frequently occur in long sequenced patterns, are down-swept (e.g., starting at approximately 23 Hz and ending at approximately 18 Hz), and can be repeated over the course of many hours (Watkins et al. 1987). In temperate waters, intense bouts of these patterned sounds are very common from fall through spring, but also occur to a lesser extent during the summer in high latitude feeding areas (Clark and Charif 1998). Richardson et al. (1995b) reported this call occurring in short series during spring, summer, and fall, and in repeated stereotyped patterns in winter. The seasonality and stereotype nature of these vocal sequences suggest that they are male reproductive displays (Watkins 1981; Watkins et al. 1987); a notion further supported by data linking these vocalizations to male fin whales only (Croll et al. 2002). In Southern California, the 20-Hz pulses are the dominant fin whale call type associated both with call-counter-call between multiple animals and with singing (Navy 2010; U.S. Navy 2012). An additional fin whale sound, the 40-Hz call described by Watkins (1981), was also frequently recorded, although these calls are not as common as the 20-Hz pulse. Seasonality of the 40-Hz calls differed from the 20-Hz pulse, since 40-Hz calls were more prominent in the spring, as observed at other sites across the northeast Pacific Ocean (Sirovic et al. 2012). Source levels of Eastern Pacific Ocean fin whale 20-Hz pulse has been reported as 189 ± 5.8 dB re 1 µPa-m (Weirathmueller et al. 2013). Some researchers have also recorded moans of 14–118 Hz, with a dominant frequency of 20 Hz, tonal vocalizations of 34–150 Hz, and songs of 17–25 Hz (Watkins 1981; Edds 1988; Cummings and Thompson 1994). In general, source levels for fin whale vocalizations are 140–200 dB re 1 µPa-m (as compiled by Erbe 2002b; see also Clark and Gagnon 2004). The source depth of calling fin whales has been reported to be about 50 m (164 ft; (Watkins et al. 1987). Although acoustic recordings of fin whales from many diverse regions show close adherence to the typical 20-Hz bandwidth and sequencing when performing these vocalizations, there have been slight differences in the pulse patterns, indicative of some geographic variation (Watkins et al. 1987; Thompson et al. 1992).

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

Direct studies of fin whale hearing have not been conducted, but it is assumed that fin whales can hear the same frequencies that they produce (low) and are likely most sensitive to this frequency range (Richardson et al. 1995b; Ketten 1997). This suggests fin whales, like other baleen whales, are more likely to have their best hearing capacities at low frequencies, including frequencies lower than those of normal human hearing, rather than mid- to high-frequencies (Ketten 1997). In a study using computer tomography scans of a calf fin whale skull, Cranford and Krysl (2015) found sensitivity to a broad range of frequencies between 10 Hz–12 kHz and a maximum sensitivity to sounds in the 1–2 kHz range. In terms of functional hearing capability, fin whales belong to the low-frequency group, which have a hearing range of 7 Hz–35 kHz (NOAA 2018).

Recovery Planning

See the 2010 Final Recovery Plan for the fin whale for complete downlisting/delisting criteria for both of the following recovery goals:

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

4.2.3 Humpback Whale—Central America Distinct Population Segment

The humpback whale is a widely distributed baleen whale found in all major oceans. The humpback whale was originally listed as endangered on December 2, 1970 (35 Fed. Reg. 18319). Since then, NMFS has designated 14 DPSs (see Figure 2) with four identified as endangered (Cape Verde Islands/Northwest Africa, Western North Pacific, Central America, and Arabian Sea) and one as threatened (Mexico).

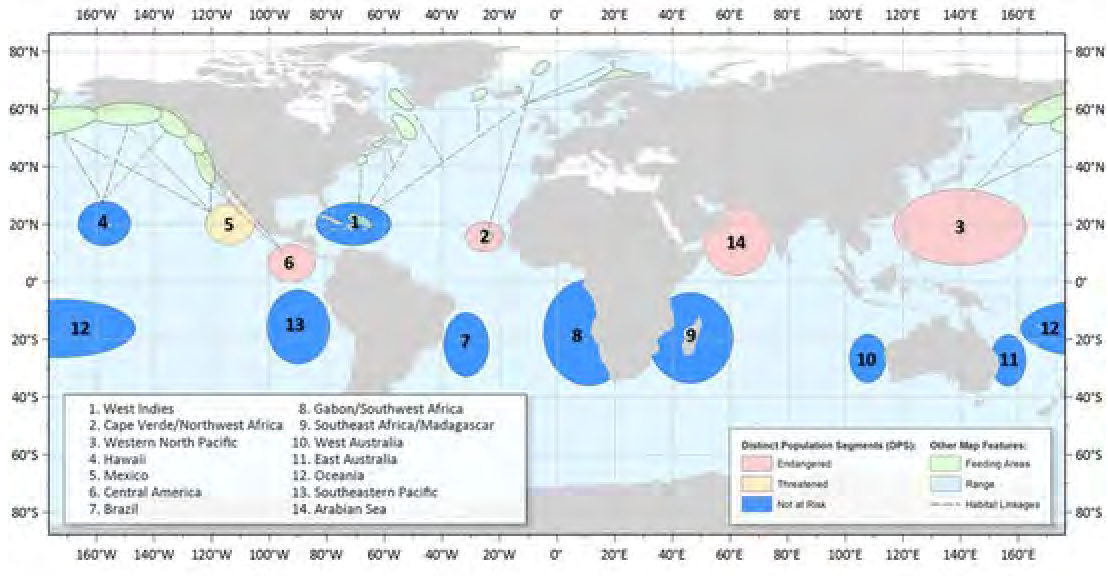

Figure 2. Map identifying 14 distinct population segments with one threatened and four endangered, based on primary breeding location of the humpback whale, their range, and feeding areas (Bettridge et al. 2015a)

Information available from the recovery outline (NMFS 2022), the recent stock assessment report (Carretta et al. 2024), the status review (Bettridge et al. 2015b), and the final listing were used to summarize the life history, population dynamics and status of the species as follows.

Life History

Humpback whales can live, on average, 50 years. They have a gestation period of 11–12 months, and calves nurse for one year. Sexual maturity is reached between five and 11 years of age. Every one to five years, females give birth to a single calf, with an average calving interval of two to three years. Humpback whales mostly inhabit coastal and continental shelf waters. They winter at lower latitudes, where they calve and nurse, and summer at high latitudes, where they feed. Central America DPS humpback whales breed off the Pacific coasts of Costa Rica, Panama, Guatemala, El Salvador, Honduras, and Nicaragua during the months of January, February, and March (Rasmussen et al. 2012). In addition to using the action area as a migratory corridor, Central America DPS humpback whales also breed, calve, and nurse in the waters off southern Mexico (e.g., Guerrero, within the action area), in winter and early spring (January through March; (Dobson et al. 2015; Martien et al. 2021; Audley 2022). Humpback whales exhibit a wide range of foraging behaviors and feed on a range of prey types, including: small schooling fishes, euphausiids, and other large zooplankton (Bettridge et al. 2015b).

Threats

Humpback whales were originally listed as endangered because of past commercial whaling, and the five DPSs that remain listed (Cape Verde Islands/Northwest Africa, Western North Pacific, Central America, Arabian Sea, and Mexico) have likely not yet recovered from this. According to historical whaling records from five whaling stations in British Columbia, 5,638 humpback whales were killed between 1908 and 1967 (Gregr et al. 2000). We have no way of knowing the degree to which a specific DPS of humpback whale was affected by historical whaling. However, it is likely that individuals from the Central America DPSs were taken, based on where the whalers were hunting off British Columbia (i.e., the purported feeding grounds for this DPS). Prior to commercial whaling, hundreds of thousands of humpback whales existed. Global abundance declined to the low thousands by 1968, the last year of substantial catches (IUCN 2012). Humpback whales may be killed under "aboriginal subsistence whaling" and "scientific permit whaling" provisions of the International Whaling Commission. Humpback whales are the most frequently reported species experiencing vessel strikes in the action area and the larger Eastern Tropical Pacific region, and it is believed that overall, vessel strikes are under-reported (Ransome et al. 2021), indicating that threat to the DPS may be more severe than is understood. Additional threats include fisheries interactions (including entanglement), energy development, and harassment from whaling watching noise, harmful algal blooms, disease, parasites, and changing environmental conditions. Due to ongoing threats and the purported low population size, the Central America DPS still faces a risk of extinction.

Population Dynamics

The global, pre-exploitation estimate for humpback whales is 1,000,000 individuals (Roman and Palumbi 2003). Prior to 1905, whaling records indicate that the humpback whale population in the North Pacific was 15,000 whales. By 1966, whaling had reduced the North Pacific population to about 1,200 individuals.

The population size of whales wintering in southern Mexico and Central America was estimated using spatial capture-recapture methods based on photographic data collected between 2019–2021: 1,496 individuals (Coefficient of variation [CV]=0.171), and a minimum of 1,284 individuals (Carretta et al. 2024). This represents the best estimate of abundance for the Central America / Southern Mexico - CA-OR-WA stock of humpback whales. A population growth rate for Central America / Southern Mexico whales derived from differences between 2004–2006 estimates and the current estimate by excluding whales from southern Mexico, yields an annual growth rate of 1.6% (Standard Deviation [SD]=2.0%); however, this estimate has high uncertainty (Curtis et al. 2022).

Humpback whale abundance reportedly increased 8.2% annually in the California Current since 1989, based on mark-recapture estimates largely restricted to whales summering in California and Oregon waters (Calambokidis and Barlow 2020). These estimates include whales from the Central America / Southern Mexico - CA-OR-WA stock and the Mainland Mexico - CA-OR-WA stocks. The maximum net productivity rate for the Central America / Southern Mexico - CA-OR-WA stock is unknown. However, the maximum net productivity rate can be inferred to be as high as the maximum observed for the combined stocks, 8.2% annually, though it could be higher if one of the stocks is growing faster than another.

The Central America DPS is composed of humpback whales that breed along the Pacific coast of Costa Rica, Panama, Guatemala, El Salvador, Honduras, Nicaragua and southern Mexico. This DPS feeds almost exclusively offshore of California and Oregon in the eastern Pacific Ocean, with only a few individuals identified at the northern Washington – southern British Columbia feeding grounds. Generally, humpbacks prefer nearshore waters (Ransome et al. 2021). Sightings and detection data in the action area show that humpback whales mostly occurred in waters less than 100 m deep over winter and through March; with some sightings extending into April and early May. Distance of humpback sightings from shore ranged from 50 m–10.3 km, with a maximum of 33.4 km from shore (Audley 2022).

Vocalizations and Hearing

Humpback whale vocalization is much better understood than is hearing. Different sounds are produced that correspond to different functions: feeding, breeding, and other social calls (Dunlop et al. 2008). Males sing complex sounds while in low-latitude breeding areas in a frequency range of 20 Hz–4 kHz with estimated source levels from 144–174 dB (Winn et al. 1970; Richardson et al. 1995e; Au et al. 2000; Frazer and Mercado Iii 2000; Au et al. 2006b). Males also produce sounds associated with aggression, which are generally characterized by frequencies between 50 Hz–10 kHz with most energy below 3 kHz (Tyack 1983; Silber 1986). Such sounds can be heard up to 9 km (4.9 NM) away (Tyack 1983). Other social sounds from 50 Hz–10 kHz (most energy below 3 kHz) are also produced in breeding areas (Tyack 1983; Richardson et al. 1995e). While in northern feeding areas, both sexes vocalize in grunts (25 Hz–1.9 kHz), pulses (25–89 Hz) and songs (ranging from 30 Hz–8 kHz but dominant frequencies of 120 Hz–4 kHz), which can be very loud (175–192 dB re 1 µPa-m; (Payne 1985; Thompson et al. 1986; Richardson et al. 1995e; Au et al. 2000; Erbe 2002a). However, humpback whales tend to be less vocal in northern feeding areas than in southern breeding areas (Richardson et al. 1995e).

Humpback whales are known to produce three classes of vocalizations: (1) “songs” in the late fall, winter, and spring by solitary males; (2) social sounds made by calves (Zoidis et al. 2008) or within groups on the wintering (calving) grounds; and (3) social sounds made on the feeding grounds (Thomson and Richardson 1995a). The best-known types of sounds produced by humpback whales are songs, which are thought to be reproductive displays used on breeding grounds and sung only by adult males (Schevill et al. 1964; Helweg et al. 1992; Gabriele and Frankel. 2002; Clark and Clapham 2004; Smith et al. 2008). Singing is most common on breeding grounds during the winter and spring months, but is occasionally heard in other regions and seasons (McSweeney et al. 1989; Gabriele and Frankel. 2002; Clark and Clapham 2004). Au et al. (2006a) noted that humpback whales off Hawaii tended to sing louder at night compared to the day. There is a geographical variation in humpback whale song, with different populations singing a basic form of a song that is unique to their own group. However, the song evolves over the course of a breeding season but remains nearly unchanged from the end of one season to the start of the next (Payne et al. 1983). The song is an elaborate series of patterned vocalizations that are hierarchical in nature, with a series of songs (‘song sessions’) sometimes lasting for hours (Payne and Mcvay 1971). Components of the song range from below 20 Hz up to 4 kHz, with source levels measured between 151–189 dB re 1 µPa-m and high frequency harmonics extending beyond 24 kHz (Winn et al. 1970; Au et al. 2006c). Social calls range from 20 Hz–10 kHz, with dominant frequencies below 3 kHz (D'Vincent et al. 1985; Silber 1986; Simao and Moreira 2005; Dunlop et al. 2008). Female vocalizations appear to be simple; Simao and Moreira (2005) noted little complexity.

"Feeding" calls, unlike song and social sounds are a highly stereotyped series of narrow-band trumpeting calls. These calls are 20 Hz–2 kHz, less than one second in duration, and have source levels of 162–192 dB re 1 µPa-m (D'Vincent et al. 1985; Thompson et al. 1986). The fundamental frequency of feeding calls is approximately 500 Hz (D'Vincent et al. 1985; Thompson et al. 1986). So far, this call has only been documented among groups of humpback whales, engaged in cooperative or synchronized foraging events on Pacific herring (*Clupea pallasii*) in Alaska (D'Vincent et al. 1985; Thompson et al. 1986). The acoustics and dive profiles associated with humpback whale feeding behavior in the northwest Atlantic Ocean has been documented with digital acoustic recording tags (Stimpert et al. 2007). Underwater lunge behavior was associated with nocturnal feeding at depth and with multiple broadband click trains that were acoustically different from toothed whale echolocation. Stimpert et al. (2007) termed these sounds "mega-clicks" which showed relatively low received levels at the Digital Acoustic Recording Tags (DTAGs), which are located on the animal (143–154 dB re 1 µPa), with the majority of acoustic energy below 2 kHz.

NMFS categorizes humpback whales in the low-frequency cetacean hearing group, with a generalized frequency range between 7 Hz–36 kHz (NMFS 2024). Houser et al. (2001) produced a mathematical model of humpback whale hearing sensitivity based on the anatomy of the humpback whale ear. Based on the model, they concluded that humpback whales would be sensitive to sound in frequencies ranging from 700 Hz–10 kHz, with a maximum sensitivity between 2–6 kHz. Research by Au et al. (2001) and Au et al. (2006c) off Hawaii indicated the presence of high frequency harmonics in vocalizations up to and beyond 24 kHz. While recognizing this was the upper limit of the recording equipment, it does not demonstrate that humpback whales can actually hear those harmonics, which may simply be correlated harmonics of the frequency fundamental in the humpback whale song. The ability of humpback whales to hear frequencies around 3 kHz may have been demonstrated in a playback study. Maybaum (1990b) reported that humpback whales showed a mild response to a handheld sonar marine mammal detection and location device with frequency of 3.3 kHz at 219 dB re 1 µPa-m or frequency sweep of 3.1–3.6 kHz. In addition, the system had some low frequency components (below 1 kHz), which may have been an artifact of the acoustic equipment. This possible artifact may have affected the response of the whales to both the control and sonar playback conditions.

Recovery Planning

NMFS developed a Recovery Outline to guide and direct recovery efforts for the Central America, Mexico and Western North Pacific, DPSs of humpback whales (NMFS 2022). Until an updated recovery plan has been finalized, the Recovery Outline provides an interim strategy focused on:

1. Management activities that continue to protect humpback whales and their critical habitat.
2. Management activities that reduce medium and high risk threats to humpback whales, including vessel strike and entanglement in fishing gear.
3. Research activities to fill critical information gaps necessary to inform management actions.
4. Education and outreach activities to engage ocean users and to promote public involvement in humpback whale research and recovery.

4.2.4 Sei Whale

Sei whales are distributed worldwide, occurring in the North Atlantic Ocean, North Pacific Ocean, and Southern Hemisphere. Sei whales are not common in the Eastern Tropical Pacific, but there are reported sightings in the Gulf of California (Gendron and Rosales 1996). Sei whales mostly inhabit continental shelf and slope waters far from the coastline. Two subspecies of sei whale are recognized, *B. b. borealis* in the Northern Hemisphere and *B. b. schlegellii* in the Southern Hemisphere. The sei whale was originally listed as endangered on December 2, 1970.

Information available from the recovery plan (NMFS 2011), recent stock assessment report (Carretta et al. 2024), and status review (NMFS 2021) were used to summarize the life history, population dynamics, and status of the species as follows.

Life History

Sei whales can live, on average, between 50 and 70 years. They have a gestation period of 10–12 months, and calves nurse for six to nine months. Sexual maturity is reached between six and 12 years of age with an average calving interval of two to three years. Sei whales have a global distribution. They winter at low latitudes, where they calve and nurse, and summer at high latitudes, where they feed on a range of prey types, including: plankton (copepods and krill) small schooling fishes, and cephalopods. Winter breeding areas are currently not understood and feeding areas may change between years and seasons. Sei whales are mainly seen offshore, where they mostly inhabit waters in deep ocean basins or along the continental shelf and slope far from the coastline.

Threats

The sei whale is still endangered as a result of past commercial whaling. Japan is no longer a member of the International Whaling Commission and some sei whales (24–26 individuals) are taken each year by Japan's commercial program.[3] Other current threats include vessel strikes, fisheries interactions (including entanglement), changing environmental conditions (habitat loss and reduced prey availability), and anthropogenic noise. Given the species' overall abundance, they may be somewhat resilient to current threats. However, trends are largely unknown, especially for individual stocks, many of which have relatively low abundance estimates.

Population Dynamics

Prior to whaling, the estimated sei whale abundance was 42,000 individuals in the North Pacific and the estimate for year 1974 ranged from 7,260–12,620 individuals (Tillman 1977). More recently, the North Pacific Ocean population was estimated to be 29,632 individuals (95% Confidence Intervals [CI]=18,576–47,267 individuals) between 2010 and 2012 (IWC 2016; Thomas et al. 2016). We do not know of abundance estimates for sei whales more specifically for the Eastern Tropical Pacific.

The Eastern North Pacific stock includes sei whales found within the U.S. West Coast EEZ and in adjacent high seas waters; however, because data on abundance, distribution, and human-caused impacts are lacking for high seas regions, the status of this stock is evaluated based on data from U.S. EEZ waters of the California Current. The most recent estimate of sei whale abundance in the California Current is 864 individuals (CV=0.40), and a minimum population of 625 individuals, based on 2014 survey data (Carretta et al. 2024). Although there is no formal assessment of an abundance trend for sei whales, estimates reported in Barlow (2016) showed an increasing trend from 1991–2014 (Carretta et al. 2024).

Based on genetic analyses, there appears to be some differentiation between sei whale populations in different ocean basins. An early study of allozyme variation at 45 loci found some genetic differences between Southern Ocean and the North Pacific sei whales (Wada and Numachi 1991). However, more recent analyses of the mtDNA control region variation show no significant differentiation between Southern Ocean and the North Pacific sei whales, though both appear to be genetically distinct from sei whales in the North Atlantic (Baker and Clapham 2004; Huijser et al. 2018). Taguchi et al. (2021) conducted the first sei whale population genetic study worldwide using microsatellite DNA. He found that sei whales appear to be significantly differentiated among oceanic regions hierarchically, and sei whales in the Southern Hemisphere are more closely related to sei whales in the North Pacific than sei whales in the North Atlantic. Within ocean basin, there appears to be intermediate to high genetic diversity and little genetic differentiation despite there being different managed stocks (Danielsdottir et al. 1991; Kanda et al. 2006; Kanda et al. 2011; Kanda et al. 2013; Kanda et al. 2015; Huijser et al. 2018).

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[3] https://iwc.int/management-and-conservation/whaling/total-catches

Vocalizations and Hearing

Data on sei whale vocal behavior is limited compared to other baleen whale species and therefore less understood. Documented sei whale calls include upsweeps, downsweeps, tonal, and broadband calls. Records off the Antarctic Peninsula of broadband sounds in the 100–600 Hz range with 1.5 second duration and tonal and upsweep calls in the 200–600 Hz range of one to three second durations (McDonald et al. 2005). Vocalizations from the North Atlantic Ocean consisted of paired sequences (0.5–0.8 seconds, separated by 0.4–1.0 seconds) of 10–20 short (four milliseconds) frequency modulated sweeps between 1.5–3.5 kHz (Thomson and Richardson 1995b). Source levels of 189 ± 5.8 dB re 1 µPa-m have been established for sei whales in the northeastern Pacific Ocean (Weirathmueller 2013).

Direct studies of sei whale hearing have not been conducted, but it is assumed that they can hear the same frequencies that they produce (low) and are likely most sensitive to this frequency range (Richardson et al. 1995b; Ketten 1997). Similar to the other baleen whales in this Opinion, NMFS categorizes sei whales in the low-frequency cetacean hearing group, with a generalized frequency range between 7 Hz–36 kHz (NOAA 2018; 2024).

Recovery Planning

See the 2011 Final Recovery Plan for the sei whale for complete downlisting/delisting criteria for both of the following recovery goals:

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

4.2.5 Sperm Whale

Sperm whales have a global distribution and can be found in relatively deep waters in all ocean basins. Sperm whales movements can range over 5,000 km, likely driven by changes in prey abundance. While both males and females can be found in latitudes less than 40°, only adult males venture into the higher latitudes near the poles. The sperm whale was originally listed as endangered on December 2, 1970.

Information available from the recovery plan (NMFS 2010b), recent stock assessment reports (Carretta et al. 2024), and status review (NMFS 2015a) were used to summarize the life history, population dynamics, and status of the species as follows.

Life History

The average lifespan of sperm whales is estimated to be at least 50 years (Whitehead 2009). They have a gestation period of 1-1.5 years, and calves nurse for approximately two years. Sexual maturity for sperm whales in the North Pacific is reached between seven and 13 years of age for females with an average calving interval for four to six years. Male sperm whales reach full sexual maturity between ages 18 and 21, after which they undergo a second growth spurt, reaching full physical maturity at around age 40 (Mizroch and Rice 2013). Sperm whales mostly occur far offshore, inhabiting areas with a water depth of 600 m or more, and are uncommon in waters less than 300 m deep. However, sperm whales are frequently found in locations of high productivity that can be due to upwelling, which can occur not that far from shore, and from features such as continental slopes or steep underwater topography and canyons, or seamounts (Jaquet 1996; Jaquet and Whitehead 1996). They winter at low latitudes, where they calve and nurse, and summer at high latitudes, where they feed primarily on squid; other prey includes octopus and demersal fish (including teleosts and elasmobranchs).

Sperm whales are one of the deepest and longest diving marine mammals, with recorded dives up to 3 km in depth and durations in excess of two hours (Clarke 1976; Watkins 1985; Watkins et al. 1993). However, typical dives are generally shorter (25–45 min) and shallower (400–1,000 m). Dives are separated by 8-11-minute rests at the surface (Gordon 1987; Papastavrou et al. 1989; Jochens et al. 2006b; Watwood et al. 2006).

Stable, long-term associations among females form the core of sperm whale societies (Christal et al. 1998). Up to about a dozen females usually live in such groups, accompanied by their female and young male offspring. Young individuals are subject to alloparental care by members of either sex and may be suckled by non-maternal individuals (Gero et al. 2009). Group sizes may be smaller overall in the Caribbean Sea (6–12 individuals) versus the Pacific (25–30 individuals; (Jaquet and Gendron 2009). Males start leaving these family groups at about six years of age, after which they live in "bachelor schools," but this may occur more than a decade later (Pinela et al. 2009). The cohesion among males within a bachelor school declines with age. During their breeding prime and old age, male sperm whales are essentially solitary (Christal and Whitehead 1997).

Threats

The sperm whale is endangered as a result of past commercial whaling. Although the aggregate abundance worldwide is probably at least several hundred thousand individuals, the extent of depletion and degree of recovery of populations are uncertain. Commercial whaling is no longer allowed, however, illegal hunting may occur at biologically unsustainable levels. Continued threats to sperm whale populations include ship strikes, entanglement in fishing gear, competition for resources due to overfishing, population, loss of prey and habitat due to changing environmental conditions, and noise. The species' broad population and numbers indicate it may be somewhat resilient to current threats.

Population Dynamics

The sperm whale is the most abundant of the large whale species, with a global population of between 300,000–450,000 individuals (Whitehead 2009). The higher estimates may be approaching population sizes prior to commercial whaling. In the North Pacific, the abundance of sperm whales was estimated to be between 26,300–32,100 individuals in 1997 (95% CI=14,800–34,600 individuals) for the Eastern Tropical Pacific in 1993 (NMFS 2015a). Gerrodette and Forcada (2002) calculated an abundance estimate for sperm whales at 4,145–

49,653 individuals from data between 1986 and 2000 in the Eastern Tropical Pacific. There is insufficient sperm whale abundance data to evaluate population growth trend with any sufficient certainty. Sperm whale abundance appeared stable from 1991–2014 in the California Current (Moore and Barlow 2017). Sperm whale population structure in the eastern tropical Pacific is unknown, but the only photographic matches of known individuals from this area have been between the Galapagos Islands and coastal waters of South America (Dufault and Whitehead 1995) and between the Galapagos Islands and the southern Gulf of California (Jaquet et al. 2003), suggesting that eastern tropical Pacific animals may constitute its own distinct group.

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

Vocalizations and Hearing

Sound production and reception by sperm whales are better understood than in most cetaceans. Recordings of sperm whale vocalizations reveal that they produce a variety of sounds, such as clicks, gunshots, chirps, creaks, short trumpets, pips, squeals, and clangs (Goold 1999). Sperm whales typically produce short duration repetitive broadband clicks with frequencies below 100 Hz to greater than 30 kHz (Watkins 1977) and dominant frequencies between 1–6 kHz and 10–16 kHz. Another class of sound, “squeals,” are produced with frequencies of 100 Hz–20 kHz (e.g., Weir et al. 2007). The source levels of clicks can reach 236 dB re 1 µPa-m, although lower source level energy has been suggested at around 171 dB re 1 µPa-m (Weilgart and Whitehead 1993; Goold and Jones 1995; Weilgart and Whitehead 1997; Mohl et al. 2003). Most of the energy in sperm whale clicks is concentrated at around 2–4 kHz and 10–16 kHz (Weilgart and Whitehead 1993; Goold and Jones 1995). The clicks of neonate sperm whales are very different from typical clicks of adults in that they are of low directionality, long duration, and low frequency (between 300 Hz–1.7 kHz) with estimated source levels between 140–162 dB re 1 µPa-m (Madsen et al. 2003). The highly asymmetric head anatomy of sperm whales is likely an adaptation to produce the unique clicks recorded from these animals (Norris and Harvey 1972).

Long, repeated clicks are associated with feeding and echolocation (Whitehead and Weilgart 1991; Weilgart and Whitehead 1993; Goold and Jones 1995; Weilgart and Whitehead 1997; Miller et al. 2004). Creaks (rapid sets of clicks) are heard most frequently when sperm whales are foraging and engaged in the deepest portion of their dives, with inter-click intervals and source levels being altered during these behaviors (Miller et al. 2004; Laplanche et al. 2005). Clicks are also used during social behavior and intragroup interactions (Weilgart and Whitehead 1993). When sperm whales are socializing, they tend to repeat series of group-distinctive clicks (codas), which follow a precise rhythm and may last for hours (Watkins and Schevill 1977).

Codas are shared between individuals in a social unit and are considered to be primarily for intragroup communication (Weilgart and Whitehead 1997; Rendell and Whitehead 2004). Research in the South Pacific Ocean suggests that in breeding areas the majority of codas are produced by mature females (Marcoux et al. 2006). Coda repertoires have also been found to vary geographically and are categorized as dialects (Weilgart and Whitehead 1997; Pavan et al. 2000). For example, significant differences in coda repertoire have been observed between sperm whales in the Caribbean Sea and those in the Pacific Ocean (Weilgart and Whitehead 1997). In the South Pacific Ocean and Caribbean Sea, six acoustic “clans” were identified based on coda repertoires. These “clans” are likely an example of sympatric cultural variation in sperm whales, as smaller units of sperm whales are more likely to form groups with other units within their own clan (Rendell and Whitehead 2003). Three coda types used by male sperm whales have recently been described from data collected over multiple years: these codas are associated with dive cycles, socializing, and alarm (Frantzis and Alexiadou 2008).

Our understanding of sperm whale hearing stems largely from the sounds they produce. The only direct measurement of hearing was from a young stranded individual from which auditory evoked potentials were recorded (Carder and Ridgway 1990). From this whale, responses support a hearing range of 2.5–60 kHz and highest sensitivity to frequencies between 5–20 kHz. Other hearing information consists of indirect data. For example, the anatomy of the sperm whale’s inner and middle ear indicates an ability to best hear high-frequency to ultrasonic hearing (Ketten 1992). The sperm whale may also possess better low-frequency hearing than other odontocetes, although not as low as many baleen whales (Ketten 1992). Reactions to anthropogenic sounds can provide indirect evidence of hearing capability, and several studies have made note of changes seen in sperm whale behavior in conjunction with these sounds. For example, sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders and submarine sonar (Watkins and Schevill 1975b; Watkins et al. 1985). In the Caribbean Sea, Watkins et al. (1985) observed that sperm whales exposed to 3.25–8.4 kHz pulses (presumed to be from submarine sonar) interrupted their activities and left the area. Similar reactions were observed from artificial sound generated by banging on a boat hull (Watkins et al. 1985). André et al. (1997) reported that foraging whales exposed to a 10 kHz pulsed signal did not ultimately exhibit any general avoidance reactions: when resting at the surface in a compact group, sperm whales initially reacted strongly, and then ignored the signal completely. A recent study compared sperm whale reactions to continuous active sonar and traditional pulsed active sonar. Continuous active sonar may be used at a lower amplitude than traditional pulsed active sonar, but has a higher cumulative sound energy. Sperm whales reduced their time spent foraging during high sound exposure levels compared to high sound pressure levels (Isojunno et al. 2020). This suggests that cumulative sound energy may be an important driver of sperm whales behavioral responses to active sonar. Thode et al. (2007) observed that the acoustic signal from the cavitation of a fishing vessel’s propeller (110 decibels referenced to a pressure of one dB re 1 μPa^2-s between 250 Hz–1 kHz) interrupted sperm whale acoustic activity and resulted in the animals converging on the vessel. Sperm whales have also been observed to stop vocalizing for brief periods when codas are being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones 1995). Because they spend large amounts of time at depth and use low frequency sound, sperm whales are likely to be susceptible to low frequency sound in the ocean (Croll et al. 1999). Nonetheless, sperm whales are considered to be part of the high-frequency marine mammal hearing group, with a hearing range between 150 Hz–160 kHz (NOAA 2018; 2024).

Recovery Planning

See the 2010 Final Recovery Plan for the sperm whale for complete downlisting/delisting criteria for both of the following recovery goals:

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

4.2.6 Green Sea Turtle—East Pacific Distinct Population Segment

On April 6, 2016, NMFS listed 11 DPSs of green sea turtles as threatened or endangered under the ESA. Eight DPSs are listed as threatened: Central North Pacific, East Indian-West Pacific, East Pacific, North Atlantic, North Indian, South Atlantic, Southwest Indian, and Southwest Pacific. Three DPSs are listed as endangered: Central South Pacific, Central West Pacific, and Mediterranean. Only the threatened East Pacific DPS green sea turtles are expected to occur within the action of this Opinion.

We used information available in the 2007 five-year review (NMFS and USFWS 2007) and 2015 Status Review (Seminoff et al. 2015) to summarize the life history, population dynamics and status of the species.

Life History

The green sea turtle is the largest of the hardshell marine turtles, growing up 1.2 m long and weigh up to 350 pounds (159 kilograms). Age at first reproduction for females is 20–40 years. Green sea turtles lay an average of three nests per season with an average of 100 eggs per nest. The remigration interval is two to five years. Nesting occurs primarily on beaches with intact dune structure, native vegetation and appropriate incubation temperatures. In Michoacán, nesting occurs from October through January (Seminoff et al. 2015). Hatchlings emerge from the nest after about 60 days. After emerging from the nest, hatchlings swim to offshore areas and go through a post-hatchling pelagic stage where they are believed to live for several years. During this life stage, green sea turtles feed close to the surface on a variety of marine algae and other life associated with drift lines and debris. Adult turtles exhibit site fidelity and migrate hundreds to thousands of kilometers from nesting beaches to foraging areas. Post-nesting movements of female East Pacific green turtles indicate that individuals in the region (e.g., Costa Rica) stay in the coastal areas of Central America (Blanco 2010). Green sea turtles spend the majority of their lives in coastal foraging grounds, which include open coastlines and protected bays and lagoons. Green turtles nesting in Michoacán move north and south, to feeding areas from Colombia to the

Gulf of California (Alvarado and Figueroa 1992). Adult green turtles feed primarily on seagrasses and algae, although they also eat jellyfish, sponges and other invertebrate prey.

Threats

The population decline for the East Pacific DPS was primarily caused by commercial harvest of green turtles for subsistence and other uses (e.g., sea turtle oil as a cold remedy). The observed increases in nesting abundance for the largest nesting aggregation in the region (Michocán, Mexico), and indications of stability at the Galapagos, and record high numbers at sites in Costa Rica, all suggest that the population has some resilience (Seminoff et al. 2015).

Conservation laws are in place in several countries across the range of the DPS, but enforcement is inconsistent, limiting effectiveness. Incidental bycatch in commercial fishing gear, continued harvest, coastal development and beachfront lighting are all continuing threats for the East Pacific DPS.

Population Dynamics

There are 39 nesting sites for the East Pacific DPS, with an estimated 20,062 nesting females. The largest nesting site is at Colola beach, Michoacán, Mexico, which hosts 58% of the nesting females (11,588 nesting females) for the DPS (Seminoff et al. 2015). There are other nesting sites for the East Pacific DPS near the action area in the state of Michoacán. Maruata beach hosts 1,149 nesting females annually, with smaller nesting beaches occurring at Llorona (90 nesting females), Motin de Oro (240 nesting females), and Arenas Blancas (90 nesting females; (Seminoff et al. 2015).

The Galapagos has the second largest nesting assemblage for green turtles in the eastern Pacific Ocean, with a total of 3,603 adult female nesters from 2001–2002 (Zárate et al. 2006). Observations of green sea turtle nesting throughout Costa Rica and have identified at least 26 nesting sites that collectively host upwards of 2,800 nesting females in the population (Seminoff et al. 2015).

Rare and unique haplotypes are present in the East Pacific DPS. Genetic sampling has identified four regional stocks in the Eastern Pacific DPS: Revillagigedos Archipelago, Mexico, Michoacán, Mexico, Central America (Costa Rica), and the Galápagos Islands, Ecuador (Seminoff et al. 2015). In general, there has been insufficient data to support population growth estimates. The most long-term data for East Pacific DPS nesting is from Colola, Mexico, and analysis indicates that the population there is increasing and is likely to continue to do so.

Hearing

Sea turtles are considered able to detect low frequency sound, typically hearing frequencies from 30 Hz–2 kHz, with a range of maximum sensitivity between 100–800 Hz (Ridgway et al. 1969b; Lenhardt 1994; Bartol et al. 1999; Lenhardt 2002; Bartol and Ketten 2006). Piniak et al. (2016) found green sea turtle juveniles capable of hearing underwater sounds at frequencies of 50 Hz–1.6 kHz, with maximum sensitivity at 200–400 Hz). Other studies have similarly found greatest sensitivities between 200–400 Hz for the green turtle with a range of 100–500 Hz (Ridgway et al. 1969b; Bartol and Ketten 2006).

These hearing sensitivities are similar to those reported for two terrestrial species: pond and wood turtles. Pond turtles respond best to sounds between 200–700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz, and almost no sensitivity above 3 kHz (Wever and Vernon 1956a). Wood turtles are sensitive up to about 500 Hz, followed by a rapid decline above 1 kHz and almost no responses beyond 3–4 kHz (Patterson 1966).

Recovery Planning

See the 1998 and 1991 recovery plans for the Pacific, East Pacific and Atlantic populations of green sea turtles for complete down-listing/delisting criteria for recovery goals for the species (NMFS and USFWS 1991; NMFS and USFWS 1998). Broadly, recovery plan goals emphasize the need to protect and manage nesting and marine habitat, protect and manage populations on nesting beaches and in the marine environment, increase public education, and promote international cooperation on sea turtle conservation topics.

4.2.7 Hawksbill Sea Turtle

The olive ridley sea turtle is a small, mainly pelagic, sea turtle with a circumglobal distribution in tropical and subtropical waters in the Atlantic, Pacific and Indian Oceans. The species was listed under the ESA on July 28, 1978 (43 Fed. Reg. 32800). The species was separated into two listing designations: endangered for breeding populations on the Pacific coast of Mexico, and threatened wherever found except where listed as endangered (i.e., in all other areas throughout its range). Along the Pacific coast of Mexico there are beaches where large-scale synchronized nesting, known as arribadas, occurs (Figure 3).

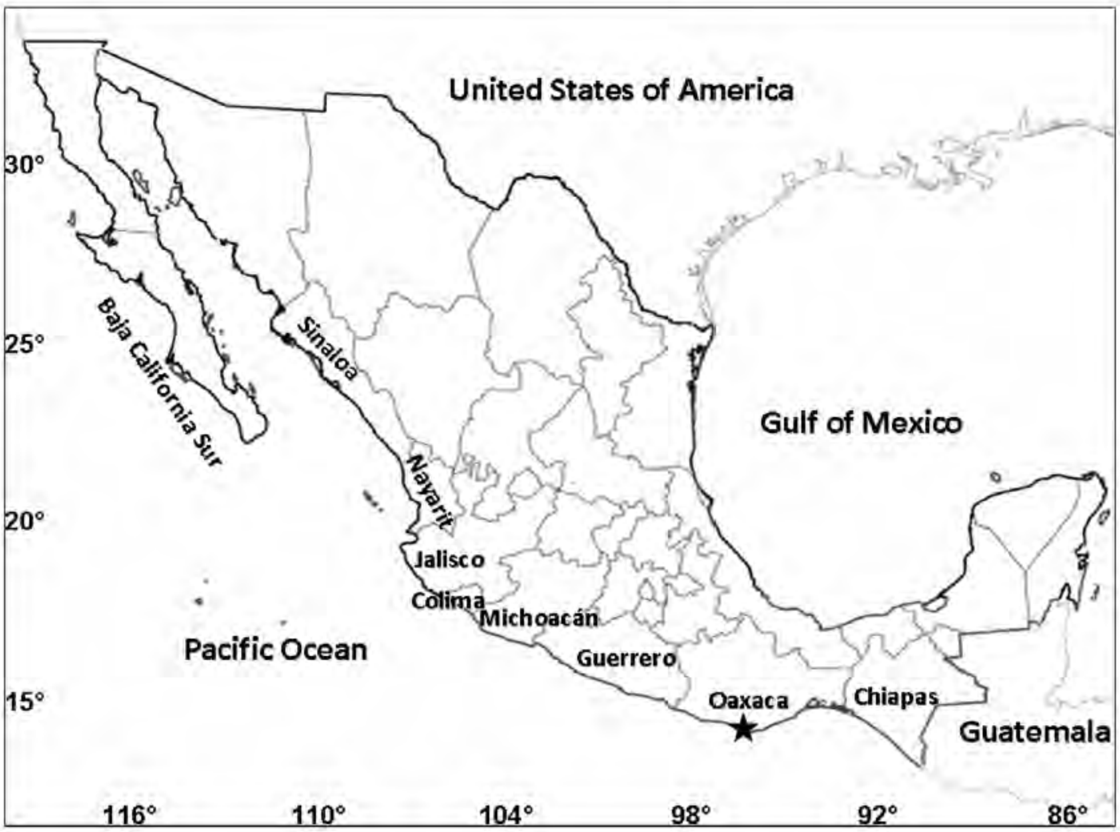

Figure 3. Map of Mexican states where Olive Ridley sea turtle nesting occurs; arribada-nesting beach at La Escobilla, Oaxaca is starred (Hernández-Echeagaray et al. 2012)

We used information available in the Five Year Review (NMFS and USFWS 2014b) to summarize the life history, population dynamics and status of the endangered Pacific coast of Mexico breeding population of the olive ridley sea turtle.

Life History

Olive ridley females mature at 10–18 years of age. They lay an average of two clutches per season (three to six months in duration). The annual average clutch size is 100–110 eggs per nest. Olive ridleys commonly nest in successive years. Females nest in solitary or in arribadas, where large aggregations coming ashore at the same time and location. There are six arribada nesting beaches and nine solitary nesting beaches in Mexico. At least four of the arribada nesting beaches are in the action area.

Olive ridleys can nest throughout the year, but there tends to be a peak in nesting during the rainy season (Hart et al. 2014). In Nayarit, Mexico, nesting occurred from June to November, with a peak from August to October. Peak nesting in Oaxaca for olive ridleys is between August and January (Chaloupka et al. 2004; Vannini and Jaillet 2009). Hatchlings emerge between 50–60 days after nesting (NMFS 1998b).

The post-breeding behavior of olive ridleys in the eastern Pacific Ocean is unique in that they are nomadic, migrating across ocean basins. This contrasts with other sea turtle species, which typically migrate to a particular feeding ground after nesting. As adults, olive ridleys forage on crustaceans, fish, mollusks, and tunicates, primarily in pelagic habitats.

Threats

Olive ridleys became targeted in a fishery in Mexico and Ecuador, which severely depleted the population from an estimated ten million olive ridleys nesting along the Pacific coast of Mexico to one million by 1969. Olive ridley breeding populations on the Pacific coast of Mexico were listed as endangered in response to this severe population decline. Legal harvest of olive ridleys was prohibited in 1990 (Márquez et al. 1996), although illegal harvest still occurs. The population is threatened by incidental capture in fisheries, exposure to pollutants and changing environmental conditions. In spite of the severe population decline, the olive ridley breeding populations on the Pacific coast of Mexico appear to have some resilience as evidenced in locations with increased nesting (NMFS and USFWS 2014a).

Population Dynamics

Although we do' not have a global estimate of olive ridley sea turtle abundance, they are considered to be the most abundant species of sea turtle. The range of the endangered Pacific coast breeding population extends as far south as Peru and up to California. Shipboard transects along the Mexico and Central American coasts from 1992–2006 indicate an estimated 1.39 million adults.

There are six primary arribada nesting beaches in Mexico, the largest being La Escobilla, Oaxaca, with about 200,000 nests laid annually (Hernández-Echeagaray et al. 2012). At Nuevo Vallarta, Nayarit, about 4,900 nests are laid annually (NMFS and USFWS 2014b).

Population growth rate and trend information for olive ridleys is difficult to discern, owing to its lack of consistent monitoring data in nesting areas across its range, but some indications are available (NMFS and USFWS 2014a). Olive ridley abundance appears to be increasing based on the nesting La Escobilla, Oaxaca: from 50,000 nests in 1988 to more than one million in 2000. Although there has been decreases in nesting at Chacahua, Oaxaca, but other sites have been stable. At-sea estimates of olive ridleys off Mexico and Central America also support an increasing population trend.

Genetic studies have identified four main lineages for the olive ridley: east India, Indo-Western Pacific, Atlantic, and the eastern Pacific. Rookeries on the Pacific coasts of Costa Rica and Mexico were not genetically distinct, and fine-scale population structure was not found when solitary and arribada nesting beaches were examined. Low levels of genetic diversity among Mexican nesting sites are attributed to a population collapse caused by past overharvest.

Hearing

We are not aware of hearing information specific to olive ridley sea turtles, so we are presenting information about sea turtle hearing generally. Sea turtles are considered able to detect low frequency sound, typically hearing frequencies from 30 Hz–2 kHz, with a range of maximum sensitivity between 100–800 Hz (Ridgway et al. 1969b; Lenhardt 1994; Bartol et al. 1999; Lenhardt 2002; Bartol and Ketten 2006).

These hearing sensitivities are similar to those reported for two terrestrial species: pond and wood turtles. Pond turtles respond best to sounds between 200–700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz, and almost no sensitivity above 3 kHz (Wever and Vernon 1956a). Wood turtles are sensitive up to about 500 Hz, followed by a rapid decline above 1 kHz and almost no responses beyond 3–4 kHz (Patterson 1966).

Recovery Planning

There has not been a Recovery Plan prepared specifically for olive ridley sea turtles of the breeding populations of the Pacific coast of Mexico. The 1998 Recovery Plan was prepared for olive ridleys found in the U.S. Pacific. Olive ridley sea turtles found in the Pacific could originate from the Pacific coast of Mexico or from another nesting population. As such, the recovery goals in the 1998 Recovery Plan for the U.S Pacific olive ridley sea turtle can apply to both listed populations. See the 1998 Recovery Plan for the U.S. Pacific olive ridley sea turtles for complete down listing/delisting criteria for their recovery goals. The following items were the recovery criteria identified to consider delisting:

1. All regional stocks that use U.S. waters have been identified to source beaches based on reasonable geographic parameters.
2. Foraging populations are statistically significantly increasing at several key foraging grounds within each stock region.
3. All females estimated to nest annually at source beaches are either stable or increasing for over ten years.
4. Management plan based on maintaining sustained populations for turtles is in effect.
5. International agreements in place to protect shared stocks.

4.2.8 Leatherback Sea Turtle

The leatherback sea turtle is unique among sea turtles for its large size, wide distribution (due to thermoregulatory systems and behavior), and lack of a hard, bony carapace. Leatherback turtles range from tropical to subpolar latitudes worldwide and are the largest living turtle, reaching lengths of 2 m long, and weighing up to 907.2 kilograms (2,000 pounds). Leatherback turtles occur throughout marine waters, from nearshore habitats to oceanic environments (Shoop and Kenney 1992). Movements are largely dependent upon reproductive and feeding cycles and the oceanographic features that concentrate prey, such as frontal systems, eddy features, current boundaries, and coastal retention areas (Benson et al. 2011).

The species was first listed under the Endangered Species Conservation Act (35 Fed. Reg. 8491) and listed as endangered under the ESA since 1973. In the 2020 five-year review, NMFS and U.S. Fish and Wildlife Service assessed the discreteness and significance of leatherback populations. After reviewing the best available information, the agencies identified seven leatherback populations that meet the discreteness and significance criteria of the DPS Policy (Figure 4).

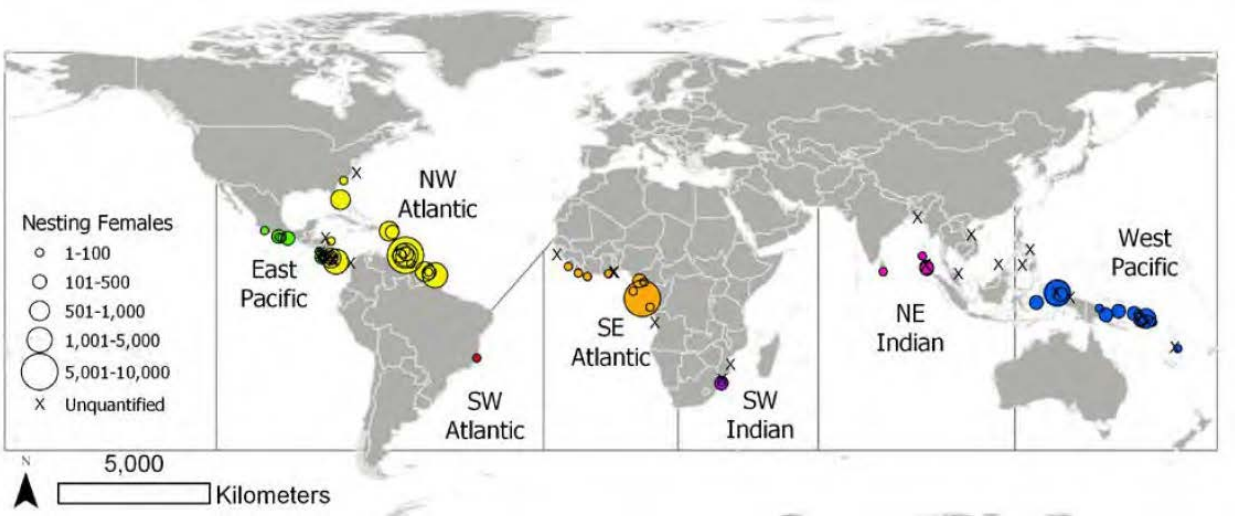

Figure 4. Map of Leatherback DPS boundaries and nesting beaches, (NMFS and USFWS 2020)

Leatherback sea turtles in the action area would belong to the East Pacific DPS. The East Pacific DPS of leatherback turtles is defined as originating from the East Pacific Ocean, north of 47° S, south of 32.531° N, east of 117.124° W, and west of the Americas. Even though seven leatherback populations qualify as DPSs, it was decided that listing them separately is not warranted (85 Fed. Reg. 48332) considering all seven DPSs would meet the definition for endangered species and the species is already listed as endangered throughout its range.

We used information available in the five-year review (NMFS and USFWS 2013), (NMFS 2020c), and the critical habitat designation (77 Fed. Reg. 61573) to summarize the life history, population dynamics and status of the species.

Life History

Avens et al. (2020) estimate a mean age at maturity of 17 years (range of 12–28 years) for Pacific leatherbacks (East and West populations combined). Females lay up to seven clutches per season, with more than 65 eggs per clutch and eggs weighing greater than 80 grams (0.17 pounds; (Reina et al. 2002; Wallace et al. 2007). The number of leatherback turtle hatchlings that make it out of the nest on to the beach (i.e., emergent success) is approximately 50% worldwide (Eckert et al. 2012). Females in the East Pacific nest every 3.7 years on average (NMFS 2020c). Natal homing, at least within an ocean basin, results in reproductive isolation between five broad geographic regions: eastern and western Pacific, eastern and western Atlantic, and Indian Ocean. The East Pacific population nests primarily on beaches in Mexico, Costa Rica, and Nicaragua.

Leatherback turtles migrate long, transoceanic distances between their tropical nesting beaches and the highly productive temperate waters where they forage, primarily on jellyfish and tunicates. Foraging areas are generally characterized by zones of upwelling, including off the edges of continents, where major currents converge, and in deep-water eddies (Saba 2013). The East Pacific population forages primarily off the coasts of Central and South America. Tagging data has indicated foraging in coastal areas off Peru and Chile (NMFS 2020c). Leatherback sea turtles feed from near the surface to depths exceeding 1,000 m, including nocturnal feeding on tunicate colonies within the deep scattering layer (Spotila 2004). Although leatherback sea turtles can dive deeper than any other reptile, most foraging dives are less than 80 m (Shillinger et al. 2011).

Jellyfish and tunicates are relatively nutrient-poor, such that leatherback turtles must consume large quantities to support their body weight. Migrating leatherback sea turtles spend a majority of their time submerged and display a pattern of continual diving. They appear to spend almost the entire portion of each dive traveling to and from maximum depth, suggesting continual foraging along the entire depth profile (Eckert et al. 1989).

Leatherback turtles weigh about 33% more on their foraging grounds than at nesting, indicating that they probably catabolize fat reserves to fuel migration and subsequent reproduction (James et al. 2005; Wallace et al. 2006). Sea turtles must meet an energy threshold before returning to nesting beaches. Therefore, their remigration intervals are dependent upon foraging success and duration (Hays 2000; Price et al. 2004). The nesting seasons for leatherbacks in the eastern Pacific in Mexico is from October to February (Vannini and Jaillet 2009), with other reports stating that the nesting season lasts until May (Martínez et al. 2007). Hatchlings emerge from their nests after about sixty days (Binckley et al. 1998).

Threats

The leatherback turtle is an endangered species whose once large nesting populations have experienced steep declines in recent decades. The primary threats to leatherback turtles include fisheries bycatch, harvest of nesting females, and egg harvesting (Martínez et al. 2007). Because of these threats, once large rookeries are now functionally extinct, and there have been range-wide reductions in population abundance. Other threats include loss of nesting habitat due to development, tourism, and sand extraction. Lights on or adjacent to nesting beaches alter nesting adult behavior and are often fatal to emerging hatchlings as they are drawn to light sources and away from the sea. Plastic ingestion (which may be mistaken for its jellyfish prey) is common in leatherback turtles and can block gastrointestinal tracts leading to death. Changing environmental conditions may alter sex ratios (as temperature at nesting sites determines hatchling sex), range (through expansion of foraging habitat), and habitat (through the loss of nesting beaches, because of sea-level rise).

Leatherback sea turtle populations may not have much capacity for resilience to additional perturbations and all seven leatherback populations are considered at a high risk of extinction (NMFS and USFWS 2020a).

Population Dynamics

Leatherback turtles are globally distributed with nesting beaches in the Atlantic, Indian, and Pacific Oceans. Mexico historically hosted the world’s largest aggregation of leatherback nesting, with 75,000 nesting females observed in 1980 during an aerial survey. Overall, Pacific populations have declined from an estimated 81,000 individuals to less than 3,000 total adults and sub adults (Spotila et al. 2000).

Overall, there has been a steep decline (97.4%) in nesting productivity for leatherbacks in the eastern Pacific over the last 30–40 years (Wallace et al. 2013a). There are 16 nesting sites for leatherbacks in the eastern Pacific, with seven sites in Mexico (Figure 5). Of the estimated 755 nesting females in the eastern Pacific, 572 nest in Mexico. Playa Barra de la Cruz/Playa Grande, in Oaxaca, has 209 nesting females (NMFS 2020c). Tierra Colorada, Guerrero, hosts 120 nesting females annually, making it the second largest nesting beach in Mexico. Playón Mexiquillo, Michoacán has 78 nesting females. Monitoring of the nesting assemblage at Mexiquillo has been continuous since 1982. During the mid-1980s, more than 5,000 nests per season were documented along 4 km of this nesting beach. By 1993, less than 100 nests were counted along the entire 18-km beach (Sarti-Martínez 2002). According to Sarti et al. (1996), nesting declined at this location at an annual rate of over 22% from 1984–1995. In Mexico, annual median nest counts vary from beach to beach, with some (Playa Barra de la Cruz /Playa Grande) increased by 9.5% annually, while others (Cahuitán) decreased from 1997/1998 through 2016/2017, with a median trend of -4.3% annually (NMFS 2020c).

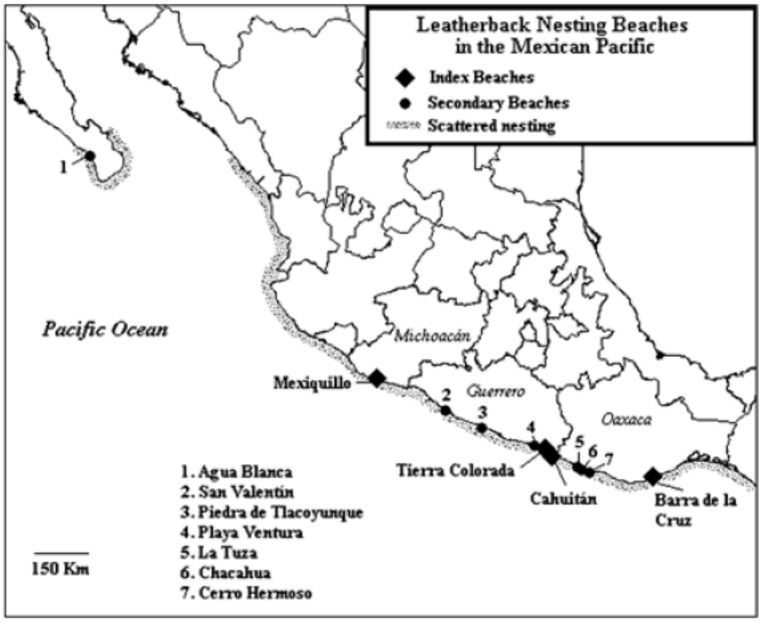

Figure 5. Leatherback nesting beaches in Mexico (Martínez et al. 2007)

Analyses of mtDNA from leatherback turtles indicates a low level of genetic diversity, pointing to possible difficulties in the future if current population declines continue (Dutton et al. 1999). Previously, Wallace et al. (2013b) had identified seven subpopulations of leatherback sea turtles globally. In the analysis of discreteness, the agencies found genetic discontinuity among seven populations. The Status Review concluded that the loss of any population would result in a significant gap (i.e., a half or quarter of an ocean basin) in the nesting, and sometimes foraging, range of the species.

Hearing

Sea turtles are considered able to detect low frequency sound, typically hearing frequencies from 30 Hz–2 kHz, with a range of maximum sensitivity between 100–800 Hz (Ridgway et al. 1969a; Lenhardt 1994; Bartol et al. 1999; Lenhardt 2002; Moein Bartol and Ketten 2006). Piniak (2012) measured hearing of leatherback turtle hatchlings in water an in air, and observed reactions to low frequency sounds, with responses to stimuli occurring between 50 Hz–1.6 kHz in air between 50 Hz–1.2 kHz in water (lowest sensitivity recorded was 93 dB re 1 μPa at 300 Hz).

These hearing sensitivities are similar to those reported for two terrestrial species: pond and wood turtles. Pond turtles respond best to sounds between 200–700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz, and almost no sensitivity above 3 kHz (Wever and Vernon 1956b). Wood turtles are sensitive up to about 500 Hz, followed by a rapid decline above 1 kHz and almost no responses beyond 3–4 kHz (Patterson 1966).

Recovery Planning

For complete down listing/delisting criteria for leatherback sea turtle recovery goals, see the 1998 Recovery Plan for the U.S. Pacific. The following items were the top five recovery actions identified in the Pacific Leatherback Five Year Action Plan:

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

4.2.9 Loggerhead Sea Turtle—North Pacific Distinct Population Segment

Loggerhead sea turtles are circumglobal, and are found in the temperate and tropical regions of the Indian, Pacific and Atlantic Oceans. The species was first listed as threatened under the ESA in 1978. On September 22, 2011, the NMFS designated nine DPSs of loggerhead sea turtles: South Atlantic Ocean and Southwest Indian Ocean as threatened, as well as Mediterranean Sea, North Indian Ocean, North Pacific Ocean, Northeast Atlantic Ocean, Northwest Atlantic Ocean, South Pacific Ocean, and Southeast Indo-Pacific Ocean as endangered. Ocean-basin scale genetic analysis supports this conclusion, with additional differentiation apparent based upon nesting beaches (Shamblin et al. 2014). The only loggerhead DPS occurring within the action area and considered in this Opinion is the North Pacific Ocean DPS.

We used information available in the 2009 status review (Conant et al. 2009), the 2020 status review (NMFS 2020b), and the final listing rule (76 Fed. Reg. 58868) to summarize the life history, population dynamics and status of the species.

Life History

Mayne et al. (2020) estimated the average maximum lifespan of loggerhead turtles to be 62.8 years (± 3.7 years). Females make reproductive migrations every 3.3 years, laying 4.6 nests per year, with an average of 122 eggs per nest. Martin et al. (2020b) estimated the average age to maturity for North Pacific loggerheads at 37.9 years old. Nesting occurs on beaches, where warm, humid sand temperatures incubate the eggs. Temperature determines the sex of the turtle during the middle of the incubation period. After emerging from their nests at night, hatchlings crawl seaward using visual cues, toward the brighter horizon of the open ocean and away from the dark, elevated silhouettes of dunes and vegetation (Pankaew and Milton 2018). After hatchlings enter the sea, they begin a 24–36-hour swim frenzy, orienting into waves to reach offshore currents (DuBois et al. 2021).

Loggerhead turtles spend the post-hatchling stage in pelagic waters. The juvenile stage is spent first in the oceanic zone and later in the neritic zone (i.e., coastal waters). While in their oceanic phase, loggerhead turtles undergo long migrations using ocean currents. Individuals from multiple nesting colonies can be found on a single feeding ground. Coastal waters provide important foraging habitat, inter-nesting habitat, and migratory habitat for adult loggerheads. Loggerhead sea turtles are known to occur in areas where sea surface temperature ranges between 10–28.7°C; however, mean sea surface temperatures, which are more indicative of preferred habitat, range between 16.3– 24°C (Eguchi et al. 2018).

Threats

Once abundant in tropical and subtropical waters, loggerhead sea turtles worldwide exist at a fraction of their historical abundance, as a result of over-exploitation. Globally, egg harvest, the harvest of females on nesting beaches and directed hunting of turtles in foraging areas remain the greatest threats to their recovery. In addition, bycatch in drift net, long-line, set-net, pound-net and trawl fisheries kill thousands of loggerhead sea turtles annually. Increasing coastal development (including beach erosion and re-nourishment, construction and artificial lighting) threatens nesting success and hatchling survival.

Neritic juveniles and adults in the North Pacific Ocean DPS are at risk of mortality from coastal fisheries in Japan and Baja California, Mexico. Habitat degradation in the form of coastal development and armoring pose a threat to nesting females. Based on these threats and the relatively small population size, the Biological Review Team concluded that the North Pacific Ocean DPS is currently at risk of extinction (Conant et al. 2009). The 2020 five-year review found that the status of the DPS has not changed since it was listed as endangered in 2011 (NMFS 2020b). The DPS continues to be endangered by intense (fisheries bycatch and changing environmental conditions) and numerous (habitat loss and modification, overutilization, and predation) threats acting on a small, subdivided population (NMFS 2020b).

Population Dynamics

All nesting for the North Pacific DPS occurs at sites in Japan (NMFS and USFWS 2020b). There was a steep (50–90%) decline in the annual nesting population in Japan during the last half of the 20th century (Kamezaki et al. 2003). Nesting has gradually increased, but is still considered to be depressed compared to historical numbers (Conant et al. 2009).

Martin et al. (2020a) calculated a 2015 abundance “snapshot” of 4,541 nesting females for three nesting beaches for which data were available: Inakahama, Maehama, and Yotsusehama on Yakushima. Because these beaches comprise approximately 52% of the total nesting population, the extrapolated 2015 total nesting abundance for the entire DPS is approximately 8,733 nesting females (USFWS 2020). North Pacific DPS loggerhead nesting likely increased between 1999 and 2012 at a rate of around 2.3% (95% CI=-1.1–15.6%) annually (Martin et al. 2020b). This is not a true growth rate of the population because, only represent a portion of the population, but annual nester counts is the best available scientific information to describe trends.

There are nine loggerhead DPSs, which are geographically separated and genetically isolated, as indicated by genetic, tagging, and telemetry data. Recent mtDNA analysis using longer sequences has revealed a more complex population sub-structure for the North Pacific Ocean

DPS than previously thought. Previously, five haplotypes were present, and now, nine haplotypes have been identified in the North Pacific Ocean DPS. This evidence supports the designation of three management units in the North Pacific Ocean DPS: 1) the Ryukyu management unit (Okinawa, Okinoerabu, and Amami), 2) Yakushima Island management unit and 3) Mainland management unit (Bousou, Enshu-nada, Shikoku, Kii, and Eastern Kyushu; (Matsuzawa et al. 2016).

Hatchlings from Japanese nesting beaches use the North Pacific Subtropical Gyre and the Kurishio Extension to migrate to foraging grounds. Two major juvenile foraging areas have been identified in the North Pacific Basin: Central North Pacific and off Mexico's Baja California Peninsula. Both of these feeding grounds are frequented by individuals from Japanese nesting beaches (Abecassis et al. 2013; Seminoff et al. 2014). Loggerhead abundance on foraging grounds off the Pacific Coast of the Baja California Peninsula, Mexico, was estimated to be 43,226 individuals (Seminoff et al. 2014).

Most of the available information seems to indicate that loggerheads are primarily found more north of the action area (Baja California), and South Pacific DPS loggerheads found more south of the action area (in Ecuador, Chile, and Peru). Apparently, loggerheads are not present on the Pacific side of Guatemala. There is anecdotal evidence and reports of loggerheads on the Pacific coast of Panama, but that they are not present on the Pacific coast of Costa Rica (Chapman and Seminoff 2016).

Hearing

Sea turtles are considered able to detect low frequency sound, typically hearing frequencies from 30 Hz–2 kHz, with a range of maximum sensitivity between 100–800 Hz (Ridgway et al. 1969b; Lenhardt 1994; Bartol et al. 1999; Lenhardt 2002; Bartol and Ketten 2006). Hearing below 80 Hz is less sensitive but still possible (Lenhardt 1994). Bartol et al. (1999) reported effective hearing range for juvenile loggerhead turtles is from at least 250–750 Hz. Both yearling and two-year old loggerhead turtles had the lowest hearing threshold at 500 Hz (yearling: about 81 dB re 1 µPa and two-year olds: about 86 dB re 1 µPa), with threshold increasing rapidly above and below that frequency (Bartol and Ketten 2006). Underwater tones elicited behavioral responses to frequencies between 50–800 Hz and auditory evoked potential responses between 100–1,131 Hz in one adult loggerhead turtle (Martin et al. 2012). The lowest threshold recorded in this study was 98 dB re 1 µPa at 100 Hz. Lavender et al. (2014) found post-hatchling loggerhead turtles responded to sounds in the range of 50–800 Hz while juveniles responded to sounds in the range of 50 Hz–1 kHz. Post-hatchlings had the greatest sensitivity to sounds at 200 Hz while juveniles had the greatest sensitivity at 800 Hz (Lavender et al. 2014).

These hearing sensitivities are similar to those reported for two terrestrial species: pond and wood turtles. Pond turtles respond best to sounds between 200–700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz, and almost no sensitivity above 3 kHz (Wever and

Vernon 1956a). Wood turtles are sensitive up to about 500 Hz, followed by a rapid decline above 1 kHz and almost no responds beyond 3–4 kHz (Patterson 1966).

Recovery Planning

Key recovery actions identified in the 1998 Recovery Plan for U.S. Pacific Populations of the Loggerhead Turtle are:

1. Reduce incidental capture of loggerheads by coastal and high seas commercial fishing operations.
2. Establish bilateral agreements with Japan and Mexico to support their efforts to census and monitor loggerhead populations and to minimize impacts of coastal development and fisheries on loggerhead stocks.
3. Identify stock home ranges using DNA analysis.
4. Determine population size and status (in U.S. jurisdiction) through regular aerial or on-water surveys.
5. Identify and protect primary foraging areas for the species.

4.2.10 Olive Ridley Sea Turtle—Mexico's Pacific Coast Breeding Colonies

The olive ridley sea turtle is a small, mainly pelagic, sea turtle with a circumglobal distribution in tropical and subtropical waters in the Atlantic, Pacific and Indian Oceans. The species was listed under the ESA on July 28, 1978 (43 Fed. Reg. 32800). The species was separated into two listing designations: endangered for breeding populations on the Pacific coast of Mexico, and threatened wherever found except where listed as endangered (i.e., in all other areas throughout its range). Along the Pacific coast of Mexico there are beaches where large-scale synchronized nesting, known as arribadas, occurs (Figure 6).

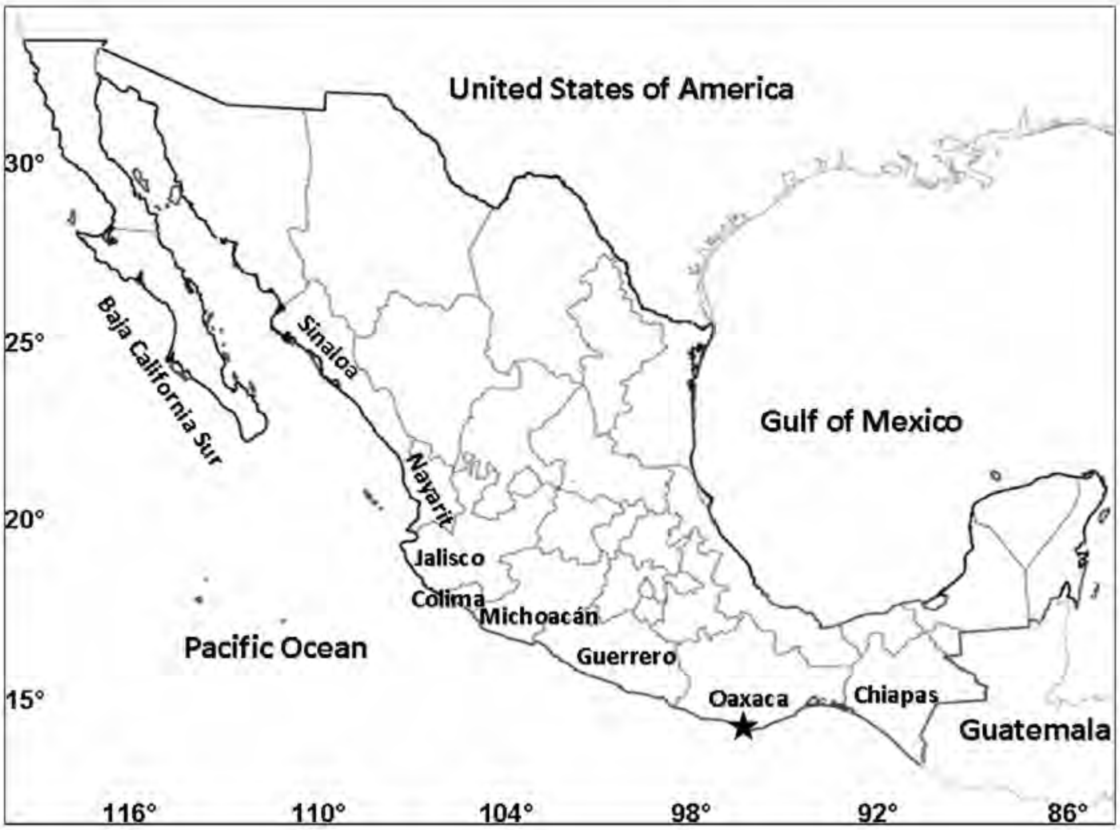

Figure 6. Map of Mexican states where Olive Ridley sea turtle nesting occurs; arribada-nesting beach at La Escobilla, Oaxaca is starred (Hernández-Echeagaray et al. 2012)

We used information available in the Five Year Review (NMFS and USFWS 2014b) to summarize the life history, population dynamics and status of the endangered Pacific coast of Mexico breeding population of the olive ridley sea turtle.

Life History

Olive ridley females mature at 10–18 years of age. They lay an average of two clutches per season (three to six months in duration). The annual average clutch size is 100–110 eggs per nest. Olive ridleys commonly nest in successive years. Females nest in solitary or in arribadas, where large aggregations coming ashore at the same time and location. There are six arribada nesting beaches and nine solitary nesting beaches in Mexico. At least four of the arribada nesting beaches are in the action area.

Olive ridleys can nest throughout the year, but there tends to be a peak in nesting during the rainy season (Hart et al. 2014). In Nayarit, Mexico, nesting occurred from June to November, with a peak from August to October. Peak nesting in Oaxaca for olive ridleys is between August and January (Chaloupka et al. 2004; Vannini and Jaillet 2009). Hatchlings emerge between 50–60 days after nesting (NMFS 1998b).

The post-breeding behavior of olive ridleys in the eastern Pacific Ocean is unique in that they are nomadic, migrating across ocean basins. This contrasts with other sea turtle species, which typically migrate to a particular feeding ground after nesting. As adults, olive ridleys forage on crustaceans, fish, mollusks, and tunicates, primarily in pelagic habitats.

Threats

Olive ridleys became targeted in a fishery in Mexico and Ecuador, which severely depleted the population from an estimated ten million olive ridleys nesting along the Pacific coast of Mexico to one million by 1969. Olive ridley breeding populations on the Pacific coast of Mexico were listed as endangered in response to this severe population decline. Legal harvest of olive ridleys was prohibited in 1990 (Márquez et al. 1996), although illegal harvest still occurs. The population is threatened by incidental capture in fisheries, exposure to pollutants and changing environmental conditions. In spite of the severe population decline, the olive ridley breeding populations on the Pacific coast of Mexico appear to have some resilience as evidenced in locations with increased nesting (NMFS and USFWS 2014a).

Population Dynamics

Although we do not have a global estimate of olive ridley sea turtle abundance, they are considered to be the most abundant species of sea turtle. The range of the endangered Pacific coast breeding population extends as far south as Peru and up to California. Shipboard transects along the Mexico and Central American coasts from 1992–2006 indicate an estimated 1.39 million adults.

There are six primary arribada nesting beaches in Mexico, the largest being La Escobilla, Oaxaca, with about 200,000 nests laid annually (Hernández-Echeagaray et al. 2012). At Nuevo Vallarta, Nayarit, about 4,900 nests are laid annually (NMFS and USFWS 2014b).

Population growth rate and trend information for olive ridleys is difficult to discern, owing to its lack of consistent monitoring data in nesting areas across its range, but some indications are available (NMFS and USFWS 2014a). Olive ridley abundance appears to be increasing based on the nesting La Escobilla, Oaxaca: from 50,000 nests in 1988 to more than one million in 2000. Although there has been decreases in nesting at Chacahua, Oaxaca, but other sites have been stable. At-sea estimates of olive ridleys off Mexico and Central America also support an increasing population trend.

Genetic studies have identified four main lineages for the olive ridley: east India, Indo-Western Pacific, Atlantic, and the eastern Pacific. Rookeries on the Pacific coasts of Costa Rica and Mexico were not genetically distinct, and fine-scale population structure was not found when solitary and arribada nesting beaches were examined. Low levels of genetic diversity among Mexican nesting sites are attributed to a population collapse caused by past overharvest.

Hearing

We are not aware of hearing information specific to olive ridley sea turtles, so we are presenting information about sea turtle hearing generally. Sea turtles are considered able to detect low frequency sound, typically hearing frequencies from 30 Hz–2 kHz, with a range of maximum sensitivity between 100–800 Hz (Ridgway et al. 1969b; Lenhardt 1994; Bartol et al. 1999; Lenhardt 2002; Bartol and Ketten 2006).

These hearing sensitivities are similar to those reported for two terrestrial species: pond and wood turtles. Pond turtles respond best to sounds between 200–700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz, and almost no sensitivity above 3 kHz (Wever and Vernon 1956a). Wood turtles are sensitive up to about 500 Hz, followed by a rapid decline above 1 kHz and almost no responses beyond 3–4 kHz (Patterson 1966).

Recovery Planning

There has not been a Recovery Plan prepared specifically for olive ridley sea turtles of the breeding populations of the Pacific coast of Mexico. The 1998 Recovery Plan was prepared for olive ridleys found in the U.S. Pacific. Olive ridley sea turtles found in the Pacific could originate from the Pacific coast of Mexico or from another nesting population. As such, the recovery goals in the 1998 Recovery Plan for the U.S Pacific olive ridley sea turtle can apply to both listed populations. See the 1998 Recovery Plan for the U.S. Pacific olive ridley sea turtles for complete down listing/delisting criteria for their recovery goals. The following items were the recovery criteria identified to consider delisting:

1. All regional stocks that use U.S. waters have been identified to source beaches based on reasonable geographic parameters.
2. Foraging populations are statistically significantly increasing at several key foraging grounds within each stock region.
3. All females estimated to nest annually at source beaches are either stable or increasing for over ten years.
4. Management plan based on maintaining sustained populations for turtles is in effect.
5. International agreements in place to protect shared stocks.

4.3 Effects of Changing Environmental Conditions on ESA-Listed Species

Large-scale changes in environmental conditions adversely affect ESA-listed species within the action area and likely will continue. The global average surface temperature was 1.09°C higher in 2011–2020 than 1850–1900, with larger increases over land (1.59°C) than over the ocean (0.88°C). Global surface temperature has increased faster since 1970 than in any other 50-year period over at least the last 2,000 years (Lee et al. 2023). As warming increases, the occurrence of marine heat waves, ocean acidification and deoxygenation are also likely to increase (Lee et al. 2023).

4.3.1 Acidification

The global atmospheric carbon dioxide concentration has now passed 400 parts per million, a level that last occurred about three million years ago, when both global average temperature and sea level were significantly higher than today. An increasing global atmospheric carbon dioxide concentration also drives an increase in ocean acidity, which has increased by 26% since the beginning of the industrial era (Intergovernmental Panel on Climate Change 2014; IPCC 2014). Changes in ocean acidity change the way chemical reactions occur in the ocean, and this can affect the way life functions in the ocean. Many animals make shells or other hard structures that include calcium carbonate, which becomes more difficult in an acidic environment; requiring more of the animal's energy and resulting in weaker shells or structures (Doney et al. 2012). There is broad consensus that the further and the faster the Earth system is pushed by the increasing carbon dioxide concentrations, the greater the risk of changes and impacts, some of which are potentially large and irreversible (Wuebbles et al. 2017).

Significant impacts to marine mammals and sea turtles from ocean acidification will be indirectly tied to foraging opportunities resulting from ecosystem changes (Busch et al. 2013; Haigh et al. 2015; Chan et al. 2017). Nearshore waters of the North Pacific have already shown a persistent drop in pH from the global ocean mean pH of 8.1, to as low as 7.43 off California (Chan et al. 2017). The distribution, abundance and migration of baleen whales reflects the distribution, abundance and movements of dense prey patches (e.g., copepods, euphausiids or krill, amphipods, and shrimp), which have in turn been linked to oceanographic features affected by changing environmental conditions (Learmonth et al. 2006b). Ocean acidification may cause a shift in plankton community composition and biochemical composition that can impact the transfer of essential compounds to predators that eat plankton (Bermúdez et al. 2016). Blue whales specialize in eating krill and are likely to change their distribution in response to changes in the distribution of krill (Payne et al. 1986a; Payne et al. 1990b; Clapham et al. 1999a). Krill have been shown to suffer decreased larval development and survival under lower pH conditions (McLaskey et al. 2016). Krill also have lower metabolic rates after both short-term and long-term exposure to low pH (Cooper et al. 2016). Increased ocean acidification may also have serious impacts on fish development and behavior (Raven et al. 2005), including sensory functions (Bignami et al. 2013) and fish larvae behavior that could impact fish populations (Munday et al. 2009), and piscivorous ESA-listed species that rely on those populations for food. Corals reefs are built with calcium carbonate and acidification can make their growth more difficult. Sea turtles, such as the hawksbill, rely on corals for foraging.

4.3.2 Sea Level and Freshwater

Global average sea level has risen by about seven to eight inches since 1900, with almost half (about three inches) of that rise occurring since 1993, a rate of rise that is greater than during any preceding century in at least 2,800 years (Wuebbles et al. 2017). As global temperatures warm, seawater is expanding, but the biggest contribution to sea level rise is from freshwater added by melting ice sheets and glaciers. Global average sea levels are expected to continue to rise by at least several inches in the next 15 years, and by one to four feet by 2100.

Freshwater from ice melt at high latitudes makes the ocean surface waters there less dense (less salty) which decreases the ability for the waters to sink and drive major global ocean currents. These currents impact the availability of nutrients that drive primary biological productivity, such as plankton blooms, which in turn impact major ecosystems that rely on that productivity, all the way up the food chain to large consumers like whales (Gennip et al. 2017). Increased sea surface temperature can alter patterns of stratification (water layers) and upwelling (vertical water movement), which influence the amount of nutrients supplied to surface waters from the deep sea leading to changes in plankton productivity and the fish populations that consume plankton (EPA 2010), and, therefore, declines in those species whose diets are dominated by fish.

4.3.3 Range Shift

Marine species ranges are expected to shift as they align their distributions to match their physiological tolerances under changing environmental conditions (Doney et al. 2012). There are indications that such range and distribution shifts are already occurring in some marine mammal populations (Silber et al. 2017). Marine mammal species often exhibit strong dependence on or fidelity to particular habitat types, oceanographic features, and migration routes (Sequeira et al. 2018). Specialized diets, restricted ranges, or reliance on specific substrates or sites (e.g., for pupping) make many marine mammal populations particularly vulnerable to changing environmental conditions (Silber et al. 2017). Marine mammals with restricted distributions linked to water temperature may be exposed to range restriction (Learmonth et al. 2006b; Issac 2009). MacLeod (2009) estimated that, based upon expected shifts in water temperature, 88% of cetaceans would be affected by changing environmental conditions, 47% would be negatively affected, and 21% would be put at risk of extinction. Hazen et al. (2012) examined top predator distribution and diversity in the Pacific Ocean in light of rising sea surface temperatures using a database of electronic tags and output from a global climate model. He predicted up to a 35% change in core habitat area for some key marine predators in the Pacific Ocean, with some species predicted to experience gains in available core habitat and some predicted to experience losses. Notably, leatherback sea turtles were predicted to gain core habitat area, whereas loggerhead sea turtles and blue whales were predicted to experience losses in available core habitat. Such range shifts could affect marine mammal and sea turtle foraging success as well as sea turtle reproductive periodicity (Pike 2014; Birney et al. 2015). Climate related species distributional shifts can alter bioenergetic demands and influence mortality events (Fedewa et al. 2020; Szuwalski et al. 2023).

Shifting ranges of important prey item for marine mammals have been observed across all ocean regions (Poloczanska et al. 2016). For ESA-listed species that undergo long migrations, individual movements are usually associated with prey availability or habitat suitability. If either is disrupted, the timing of migration can change or negatively impact population sustainability (Simmonds and Eliott. 2009). Blue whales, as predators that specialize in eating krill, are likely to change their seasonal occurrence and distribution in response to changes in the distribution of krill (Payne et al. 1986b; Payne et al. 1990a; Clapham et al. 1999b; Barlow et al. 2020; van Weelden et al. 2021). Abrahms et al. (2019) compared 10 years of blue whale movement data with the timing of the spring phytoplankton bloom resulting in increased prey availability in the California Current Ecosystem. Blue whales closely tracked the long-term average phenology of the spring bloom. This study showed that both long-term memory and resource tracking play key roles in the long-distance migrations of blue whales and possibly other marine megafauna. Results of this study suggest that such species may struggle to respond to rapid deviations from historical mean environmental conditions (Abrahms et al. 2019). If blue whales cannot find the biomass of krill necessary to sustain their population numbers, their populations seem likely to experience declines similar to those observed in other krill predators, which would cause dramatic declines in their population sizes or would increase the year-to-year variation in population size; either of these outcomes would dramatically increase the extinction probabilities of these whales. Findings from Millien et al. (2025) suggest that humpback whales integrate information they gather from their immediate environment to predict the oceanic conditions at distant locations and adjust the timing of their migration, maximizing their interaction with that of their prey. The ability of humpback whales to fully succeed in tracking their preys may be compromised by rapidly changing environmental conditions.

Changing environmental conditions can influence marine mammal reproductive success and fitness by altering prey availability. Breeding in many marine mammal species may be timed to coincide with maximum abundance of suitable prey, either for the lactating mother or the calf at weaning, so that any changes in the environmental conditions which determine prey abundance may cause a mismatch in synchrony between predator and prey, either in time or location (Learmonth et al. 2006b). Migratory species that travel long distances between feeding and breeding areas may be particularly vulnerable to mismatching. Pecl and Jackson (2008) predicted changing environmental conditions will likely result in squid that hatch out smaller and earlier, undergo faster growth over shorter life-spans, and mature younger at a smaller size. This could have negative consequences for species such as sperm whales, whose diet can be dominated by cephalopods. Reduced prey availability has been suggested to explain lower rates of conception in female sperm whales (Whitehead 1997).

Briscoe et al. (2025) integrated three decades of satellite tracking data from juvenile North Pacific loggerhead sea turtles with observations of sea surface temperature and chlorophyll-a concentrations to examine higher trophic level response to changing environmental conditions within the eastern bounds of the North Pacific Transition Zone (NPTZ), defined as the region between 30–45° N, 180–140°W. Between 1997–2024, the NPTZ warmed by 1.6°C and experienced an approximately 19% decline in mean surface chlorophyll-a concentration, a proxy for reduced productivity (Briscoe et al. 2025). Over the same period, the average latitude of loggerhead sea turtle foraging habitat in the NPTZ shifted northwards by 450–600 km. In most years both the southern and northern range limits for the loggerhead turtle have shifted northward in tandem, indicating a habitat range shift rather than a range expansion (Briscoe et al. 2025).

4.3.4 Invasive Species and Pathogens

The potential for invasive species to spread increases under the influence of changing environmental conditions. As water temperatures warm, native species ranges can shift poleward, opening ecological niches that could be occupied by more invasive and exotic species, that can be introduced via ships ballast water or through other sources (Ruiz et al. 1999; Philippart et al. 2011). Invasive species that are better adapted to warmer water temperatures can outcompete native species that are physiologically geared towards lower water temperatures (Lockwood and Somero 2011). Shifts in environmental conditions and host ranges can result in the spread of novel pathogens to new areas (Simmonds and Eliott. 2009). For example, research suggests increases in sea surface temperature can increases harmful algal blooms (Simmonds and Eliott. 2009). Moore et al. (2011) estimated that the impacts of a dinoflagellate establishment would likely intensify with a warming climate, resulting in roughly 13 more days of potential bloom conditions per year by the end of the 21st century. Acevedo-Whitehouse and Duffus (2009) proposed that the rapidity of environmental changes can harm immune system functions and reproductive parameters in wildlife to the detriment of population health and viability.

4.3.5 Summary

Changing environmental conditions can impact species abundance, geographic distribution, migration patterns, and susceptibility to disease and contaminants, as well as the timing of seasonal activities and community composition and structure (MacLeod et al. 2005a; Robinson et al. 2005a; Kintisch 2006b; Learmonth et al. 2006a; McMahon and Hays 2006a; Evans and Bjørge 2013; IPCC 2014; Lonhart et al. 2019; Sanford et al. 2019; Santos et al. 2024). Increasing atmospheric temperatures have already contributed to documented changes in the quality of freshwater, coastal and marine ecosystems and to the decline of endangered and threatened species populations (Mantua et al. 1997; Karl 2009). Changing environmental conditions are expected to have the most pronounced effects on vulnerable species whose populations are already in tenuous positions (Williams et al. 2008). Many of the ESA-listed species and habitats considered in this Opinion have likely already been impacted by the threat of changing environmental conditions through the pathways described above. We expect the risk of extinction for many ESA-listed species to increase in the future due to continued changing environmental conditions.

5 ENVIRONMENTAL BASELINE

The *environmental baseline* refers to the condition of the listed species, without the consequences to the listed species caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process. The impacts to listed species or designated critical habitat from Federal agency activities or existing Federal agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 CFR §402.02).

5.1.1 Oceanic Temperature Regimes

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

During 2014–2016, a record-breaking marine heat wave occurred in the North Pacific, which resulted in an unprecedented multi-year warming event. This warm water region was located along the west coast of North America and spread as far south as the Baja California Peninsula, which is north of the action area but supports important foraging for many species in this Opinion. Water temperatures were as much as 4°C higher than normal at depths from 0–300 m. This warm water region was accompanied by a strong El Niño event from 2015–2016.

The heatwave pushed some prey species, like anchovies, closer to shore (Santora et al. 2020). This subsequently shifted whale distribution and increased whale foraging in nearshore waters where there is more overlap with commercial and recreational fixed-gear fisheries. At the same time, there was a change in fishing effort in central California due to a harmful algal bloom at the start of the Dungeness crab fishery season (Santora et al. 2020; Saez et al. 2021). Findings by Santora et al. (2020) suggest that changes in humpback whale distribution and movements (shifts from onshore to offshore feeding), triggered by changes in prey type and availability caused by the marine heatwave, resulted in an increased vulnerability of humpbacks to fishing gear entanglement. Feist et al. (2021) found that a delayed Dungeness crab fishery opening in California due to a harmful algal bloom in spring of 2016 led to about five to seven times average levels of fishing activity, which was consistent with a high rate of large whale entanglement that year. Ingman et al. (2021) found that humpback and blue whales migrations towards feeding areas has been occurring earlier in recent years without concomitant earlier departure time, resulting in longer periods when blue and humpback whales are at risk of entanglement in pot and trap fishery gear (Ingman et al. 2021). More information on large whale entanglements in fishing gear can be found below in Marine Mammals, Section 5.1.4.1, under Fishery Interactions.

Studies suggest that periods of what was once considered "anomalous" warm water conditions are occurring more frequently. The current rate of increase in oceanic and atmospheric heat content has increased the frequency and duration of marine heatwaves, or "prolonged discrete anomalously warm water events" (Hobday et al. 2016); a trend that is expected to continue (Oliver et al. 2018) in conjunction with changes in the strength, direction, and variability of major ocean currents (Hoegh-Guldberg and Bruno 2010). On a global scale, the occurrence probabilities of the duration, intensity, and cumulative intensity of most documented, large, and impactful marine heatwaves have increased more than 20-fold as a result of changing environmental conditions (Laufkötter et al. 2020).

In addition to period variation in weather and climate patterns that affect oceanographic conditions in the action area, longer-term trends in changing environmental conditions also have the potential to alter habitat suitable for ESA-listed species in the action area on a much longer time scale (see Effects of Changing Environmental Conditions on ESA-Listed Species, Section 4.3). Possible effects of this trend in changing and/or variability of environmental conditions for ESA-listed marine species in the action area include the alteration of community composition and structure, changes to migration patterns or community structure, changes to species abundance, increased susceptibility to disease and contaminants, altered timing of breeding and nesting, and increased stress levels (MacLeod et al. 2005b; Robinson et al. 2005b; Kintisch 2006a; Learmonth et al. 2006c; McMahon and Hays 2006b). However, gaps in information and the complexity of environmental interactions complicate the ability to predict the effects of these changes and/or variability may have to these species from year to year in the action area (Kintisch 2006a; Simmonds and Isaac 2007).

5.1.2 Vessel Activity

Vessels have the potential to affect animals through strikes, sound, and disturbance associated with their physical presence. Responses to vessel interactions include interruption of vital behaviors and social groups, separation of mothers and young, and abandonment of resting areas (Mann et al. 2000; Samuels et al. 2000; Boren et al. 2001; Constantine 2001; Nowacek 2001). Whales have been documented to exhibit avoidance behavior near vessels. For example, a blue whale aborted its ascent when it was 57.5 m from the vessel, and stayed underwater for three minutes beyond its projected surfacing time (Szesciorka et al. 2019). There are 13 seaports on the Pacific coast of Mexico, with the second largest—Manzanillo in Colima, in the action area. Manzanillo hosts about 1,000 cargo ships and 11 million tons of cargo annually.[4] There are several cruise ship routes in the region, traveling from Los Angeles and San Diego to Mexican ports on the Baja California peninsula and Puerto Vallarta in Jalisco.

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[4] https://shipnext.com/port/manzanillo-mxzlo-mex. (Accessed 1/14/2026).

5.1.2.1 Vessel Strike

Vessel strikes are considered a serious and widespread threat to air breathing marine vertebrates, including ESA-listed marine mammals (especially large whales) and sea turtles. Generally, the most well documented “marine road” interaction is with large whales (Pirotta et al. 2019). This threat is increasing as commercial shipping lanes cross important breeding and feeding habitats and as whale populations recover and populate new areas or areas where they were previously extirpated (Swingle et al. 1993; Wiley et al. 1995). As vessels continue to become faster and more widespread, an increase in vessel interactions with cetaceans is to be expected. Vessel traffic within the action area can come from both private (e.g., commercial, recreational) and Federal vessel (e.g., military, research), but traffic that is most likely to result in vessel strikes comes from commercial shipping. All sizes and types of vessels can hit whales, but most lethal and severe injuries are caused by vessels 80 m or longer (Laist et al. 2001). For whales, studies show that the probability of fatal injuries from vessel strikes increases as vessels operate at speeds above 26 km/h (14 kt; (Laist et al. 2001). Injury is generally caused by the rotating propeller blades, but blunt injury from direct impact with the hull also occurs. Evidence suggests that not all whales killed because of vessel strike are detected, particularly in offshore waters. Some detected carcasses are never recovered while those that are recovered may be in advanced stages of decomposition that preclude a definitive cause of death determination (Glass et al. 2010). The vast majority of commercial vessel strike mortalities of cetaceans are likely undetected and unreported. Most animals killed by vessel strike likely end up sinking rather than washing up on shore (Cassoff 2011). Kraus et al. (2005) estimated that 17% of vessel strikes are actually detected. Therefore, it is likely that the number of documented cetacean mortalities related to vessel strikes is much lower than the actual number of mortalities associated with vessel strikes, especially for less buoyant species such as blue, humpback, and fin whales (Rockwood et al. 2017).

There is vessel traffic in the area broadly, but the specific area where the survey will take place is not within common, high-use routes for commercial shipping Womersley et al. 2022. However, the region in and around the action area is regarded as suffering from a lack of reporting of large whale vessel strikes as a result of independent review of external sources (e.g., newspapers, online media reports, etc.) finding multiple additional reports of large whale vessel strikes than those that were reported to the International Whaling Commission’s Ship Strike Database (Ransome et al. 2021). In about half of the reported vessel strikes, the large whale died (47.5%) or sustained life-threatening injuries (5%), while in a smaller percentage (7.5%) of the cases the whale was expected to survive. In the remaining 40% of cases, the fate of the whale was unknown. In most cases, the species of whale was not identified. In half of the reported vessel strikes, the type of vessel was not known, with small vessels (less than 15 m) making up 27.5% of the known vessels involved in whale strikes. The reported small vessel types involved in whale strike incidents included fishing vessels, whale-watch vessels, and sailing vessels (Ransome et al. 2021).

The potential lethal effects of vessel strikes are particularly profound on species with low abundance. However, all whale species have the potential to be affected by vessel strikes. Of 11 species of cetaceans known to be threatened by vessel strikes in the northern hemisphere, fin whales are the mostly commonly struck species, but North Atlantic right, gray, humpback, and sperm whales are also struck (Laist et al. 2001; Vanderlaan and Taggart 2007). In cases where the species was identified, humpback whales are the most frequently reported species involved in vessel strike incidents, with fewer reported instances involving other species (e.g., Bryde's whale, sperm whale, gray whale, and blue whale) throughout the Eastern Tropical Pacific region (Ransome et al. 2021).

Vessel strikes are a poorly studied threat to sea turtles, but have the potential to be highly significant given that they can result in serious injury and mortality (Work et al. 2010b). All sea turtles must surface to breathe and several species are known to bask at the sea surface for long periods. Although sea turtles can move somewhat rapidly, they apparently are not adept at avoiding vessels that are moving at more than 4 km/h (2.6 kt); most vessels move far faster than this in open water (Hazel and Gyuris 2006; Hazel et al. 2007; Work et al. 2010b). Both live and dead sea turtles are often found with deep cuts and fractures indicative of a collision with a vessel hull or propeller (Hazel et al. 2007). Hazel et al. (2007) suggests that green turtles may use auditory clues to react to approaching vessels rather than visual cues, making them more susceptible to strike or vessel speed increases. For green sea turtles at nesting beaches and on foraging grounds in the Galapagos Marine Reserve, researchers found that vessel strike was a significant threat, with about 4.5% (174 individuals) showing evidence of injuries consistent with a vessel strike (Denkinger et al. 2013). Despite being in a fairly remote and sparsely populated marine reserve, vessel strike of green sea turtles still occurred; it is reasonable to assume that in more densely populated area like the action area, with a comparatively higher degree of vessel traffic, vessel strike of sea turtles could potentially be a problem. Although it is reasonable to consider vessel strikes of sea turtles occurring in the action area, data is lacking to evaluate the extent of that threat.

5.1.3 Deep-Sea Mining

Exploration for deep-sea minerals, particularly polymetallic nodules, is expanding in the Clarion-Clipperton Zone (CCZ), which partially overlaps with the action area. Katona et al. (2023) identified that at least 30 species of sharks, rays, and chimaeras inhabit areas earmarked for mining in the CCZ. Of these, 26 species overlap with zones proposed for sulfide mining. While nodule mining occurs on abyssal plains (4,000–6,000 m), the process generates significant sediment plumes. Field trials indicate that while the majority of the benthic plume remains close to the seafloor (highest concentrations at 1 m altitude), fine suspended sediment can travel up to 500 m downslope before redeposition (Gazis et al. 2025). This sedimentation can smother benthic fauna that are not adapted to high particle loads. Furthermore, the discharge of wastewater (used to lift nodules to the surface) back into the mid-water column poses risks of respiratory distress, visual impairment, and metal toxicity to pelagic species (Judah et al. 2025). The eastern North Pacific Ocean, spans approximately six million km² stretching between Hawaii and Central America (Lodge et al. 2014). Bounded by the Clarion fracture zone to the north and the Clipperton fracture zone to the south, the CCZ reaches to depths of 4,000-5,500 meters (Wedding et al. 2015). In this zone, there are deep seamounts and abyssal hills, and polymetallic nodules containing manganese, nickel, cobalt, and copper, which are metals critical for the development of batteries, and permanent magnets used in wind energy turbines and electric vehicle motors.

Interest in extracting these metals from the CCZ has grown over the last two decades, including recent interest from the U.S. The International Seabed Authority (ISA) implemented a system of Regional Environmental Management Plans. This framework includes a spatial management network of nine "Areas of Particular Environmental Interest" (APEIs)—zones where mining is prohibited (Wedding et al. 2015). These APEIs were designated based on ecological principles and the distribution of key community drivers, such as seafloor organic matter flux and nodule density. The ISA requires mining contractors to establish rigorous ecological baselines within their exploration license areas. As a result, there has been recent scientific inquiry focused on generating faunal habitat associations (Amon et al. 2017; Simon-Lledó et al. 2019a; Simon-Lledó et al. 2019b; Simon-Lledó et al. 2019; Simon-Lledó et al. 2020; Rakka et al. 2025) and evaluating species connectivity across the vast abyssal plain (Kersten et al. 2017; Taboada et al. 2018; Bribiesca-Contreras et al. 2021; Drazen et al. 2021). Recent data from 2024–2025 mining collector tests (e.g., the SMARTEX expedition) quantified these impacts, revealing a 37% decline in faunal density and a 32% loss of species diversity within mining tracks, with effects extending into adjacent un-mined areas due to sediment plume dispersal (Stewart et al. 2025). New data from 2024 identifies previously unknown ecosystems within the subseafloor crust that are directly vulnerable to mining excavation, fundamentally expanding the known 'impact zone' of extraction activities beyond the surface sediment layer (Bright et al. 2024).

As this is an emerging development in the region, we are not certain of the effects deep-sea mining may have on ESA-listed species, or the faunal habitat or prey they rely on. Given the recent increase in interest in deep-sea mining in the proposed action area, we consider it is reasonable to expect that there can be effects from activities associated with deep-sea mining could occur for ESA-listed species in the action area. We currently have a limited understanding of the effects from deep-sea mining to ESA-listed species, including in the action area. With such an emphasis on gathering ecological baseline data prior to mining, we would expect that any effects would become more apparent in the future, although data is largely currently lacking.

5.1.4 Fishery Interactions

Fisheries constitute an important and widespread use of ocean resources throughout the action area. Fisheries can adversely affect fish populations, other species, and habitats. Non-target species are captured in fisheries (i.e., bycatch) and can represent a significant threat to non-target populations. Direct effects of fisheries interactions on marine mammals and sea turtles include entanglement and entrapment, which can lead to fitness consequences or mortality because of injury or drowning. Indirect effects include reduced prey availability, including overfishing of targeted species, and destruction of habitat.

5.1.4.1 Marine Mammals

Entrapment and entanglement in fishing gear is a frequently documented source of human-caused mortality in cetaceans (see Dietrich et al. 2007). An extensive analysis of global risks to marine mammals, identified incidental catch as the most common threat category (Avila 2018). For some marine mammal populations, the impacts from fisheries likely have significant demographic effects (Read et al. 2006). Many marine mammals that die from entanglement in commercial fishing gear tend to sink rather than strand ashore, thus making it difficult to fully assess the magnitude of this threat. When not immediately fatal, entanglement or ingestion of fishing gear can impede the ability of marine mammals to feed and can cause injuries that eventually lead to infection and death (Wells et al. 2008; Cassoff et al. 2011; Moore and Van der Hoop 2012). Other sublethal effects of entanglement include increased vulnerability to additional threats, such as predation and ship strikes, by restricting agility and swimming speed. There are also costs likely to be associated with nonlethal entanglements in terms of energy and stress (Moore and Van der Hoop 2012).

There is a lack of information regarding large whale entanglement specific to the action area and the Eastern Tropical Pacific Ocean more broadly. Fisheries interactions are regarded as a prominent threat to large whales throughout the Mexican Pacific (Reeves et al. 2013; Arellano-Peralta and Medrano-González 2015), with gillnets identified as particular threat in terms of gear type. With numerous small-scale fisheries present in the action area (Colima, Jalisco, and Michoacán), many of them using gillnets in nearshore waters (Gomez-Vanega et al. 2021), we can reasonably assume that there is a risk to large whales from fisheries entanglement. Shark fisheries in the Mexican Pacific, which use long-lines and gillnets further offshore, have reported record landings in recent years (Sosa-Nishizaki et al. 2020); the presence of these fisheries within the range of large whales poses a risk of entanglement offshore.

In addition to direct impacts like entanglement, marine mammals may also be subject to indirect impacts from fisheries. Fisheries can have a profound influence on fish populations. In a study of retrospective data, Jackson et al. (2001) concluded that ecological extinction caused by overfishing precedes all other pervasive human disturbance of coastal ecosystems, including pollution and changing environmental conditions. Marine mammals probably consume at least as much fish as is harvested by humans (Kenney et al. 1985). Many cetacean species (particularly fin and humpback whales) are known to feed on species of fish that are harvested by humans (Carretta et al. 2016). Thus, competition with humans for prey is a potential concern. Reductions in fish populations, whether natural or human-caused, may affect the survival and recovery of ESA-listed marine mammal populations. Even species that do not directly compete with human fisheries could be indirectly affected by fishing activities through changes in ecosystem dynamics. However, in general the effects of fisheries on marine mammals through changes in prey abundance remain unknown in the action area.

5.1.4.2 Sea Turtles

Sea turtle bycatch occurs in both large-scale commercial fishing operations as well as small-scale and artisanal fisheries throughout the action area. Sea turtle bycatch rates (i.e., individuals captured per unit of fishing effort) and mortality rates (i.e., individuals killed per number captured) can vary widely both within and across particular fisheries due to a combination of factors. These include gear types and gear configurations, fishing methods (e.g., depth fished, soak times), fishing locations, fishing seasons, time fished (i.e., day versus night), and turtle handling and release techniques used (Wallace et al. 2010a; Lewison et al. 2013). Wallace et al. (2010b) estimated that worldwide, 447,000 sea turtles are killed each year from bycatch in commercial fisheries. If mortality is not directly observed during gear retrieval, it may occur after the turtle is released due to physiological stress and injury suffered during capture. Recent studies indicate that underwater entrapment in fishing gear (i.e., trawls and gillnets) followed by rapid decompression when gear is brought to the surface may cause gas bubble formation within the blood stream (i.e., embolism) and tissues leading to organ injury, impairment, and even post-release mortality in some bycaught turtles (Garcia-Parraga et al. 2014; Fahlman et al. 2017). Fishery interaction remains a major factor in sea turtle recovery.

Lewison et al. (2014) used the bycatch data from 1990–2008 to identify global hotspots of turtle bycatch intensity. High-intensity sea turtle bycatch was most prevalent in three regions: the eastern Pacific Ocean, southwest Atlantic Ocean, and Mediterranean Sea. Lewison et al. (2014) found relatively high bycatch of sea turtles during longlining operations off the Pacific coast of Mexico from 1990–2008. There are sea turtle bycatch reduction efforts that have been undertaken in Mexico, but mortality still occurs (Wang et al. 2010; Trejo and Diaz 2012; Bojórquez-Tapia et al. 2017).

Leatherback turtles in the eastern Pacific Ocean from beaches in Costa Rica and Mexico migrate thousands of kilometers and overlap on feeding grounds in the U.S. West Pacific with leatherbacks originating from Indonesia and Papua New Guinea. This migration puts leatherback turtles in proximity of numerous fisheries, especially longlines. Spotila (2000) reported a conservative estimate of annual leatherback fishery-related mortality (from longlines, trawls and gillnets) in the Pacific Ocean during the 1990s of 1,500 animals. He estimated that this represented about a 23% mortality rate (or 33% if most mortality was focused on the East Pacific population).

5.1.5 Pollution

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

5.1.5.1 Marine Debris

Marine debris has become a widespread threat for a wide range of marine species that are increasingly exposed to it on a global scale. Marine debris is an ecological threat that is introduced into the marine environment through ocean dumping, littering, and hydrologic or wind transport of these materials from land-based sources (Gallo et al. 2018). Marine debris has been discovered to be accumulating in gyres throughout the oceans. Plastic debris is the most abundant worldwide, accounting for more than 80% of all marine debris (Poeta et al. 2017) and an estimated four to twelve million metric tons of plastic enter the oceans annually (Jambeck et al. 2015). Despite debris removal and outreach to heighten public awareness, marine debris in the environment has not been reduced (NRC 2008) and continues to accumulate in the ocean and along shorelines within the action area.

The most common impacts of marine debris are associated with ingestion or entanglement. Both types of interactions can result in injury or death of many different marine species taxa. Ingestion occurs when debris items are intentionally or accidentally eaten (e.g. through predation on already contaminated organisms or by filter feeding activity, in the case of large filter feeding marine organisms, such as whales) and enter in the digestive tract. Ingested debris can damage digestive systems and plastic ingestion can also facilitate the transfer of lipophilic chemicals (especially persistent organic pollutants) into the animal’s bodies. Entanglement is fishing gear also represents a major, ongoing threat to many marine species. Globally, 6.4 million tons of fishing gear is lost in the oceans every year (Wilcox et al. 2015). Drifting “ghost gear” in the ocean can fish unattended for decades (ghost fishing), killing, injuring or impairing large numbers of marine animals through entanglement.

Marine debris is a significant concern for ESA-listed species. The initial developmental stages of all turtle species are spent in the open sea. During this time both juvenile turtles and their buoyant food are drawn by advection into fronts (convergences, rips, and driftlines). The same process accumulates large volumes of marine debris, such as plastics and lost fishing gear, in ocean gyres (Carr 1987). It is thought that sea turtles eat plastic because it closely resembles jellyfish, a common natural prey item (Schuyler 2014). Ingestion of plastic debris can block the digestive tract which can cause turtle mortality as well as sublethal effects including dietary dilution, reduced fitness, and absorption of toxic compounds (Lutcavage et al. 1997; Laist et al. 1999). Santos et al. (2015) found that a surprisingly small amount of plastic debris was sufficient to block the digestive tract and cause death. They reported that 10.7% of green turtles in Brazilian waters were killed by plastic ingestion, while 39.4% had ingested enough plastic to have killed them. These results suggest that debris ingestion is a potentially important source of turtle mortality, one that may be masked by other causes of death. Gulko and Eckert (2003) estimated that between one-third and one-half of all sea turtles ingest plastic at some point in their lives. One study found plastic in 37% of dead leatherback turtles and determined that 9% of those deaths were a direct result of plastic ingestion (Mrosovsky et al. 2009). Plastic ingestion is very common in leatherback turtles and can block gastrointestinal tracts leading to death (Mrosovsky et al. 2009).

Schuyler et al. (2016) synthesized the factors influencing debris ingestion by turtles into a global risk model, taking into account the area where turtles are likely to live, their life history stage, the distribution of debris, the time scale, and the distance from stranding location. They found that up to 52% of sea turtles globally have ingested plastic debris and oceanic life stage turtles are at the highest risk of debris ingestion. Based on their model, olive ridley turtles are the most at-risk species; green, loggerhead, and leatherback turtles were also found to be at a high and increasing risk from plastic ingestion (Schuyler et al. 2016). This study also found the North Pacific gyre to be a regional hotspot for sea turtle debris ingestion. The North Pacific Ocean is among the most polluted ocean regions globally, with roughly half of all fish specimens and more than 75% of all sea turtle specimens examined in this region having consumed plastic (Savoca et al. 2022). The North Pacific Subtropical gyre is a clockwise circular pattern of four prevailing ocean currents (North Pacific, California, North Equatorial, and Kuroshio currents) where debris from around the North Pacific Rim gathers and circulates (PISC 2016). In addition to ingestion risks, sea turtles can also become entangled in marine debris such as fishing nets, monofilament line, and fish-aggregating devices (NRC 1990; Lutcavage et al. 1997; Laist et al. 1999). Turtles are particularly vulnerable to ghost nets due to their tendency to use floating objects for shelter and as foraging stations (Kiessling 2003; Dagorn et al. 2013).

Many cases of marine debris ingestion and entanglement have been reported around the world for marine mammals (Poeta et al. 2017). Baulch and Perry (2014) found that the proportion of cetacean species ingesting debris or becoming entangled in debris is increasing. Based on stranding data, they found that recorded rates of ingestion have increased by a factor of 1.9 and rates of entanglement have increased by a factor of 6.5 over the last 40 years (1970–2010). Ingestion of marine debris can also have fatal consequences for large whales. Over half of cetacean species (including blue, fin, humpback, sei, and sperm whales) are known to ingest marine debris (mostly plastic), with up to 31% of individuals in some populations containing marine debris in their guts and being the cause of death for up to 22% of individuals found stranded on shorelines (Baulch and Perry 2014).

Data on marine debris across the action area is largely lacking; therefore, it is difficult to draw conclusions as to the extent of the problem and its impacts on populations of ESA-listed species in the Eastern Tropical Pacific Ocean. We consider it is reasonable to expect that similar effects from marine debris documented within the North Pacific and adjacent regions could also be occurring to ESA-listed species in the action area.

5.1.5.2 Pollutants and Contaminants

Exposure to pollution and contaminants have the potential to cause adverse health effects in marine species. Marine ecosystems receive pollutants from a variety of local, regional, and international sources, and their levels and sources are therefore difficult to identify and monitor

(Grant and Ross 2002). Marine pollutants come from multiple municipal, industrial, and household as well as from atmospheric transport (Iwata 1993; Grant and Ross 2002; Garrett 2004; Hartwell 2004). Contaminants may be introduced by rivers, coastal runoff, wind, ocean dumping, dumping of raw sewage by boats and various industrial activities, including offshore oil and gas or mineral exploitation (Grant and Ross 2002; Garrett 2004; Hartwell 2004).

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

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

In sea turtles, a variety of heavy metals (e.g., arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver and zinc) have been found in tissues in levels that increase with sea turtle size (Godley et al. 1999; Saeki et al. 2000; Anan et al. 2001; Fujihara et al. 2003; Gardner et al. 2006; Storelli et al. 2008; Barbieri 2009; Garcia-Fernandez et al. 2009). Cadmium has been found in leatherback turtles at the highest concentration compared to any other marine vertebrate (Gordon et al. 1998; Caurant et al. 1999). Newly emerged hatchlings have higher concentrations than are present when laid, suggesting that metals may be accumulated during incubation from surrounding sands (Sahoo et al. 1996). Although trace metals like lead and mercury have been detected in sea turtle hatchlings and eggs in the Eastern Pacific, the concentrations are not a level that would be considered problematic, with no evidence of impacts to clutch success (Páez-Osuna et al. 2010; Páez-Osuna et al. 2011; Roe et al. 2011).

Sea turtle tissues have been found to contain organochlorines and many other persistent organic pollutants. Polychlorinated biphenyl (better known as PCB, found in engine coolants) concentrations in sea turtles are reportedly equivalent to those in some marine mammals, with liver and adipose levels of at least one congener being exceptionally high (PCB 209: 500-530 ng/g wet weight; Davenport 1990; Oros 2009). PCBs have been found in leatherback turtles at concentrations lower than expected to cause acute toxic effects, but might cause sublethal effects on hatchlings (Stewart 2011). Further study has shown that polybrominated diphenyl ethers (i.e., the brominated flame retardants described above) in leatherback eggs show a negative correlation to hatching success (De Andrés et al. 2016).

Pollutants and contaminants are both ubiquitous and persistent in the environment, marine mammals and sea turtles will continue to be exposed. We currently have a limited understanding of the effects from contaminants to ESA-listed species, including in the action area, but it is possible that the effects could be sublethal and long-term in nature, and include impacting reproduction, immune function, and endocrine activity. These are effects that would become more apparent as time goes on.

5.1.6 Aquatic Nuisance Species

Aquatic nuisance species are organisms, introduced into new habitats throughout the world that produce harmful impacts on aquatic ecosystems and native species.[5] They are also referred to as invasive, alien, or non-indigenous species. The introduction of non-native species is considered one of primary threats to at-risk species (Anttila et al. 1998; Wilcove and Chen 1998; Pimentel et al. 2004; Dueñas et al. 2018; Noss et al. 2020; Costante 2021). Invasive species consistently rank as one of the top threats to the world's oceans (Raaymakers and R. Hilliard 2002; Raaymakers 2003; Terdalkar et al. 2005; Pughiuc 2010; Hughes et al. 2020; Occhipinti-Ambrogi 2021; Salimi et al. 2021).

A variety of vectors are thought to have introduced non-native species including, but not limited to aquarium and pet trades, recreation, hull fouling, and ballast water discharges from ocean-going vessels. Common impacts of invasive species are alteration of habitat and nutrient availability, as well as altering species composition and diversity within an ecosystem (Strayer 2010). Introduction of these species is cited as a major threat to biodiversity, second only to habitat loss (Wilcove et al. 1998). Shifts in the base of food webs, a common result of the introduction of invasive species, can fundamentally alter predator-prey dynamics up and across food chains (Moncheva and Kamburska 2002), potentially affecting prey availability and habitat suitability for ESA-listed species. Currently, there is little information on the level of aquatic nuisance species and the impacts of these invasive species may have on ESA-listed marine mammals and sea turtles in the action area through the duration of the project. Therefore, we are not able to discern the level of risk and degree of impact to those ESA-listed species for this Opinion.

5.1.7 Fibropapillomatosis in Sea Turtles

Fibropapillomatosis is a neoplastic disease that can negatively impact ESA-listed sea turtle populations. Fibropapillomatosis has long been present in sea turtle populations with the earliest

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[5] http://www.anstaskforce.gov

recorded mention from the late 1800s in the Florida Keys (Hargrove et al. 2016). Fibropapillomatosis has been reported in every species of marine turtle but is of greatest concern in green turtles, the only known species where this disease has reached a panzootic status (Williams Jr et al. 1994). Prevalence rates as high as 45–50% have been reported within some California green turtle populations (Jones et al. 2015; Hargrove et al. 2016). Fibropapillomatosis primarily affects medium-sized immature turtles in coastal foraging pastures. Disease prevalence rose in the 1980s, spreading substantially in both Florida and Hawaii in green sea turtle populations (Work and Balazs 2013; McCorkle 2016).

A herpesvirus (ChHV5) is considered the most likely pathogenic agent of fibropapillomatosis (Jones et al. 2016). The disease is characterized by both internal and external tumorous growths, which can range in size from very small to extremely large. Large tumors can interfere with feeding and essential behaviors, and tumors on the eyes can cause permanent blindness (Foley et al. 2005). Renan de Deus Santos et al. (2017) assessed stress responses (corticosterone, glucose, lactate, and hematocrit) to capture and handling in green sea turtles with different fibropapillomatosis severity levels. Their findings suggest that moderate fibropapillomatosis severity may affect a turtle’s ability to adequately feed themselves (as evidenced by poor body condition), and advanced-stage fibropapillomatosis severity may result in an impaired corticosterone response. Expression of fibropapillomatosis differs across ocean basins and to some degree within basins (Hargrove et al. 2016). In Hawaii, tumors have been reported on the internal organs of green sea turtles and oral tumors are common and often severe (Hargrove et al. 2016).

While fibropapillomatosis can result in reduced individual fitness and survival, documented mortality rates in Hawaii have been low and do not seem to impede population growth in places that are intensively monitored (e.g., Florida and Hawaii) as evidenced by increasing nesting trends (Hargrove et al. 2016). However, fibropapillomatosis cannot be discounted as a potential threat to sea turtle populations (particularly green turtles) as the distribution, prevalence rate, severity, and environmental co-factors associated with the disease have the capacity to change over time (Jones et al. 2015).

Environmental factors likely play a role in the development of fibropapillomatosis. Most sites with a high frequency of fibropapillomatosis tumors are areas with some degree of water quality degradation resulting from altered watersheds (Hargrove et al. 2016). Despite there being a strong positive correlation between the prevalence of fibropapillomatosis in green turtle populations and areas with degraded water quality, it is difficult to identify one specific causal contaminant or a combination of such working synergistically to lead to fibropapillomatosis formation. Results from a study by Yan et al. (2018) suggest that PCBs may play a role in fibropapillomatosis in Hawaiian green turtles.

A review of sea turtle fibropapillomatosis reports in east Pacific from 1990–2024 found East Pacific green turtles, olive ridley, and leatherback turtles, either at feeding or nesting sites of

USA, Central and South America, including several States along Mexico's Pacific coast (Espinoza et al. 2024). They noted a rapid increase of the disease during the last 10 years in northwestern Mexico. We are not aware of the severity of the impact of fibropapillomatosis on sea turtles in the action area but it is another factor degrading the overall health of the sea turtles there.

5.1.8 Anthropogenic Sound

A wide variety of natural and anthropogenic sound sources contribute to ocean soundscape throughout the world's oceans. There is a variable natural component to the ambient noise level as a result of events such as earthquakes, rainfall, waves breaking, and lightning hitting the ocean as well as biological noises such as those from snapping shrimp, other crustaceans, fishes, and the vocalizations of marine mammals (Crawford and Huang 1999; Patek 2002; Hildebrand 2004b). Several studies have shown that anthropogenic sources of noise have increased ambient noise levels in the ocean over the last 50 years (NRC 1994; Richardson et al. 1995e; NRC 2000; NRC 2003b; Jasny et al. 2005; NRC 2005b). Much of this increase is due to increased shipping as ships become more numerous and of larger tonnage (NRC 2003b). Anthropogenic sources of noise in the ocean include vessels (primarily from engines and propellers), geophysical surveys (seismic or high resolution), sonar, industrial (e.g., oil and gas drilling projects), underwater construction, and explosions (Richardson et al. 1995e; Hatch and Wright 2007b).

The ESA-listed species that occur in the action area are exposed to anthropogenic sounds that are recognized as a potential stressor that can harm marine animals and significantly interfere with their normal activities (NRC 2005a). Noise is of particular concern to marine mammals because many species use sound as a primary sense for navigating, finding prey, avoiding predators, and communicating with other individuals. Despite the potential impacts on individual ESA-listed marine mammals and sea turtles, information is not currently available to determine the potential population level effects of cumulative anthropogenic sound sources in the marine environment (MMC 2007). For example, we currently lack empirical data on how sound impacts growth, survival, reproduction, and vital rates, nor do we understand the relative influence of such effects on the population being considered. As a result, the consequences of anthropogenic sound on ESA-listed marine mammals and sea turtles at the population or species scale remain uncertain.

5.1.8.1 Acoustic Geophysical Surveys

Offshore marine geophysical surveys involve the use of acoustic energy sources operated in the water column to probe the seafloor surface and beneath, returning signals that are interpreted for geologic data. There are two major categories of acoustic geophysical surveys: (1) high resolution surveys which is often used for seafloor mapping and (2) deep seismic surveys to profile below the seafloor. Equipment for both types of surveys (e.g., MBES and airguns) have already been described for the proposed action of this Opinion.

In other regions (e.g., Gulf of America, formerly known as the Gulf of Mexico) where frequent seismic activity is associated with oil and gas development, seismic surveys conducted in the action area have been primarily for scientific research. Seismic research in the area has been conducted to better understand how magmatic and hydrothermal plumbing systems beneath the submarine volcanic ridge have changed in order to study volcanic cycles on decadal timescales.

For past scientific research seismic surveys in the action area, NMFS issued MMPA IHAs and ESA ITSs that specify the conditions under which researchers can operate seismic sound sources, such as airguns, including mitigation measures to minimize adverse effects to protected species. Past NSF funded seismic surveys in the region include two high-energy surveys, one in 2025, and one in 2022, both off the Pacific coast of Mexico, and a high-energy survey in 2008 in the Eastern Tropical Pacific that overlaps with the action area. All surveys did not expect harm to any ESA-listed species and take was only anticipated by harassment.

5.1.8.2 Active Sonar

Active sonar emits high-intensity acoustic energy and receives reflected and/or scattered energy. A wide range of sonar systems are in use for both civilian and military applications and some are similar to what is used for geophysical surveys especially for high resolution sea floor mapping. The primary sonar characteristics that vary with application are the frequency band, signal type (pulsed or continuous), rate of repetition, and source level. Sonar systems can be divided into categories, depending on their primary frequency of operation; low frequency for 1 kHz and less, mid frequency for 1–10 kHz; high frequency for 10–100 kHz; and very high frequency for greater than 100 kHz (Hildebrand 2004a). Low frequency systems are designed for long-range detection (Popper et al. 2014a) and may be used in military surveillance systems. Mid-frequency may also be used in the military but also include commercial applications like depth sounders. Commercial sonars are designed for applications like fish finding and depth sounding typically generate sound from mid- to high-frequencies, 3–200 kHz (Hildebrand 2004a). Depth sounders are operated primarily in the nearshore and shallow environments, but fish finders may be operated in deeper waters as well. It is reasonable to assume that fishing in the action area may be using fish finder finders, but we do not know the extent that all of these different systems, military or commercial applications, are being operated in the action area and therefore unable to evaluate how much they are impacting the soundscape.

5.1.8.3 Vessel Sound and Commercial Shipping

Individual vessels produce unique acoustic signatures, although these signatures may change with vessel speed, vessel load, and activities that may be taking place on the vessel. Sound levels are typically higher for the larger and faster vessels. Peak spectral levels for individual commercial vessels are in the frequency band of 10–50 Hz and range from 195 dB re μPa^2-s at 1 m for fast-moving (greater than 20 kt) supertankers to 140 dB re μPa^2-s at 1 m for smaller vessels (NRC 2003b). Sound emitted from large vessels is the principal source of low frequency noise in the ocean and marine mammals are known to react or to be affected by that noise

(Richardson et al. 1995d; Foote et al. 2004; Hildebrand 2005b; Hatch and Wright 2007a; Holt et al. 2008; Melcon et al. 2012; Anderwald et al. 2013; Kerosky et al. 2013; Erbe et al. 2014; Guerra et al. 2014; May-Collado and Quinones-Lebron 2014; Williams et al. 2014). Although large vessels emit predominantly low frequency sound, studies report broadband sound from large cargo vessels above 2 kHz, which may interfere with important biological functions of cetaceans (Holt 2008). At frequencies below 300 Hz, ambient sound levels are elevated by 15–20 dB when exposed to sounds from vessels at a distance (McKenna et al. 2013b).

Much of the increase in sound in the ocean environment over the past several decades is due to increased shipping, as vessels become more numerous and of larger tonnage (NRC 2003b; Hildebrand 2009b; McKenna et al. 2012). Shipping traffic constitutes a major source of low-frequency (5–500 Hz) sound in the ocean (Hildebrand 2004a), particularly in the Northern Hemisphere where the majority of vessel traffic occurs. (Ross 1976) estimated that between 1950 and 1975 shipping had caused a rise in ambient ocean noise levels of 10 dB; based on his estimates, Ross (1976) predicted a continuously increasing trend in ocean ambient noise of 0.55 dB per year. Chapman and Price (2011) recorded low frequency deep ocean ambient noise in the Northeast Pacific Ocean from 1976 to 1986 and reported that the trend of 0.55 dB per year predicted by Ross (1976) persisted until at least around 1980; afterward, the increase per year was significantly less, about 0.2 dB per year.

While commercial shipping contributes a large portion of oceanic anthropogenic noise, other sources of maritime traffic can also impact the marine environment. These include recreational boats, whale-watching boats, research vessels, and fishing vessels.

Vessel noise can result from several sources including propeller cavitation, vibration of machinery, flow noise, structural radiation, and auxiliary sources such as pumps, fans and other mechanical power sources. Kipple and Gabriele (2007) measured sounds emitted from 38 vessels ranging in size from 4.2–293 m at speeds of 18.5 km/h (10 kt) and at a distance of approximately 457.2 m from the hydrophone. Sound levels ranged from a minimum of 157 to a maximum of 182 dB re 1 µPa-m, with sound levels showing an increasing trend with both increasing vessel size and with increasing vessel speed. Vessel sound levels also showed dependence on propulsion type and horsepower. McKenna et al. (2012) measured radiated noise from several types of commercial ships, combining acoustic measurements with ship passage information from Automatic Identification System data. On average, container ships and bulk carriers had the highest estimated broadband source levels (186 dB re 1 μPa^2 between 20–1,000 Hz), despite major differences in size and speed. Differences in the dominant frequency of radiated noise were found to be related to ship type, with bulk carrier noise predominantly near 100 Hz while container ship and tanker noise was predominantly below 40 Hz. The tanker had less acoustic energy in frequencies above 300 Hz, unlike the container and bulk carrier.

As previously mentioned in Section 5.1.2 Vessel Activity, there are thirteen seaports on the Pacific coast of Mexico, with the two largest in Michoacán and Manzanillo near the action area.

Shipping vessels from these ports could transit the action area. In the Clarion Clipperton Zone, which encompasses the action area, noise from shipping vessels was identified as a major low-frequency sound (Niu et al. 2021). Due to the regional vessel activity it is reasonable to assume vessels are contributing to noise in the action area, but we are not able to quantify that contribution to the ambient sound level or evaluate the impact it has to the ESA-listed species there.

5.1.9 Military Activities

Military operations may use vessels and sonar which contribute noise to the ocean, as already discussed. Military exercises may also use explosives which can add considerable amounts of acoustic energy to the ocean. The action area includes international waters that do not encompass any of the U.S. Navy Testing and Training Areas.

Mexico has a Navy and its Pacific Force is headquartered in Manzanillo, Colima. We are not aware of the type or extent of operations conducted by the Mexican Navy (or other countries' Navies that may be conducting activities) in or adjacent the action area, we therefore are not able to evaluate the contribution those operations to ocean noise or to other stressors of ESA-listed marine mammals and sea turtles in the action area.

5.1.10 Scientific Research Activities

Regulations for section 10(a)(1)(A) of the ESA allow issuance of permits authorizing take of certain ESA-listed species for the purposes of scientific research. Prior to the issuance of such a permit, the proposal must be reviewed for compliance with section 7 of the ESA. Scientific research permits issued by NMFS currently authorize studies of ESA-listed species in the Pacific Ocean off Mexico, some of which extend into portions of the action area for the proposed action. Marine mammals and sea turtles have been the subject of field studies for decades. The primary objective of most of these field studies has generally been monitoring populations or gathering data for behavioral and ecological studies. Over time, NMFS has issued dozens of permits on an annual basis for various forms of "take" of marine mammals and sea turtles in the action area from a variety of research activities. There have been numerous research permits issued since 2009 under the provisions of both the MMPA and ESA authorizing scientific research on marine mammals and sea turtles, including for research in the action area.

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

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

5.2 Impact of the Baseline on Endangered Species Act-Listed Species

Collectively, the stressors described above have had, and likely continue to have, lasting impacts on the ESA-listed marine mammals and sea turtles in the action area likely to be adversely affected by the proposed action. Some of these stressors result in mortality or serious injury to individual animals (e.g., vessel strikes, incidental bycatch, entanglement), whereas others result in more indirect (e.g., fishing that impacts prey availability) or nonlethal (e.g., vessel noise) impacts.

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

The best indicator of the aggregate impact of the environmental baseline on ESA-listed resources is the status and trends of those species. As noted in Section 4.2, some of the species considered in this consultation are experiencing increases in population abundance, some are declining, and for others, their status trend remains unknown. Taken together, this indicates that the environmental baseline and measures taken, or not taken, to recover species are affecting species in different ways. The species experiencing increasing population abundances are doing so despite the potential negative impacts of the activities described in the environmental baseline, and their status may be improving due to recovery efforts. While the environmental baseline may slow their recovery, it is not preventing their recovery. For the species that may be declining in abundance, the suite of conditions described in the environmental baseline may be preventing their recovery. However, it is also possible that their populations are at such low levels (e.g., due to historical commercial whaling) that even when the species' primary threats are removed, the species may recovery very slowly or may not be able to achieve recovery. At small population sizes, species may experience phenomena such as demographic stochasticity, inbreeding depression, and Allee effects, among others, that cause their limited population size to become a threat in and of itself. A review of the status and trends of each species is discussed in the Status of the Species for Further Analysis (Section 4.2) of this consultation.

6 ANALYSIS OF EFFECTS

The ESA section 7 regulations (50 CFR §402.02) define *effects of the action* as "all consequences to listed species that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action but that are not part of the action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action." To understand the effects of the action to listed species, we employ a stressor-exposure-response analysis. The stressors resulting from this action were identified in section 2.3 1.1.1 and the stressors analyzed here are sound from operational noise, specifically, the airguns used for the seismic survey. The following analysis is structured to separately assess the exposure of listed species, followed by separate assessments of the responses of listed species to that exposure. To conclude this section, we summarize the combination of exposure and response for each species.

6.1 Exposure

In this section, we consider the exposures to the various stressors that could cause an effect to ESA-listed species that are likely to co-occur with the action's modifications to the environment in space and time, and identify the nature of that co-occurrence. We describe the timing and location of the stressors to identify the populations, life stages, or sexes of each ESA-listed species likely to be exposed. We also describe the duration, frequency, and intensity of stressors to quantify the number of exposures that are reasonably certain to occur. We then determine to which populations those exposed individuals belong.

6.1.1 Airgun Noise and Acoustic Thresholds

Airguns contribute a massive amount of anthropogenic energy to the world's oceans, 3.9×10^{13} Joules cumulatively (Hildebrand 2005a). Most of the airgun energy emitted is in the low-frequency range 10–500 Hz (Hildebrand 2009a), airguns also emit energy up to 150 kHz (Goold and Coates 2006).

Sound from seismic airguns can have one or more of the following effects: temporary or permanent noise-induced hearing loss, non-auditory physical or physiological effects (including injury and mortality), behavioral disturbance, stress, and masking (Richardson et al. 1995d; Gordon et al. 2003; Nowacek et al. 2007; Southall et al. 2007b; Gotz et al. 2009). The degree of effect is strongly related to the signal characteristics, received level, distance from the source, and duration of the sound exposure, as well as the hearing range and behavioral state of the animal. In general, sudden, high level sounds can cause hearing loss, as can longer exposures to lower level sounds.

Threshold shift is the loss of hearing sensitivity at certain frequency ranges (Finneran 2015). It can be permanent (PTS), in which case the loss of hearing sensitivity is not fully recoverable, or temporary (TTS), in which case the animal's hearing threshold would recover over time (Southall et al. 2007b). PTS is an auditory injury, which may vary in degree from minor to significant. Loss of hearing will occur almost exclusively for noise within an animal's hearing range, if the noise threshold is exceeded. Behavioral disturbance may include a variety of effects, including subtle changes in behavior (e.g., minor or brief avoidance of an area or changes in vocalizations), more conspicuous changes in similar behavioral activities, and more sustained and/or potentially severe reactions, such as displacement from or abandonment of high-quality habitat.

In order to analyze underwater noise and the potential for effects to protected species, NMFS has developed acoustic thresholds[6]. To determine which threshold is appropriate, NMFS characterizes sound sources as impulsive or non-impulsive (for hearing threshold shifts) and intermittent or continuous (for behavioral disturbance). Impulsive sound sources produce sounds that are typically transient, brief (less than one second), broadband, and consist of high peak sound pressure with rapid rise time and rapid decay. Seismic airguns are impulsive sounds that occur in repetition, as opposed to a single event (e.g., explosives). Instead of maintaining a sound pressure level that remains above ambient sound during the entire period, like continuous sources, seismic airguns are more of an intermittent sound with a regular (predictable) pattern of bursts.

Since seismic airguns are powerful acoustic sources that can propagate low frequency signals for substantial distances (e.g., Nieukirk et al. 2004), the NSF and L-DEO conducted acoustic modeling to estimate the underwater area that that may be ensonified (area that is filled with sound) at or above acoustic thresholds used by NMFS to understand the potential for behavioral disturbance from impulsive and non-explosive sound sources. NMFS's acoustic thresholds for the onset of behavioral disturbance from impulsive and non-explosive sound sources are as follows (rms received levels):

- For marine mammals: 160 dB re 1 μPa_{rms} (NOAA 2005)
- For sea turtles: 175 dB re 1 μPa_{rms} (Accomando et al. 2025)

These acoustic threshold values are based on observations of behavioral responses from species of marine mammals or sea turtles, respectively.

6.1.2 Species Exposure

In this section, we consider the exposures to the airgun noise that could cause an effect to the ESA-listed marine mammals and sea turtles (see Section 4.2, Status of the Species for Further Analysis) that could co-occur with the action's modifications to the environment in space and time, and identify the nature of that co-occurrence. We describe the timing and location of the airgun noise to identify the populations, life stages, or sexes of the ESA-listed species likely to be exposed. We also describe the duration, frequency, and intensity of the airgun noise to quantify the number of exposures that are reasonably certain to occur. We then determine to which populations those exposed individuals belong.

In general, the exposure estimates presented in the following subsections are determined by considering:

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[6] https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-acoustic-technical-guidance-other-acoustic-tools

1. Acoustic thresholds above which NMFS considers the best available science indicates that protected species will be behaviorally harassed, sustain some level of permanent hearing impairment, or result in some level of injury;
2. The area or volume of water that will be ensonified above these levels in a day and the number of days that is expected to occur; and
3. The density or occurrence of protected species within these ensonified areas.

6.1.2.1 Marine Mammals

The Permits Division analyzed L-DEO's application for an IHA and the acoustic modeling of airgun underwater sound. In conclusion of our review, we accepted the Permits Division's analysis as the best available scientific information for evaluating exposure to ESA-listed marine mammals. Information submitted by NSF and the Permits Division included estimates of exposure to the sounds from the airgun array that will result in take, as defined under the MMPA, for all marine mammal species including those listed under the ESA.

Under the MMPA, take is defined as "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal (16 U.S.C. §1362(13)) and further defined by regulation (50 CFR §216.3) as "to harass, hunt, capture, collect, or kill, or attempt to harass, hunt, capture, collect, or kill any marine mammal." Two levels of harassment are defined under the MMPA (16 U.S.C. §1362(18)) as any act of pursuit, torment, or annoyance which:

- Has the potential to injure a marine mammal or marine mammal stock in the wild (Level A harassment); or
- Has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering (Level B harassment). Under NMFS's regulation, Level B harassment does not include an act that has the potential to injure a marine mammal or marine mammal stock in the wild.

Under the ESA, take is defined as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct" (16 U.S.C. §1532(19)). Harm is defined by regulation (50 CFR §222.102) as "an act which actually kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation which actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including, breeding, spawning, rearing, migrating, feeding, or sheltering." NMFS does not have a regulatory definition of "harass." However, on May 1, 2023, NMFS adopted as final, the previous interim policy guidance on the term "harass," defining it as to "create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to breeding, feeding, or sheltering."

NMFS's ESA "harass" definition does not specifically equate to MMPA Level A or Level B harassment, but shares some similarities with both in the use of the terms "injury/injure" and a focus on a disruption of behavior patterns. Since the ITS and proposed IHA will exempt or authorize take under the ESA and MMPA, respectively, our ESA analysis, which relies on NMFS's guidance on the ESA term harass, could result in different conclusions than those reached by the Permits Division in their MMPA analysis. Given the differences between the MMPA and ESA standards for harassment, there may be circumstances in which an act is considered harassment, and thus take, under the MMPA but not the ESA.

For ESA-listed marine mammal species, consultations that involve the Permits Division's incidental take authorization under the MMPA have historically relied on the MMPA definition of harassment. As a result, MMPA Level B harassment has been used in estimating the number of instances of harassment of ESA-listed marine mammals, whereas estimates of MMPA Level A harassment have been considered instances of harm and/or injury under the ESA depending on the nature of the effects.

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

Ensonified Area

The NSF, L-DEO, and Permits Division estimated the number of ESA-listed marine mammals that may be exposed to received levels greater than or equal to 160 dB re 1 μPa_{rms} for the airgun array associated with the proposed action. The radial distance from the airgun array to the predicted 160 dB re 1 μPa_{rms} isopleth (estimated at 3,526 m for this survey) is used to calculate the area estimated to be ensonified at or above the acoustic threshold for harassment. Based on the area predicted to be ensonified around the airgun array and the representative trackline distances traveled per day, the ensonified area calculated for a single day is 478.1 km^2. The daily ensonified area multiplied by seven survey days and then multiplied by 1.25 to account for the additional 25% contingency tracklines, results in an estimate of 14,557.8 km^2 for the total area expected to be ensonified at or above the acoustic threshold for marine mammal harassment.

Marine Mammal Density and Exposure Estimates

The number of marine mammals that can be exposed to the sound at or above the acoustic threshold for harassment from the airgun array was calculated using the ensonified area and the expected density of animals in the area. The calculation assumes 100% turnover of individuals within the ensonified area on a daily basis, that is, each individual exposed to the seismic survey activities is a unique individual that may exhibit a response.

In developing the NSF's draft environmental analysis and L-DEO's IHA application, they used estimates of marine mammal densities in the action area (Table 3) to calculate the number of animals exposed. We concur those marine mammal densities are the best available estimates for the action area NMFS (2015b).

Table 3. Densities used for calculating exposure of ESA-listed marine mammals

Species	Density (number of animals/km^2)	Source
Humpback Whale	0.00013	NMFS (2015b)
Fin Whale	0.00003	NMFS (2015b)
Sei Whale	0.00005	NMFS (2015b)
Sperm Whale	0.00019	NMFS (2015b)
Blue Whale	0.00008	NMFS (2015b)

There are limited density estimates available for marine mammals in the action area because a systematic survey has not been done in the region recently. The most applicable data has been from a NMFS (2015b) letter of authorization, issued to the NMFS Southwest Fisheries Science Center for research activities in the Eastern Tropical Pacific, which overlapped with the action area in this consultation. The density data used in the exposure estimates for that authorization relied upon survey data in the region from the mid-1980s into the mid-2000s.

An average group size is additional species information that can inform take estimates as it indicates if an animal is expected to occur solitary or multiple in proximity of each other. The total area ensonified by the seismic airgun at or above the 160 dB threshold (14,557.8 km^2) and the marine mammal density estimates for the action area (Table 3) were used along with incorporation of group size for marine mammal species, to create estimates of exposures to sound that could result in harassment from the proposed geophysical survey (Table 4).

For marine mammals where the calculated exposure was zero (i.e., fin whales), or less than the expected group size based on past surveys in the region (i.e., sei, sperm, and blue whales), exposure estimates were rounded up to group sizes based on Oliveira and DeAngelis (2024). This is because based on the available information, these species are expected to be present in the action area and thus exposed to noise from the airguns. By increasing the exposure estimates over the calculated exposure, we account for this likelihood.

Table 4. Estimated exposures of ESA-listed marine mammals to underwater sound above the 160 dB harassment threshold from the seismic airguns

Species	Estimated Exposures
Humpback Whale – Central America DPS	2
Fin Whale	2*
Sei Whale	2*
Sperm Whale	8*
Blue Whale	2*

* [a] Increased to a group size from Oliveira and DeAngelis (2024)

There are no known blue, fin, or sei whale breeding or feeding areas in the action area and they are not considered common in the action area (Wade and Gerrodette 1993). Any fin or sei whales in the action area would likely be migrating through and any exposed individuals could be either sex and vary in age.

Humpback whales are more coastal than other large whale species and more likely to be exposed when an action takes place in more nearshore areas. This high-energy seismic survey is off-shore, in water depths from 2,500-3,200 m. Over-wintering for the Central America DPS is generally January through March and is centered south of the action area, along the Pacific coasts of Central American countries, all the way down to Panama (Rasmussen et al. 2012). Whales considered a part of this DPS have been observed wintering in southern Mexico (Martien et al. 2021). While we expect that humpback whales will be largely closer to shore at the time of the proposed action, there are a handful of records of humpbacks in offshore areas near the action area in March (OBIS 2026). Based on the timing and location of the proposed action, humpback whales from the Central America DPS would be migrating to the over-wintering areas from their summer feeding grounds off the U.S. West Coast. A humpback exposed to the proposed seismic activities could be either sex and vary in age, but any mother calf pairs would be expected to migrate to feeding areas a few months after the proposed action.

Like the baleen whales, sperm whales over-winter at low latitudes but there are no known breeding or calving areas in the action area. Any sperm whale in the action area would likely be migrating through and any exposed individuals could be either sex and vary in age.

6.1.2.2 Sea Turtles

There are five ESA-listed sea turtle species that are likely to be affected by the proposed action: olive ridley, loggerhead, green, leatherback, and hawksbill. The NSF estimated the number of ESA-listed sea turtles that may be exposed to received levels of sound, from the proposed use of the airgun array, greater than or equal to 175 dB re 1 μPa_{rms} which is used to evaluate harassment (see Section 6.1.1 for Acoustic Thresholds). We reviewed and concurred with the estimates considering the best available scientific information and methods are being utilized to evaluate exposure to ESA-listed sea turtles.

Ensonified Area

The radial distance from the airgun array to the predicted 175 dB re 1 µ$\mathrm{Pa_{rms}}$ isopleth (estimated at 763 m for this survey) was used to calculate the area estimated to be ensonified at or above the acoustic threshold for harassment of sea turtles. Based on the area predicted to be ensonified around the airgun array and the representative trackline distances traveled per day, the ensonified area calculated for a single day is 322.3 km^2 for the long transit line (two survey days) and 110.4 km^2 for the racetrack survey portion (18 survey days). The daily ensonified area multiplied by the number of survey days and then multiplied by 1.25 to account for the additional 25% contingency tracklines, results in an estimate of 3,289.2 km^2 for the total area expected to be ensonified at or above the acoustic threshold for sea turtle harassment.

Sea Turtle Density and Exposure Estimates

The number of sea turtles that can be exposed to the sound at or above the acoustic threshold for harassment from the airgun array was calculated using the ensonified area and the best available information on the density of animals in the action area. The calculation assumes 100% turnover of individuals within the ensonified area on a daily basis, that is, each individual exposed to the seismic survey activities is a unique individual that may exhibit a response.

We reviewed available sea turtle densities to determine which densities constituted the best available scientific information for the ESA-listed sea turtle species likely to be adversely affected by the seismic survey.

Overall, there is a lack of sea turtle density and abundance data for the action area so the NSF and L-DEO were not able to estimate exposures for ESA-listed sea turtles that would be affected by the seismic survey (LGL 2025). Available information on ESA-listed sea turtles in the Eastern Tropical Pacific Ocean are generally on the abundance of nesting sea turtles or sea turtles in coastal waters, not near the seismic survey area nor appropriate to extrapolate to the offshore action area. We do know that these sea turtle species are present in the seismic survey area, and that there is a likelihood of exposure to the proposed seismic survey. In the absence of better information, we rely on a surrogate to estimate exposure of East Pacific DPS green, hawksbill, leatherback, North Pacific Ocean DPS loggerhead, and olive ridley turtles, that is, the area within the 175 dB re 1 µPa root mean square (rms) isopleth is where sea turtles are likely to be adversely affected by sound from the airgun array.

The sound source (i.e., airgun array) is in motion during the survey. The R/V *Langseth* moves at approximately 8.3 km/h (4.5 kt) during the survey. For the high-energy survey, the distance to the 175 dB re 1 µPa (rms) criteria is 763 m. Given the average vessel speed, and distance to the 175 dB re 1 µPa (rms), it would take the R/V *Langseth* about 5.5 minutes to move past a stationary point. This means that a sea turtle in the ensonified area could be exposed to the sound from the airgun multiple times. Therefore, the extent of take for sea turtles includes the amount of time the individual is in the 175 dB re 1 μPa (rms) ensonified area.

We are relying on the extent of the ensonified area corresponding to behavioral thresholds as a surrogate to estimate sea turtle exposure. The 175 dB re 1 μPa (rms) exclusion zone represents the distance to which sound at a potentially adverse level for sea turtles will extend from the source. If an ESA-listed sea turtle were within this exclusion zone during operations of the airgun array, it would be exposed to the stressor (i.e., the sound field produced by the airguns).

Because we are relying on the extent of the ensonified area corresponding to behavioral thresholds as a surrogate to estimate sea turtle exposure, we are not able to quantify the number of sea turtles exposed as a percentage of the population. The high-energy survey can potentially expose sea turtles in offshore waters, where we expect sea turtles to be more dispersed compared to nearshore waters.

The exposures will consist of instantaneous moments in which an individual from each species will be exposed to sound fields from seismic survey activities at or above the behavioral disturbance threshold. The overall exposure is likely relatively low compared to the abundance of each sea turtle population that may occur within the seismic survey area. As for the duration of each instance of exposure, we were unable to produce estimates specific to the proposed seismic survey due to the temporal and spatial uncertainty of the research vessel and sea turtles within the seismic survey area. However, all the exposures are expected to be less than a single day due to the movement of the research vessel and animals.

The ESA-listed sea turtles exposed to the proposed seismic survey could be comprised of a variety of life stages and exposed while engaging in different behaviors. Below, we provide a summary on the life stages of ESA-listed sea turtles that may be exposed to sound from the airgun array.

Although we do not have information on sea turtle density specific to the proposed action area, we know that sea turtles are present in the region, and that there is a likelihood of exposure to the proposed seismic activities.

For the East Pacific DPS green turtle, nesting occurs from August to January. Post-nesting movements of tracked adult East Pacific DPS green turtles show individuals moving to nearshore foraging areas anywhere from 5 to more than 1,000 km from the original nesting beach (Blanco et al 2012). Other tracking studies show that post-nesting green turtles undergoing long-distance migrations tend to follow the coastline (Hart et al. 2015). For these reasons, we do not expect posting-nesting females to be exposed to the proposed action. However, given the timing of the proposed action, and the expected emergence of hatchlings from nests, it is possible that depending on ocean currents, East Pacific DPS green turtle hatchlings could be exposed.

Tracks of satellite-tagged post-nesting female leatherbacks leaving Mexican nesting beaches from January to September show individuals moving south, well off-shore of Central and South America. Leatherback sea turtles tagged in central California foraging grounds have been tracked through the equatorial eastern Pacific, overlapping with the action area (NMFS Status Review 2020). Thus, we expect any leatherback sea turtles exposed to the action would be adult or sub-adults of either sex. We think it is unlikely that leatherback hatchlings will be exposed, because eggs laid in January would not hatch until March. The survey area is far enough off-shore that the survey would likely be completed before the hatchlings may reach it.

Olive ridleys also nest in the region but their nesting can happen over a broader period of time and starting earlier in the year, indicating there is a chance that olive ridley hatchlings could be in the action area. Hawksbill sea turtles may nest from middle to late in the year but much farther south, along Central American coasts and down to South America, so their hatchlings are not expected to be in the action area. North Pacific DPS loggerheads hatchlings are also not expected to be in the area since nesting occurs on the other side of the Pacific Ocean in Japan.

6.1.3 Auditory Injury

As previously mentioned, sound from seismic airguns can have effects more than behavioral disturbance, such as auditory injury (AUD INJ) and hearing threshold shifts. NMFS (2024) defines AUD INJ as damage to the inner ear that can result in destruction of tissue, such as the loss of cochlear neuron synapses or auditory neuropathy (Houser 2021; Finneran 2024). AUD INJ may or may not result in a PTS. PTS is subsequently defined as a permanent, irreversible increase in the threshold of audibility at a specified frequency or portion of an individual's hearing range above a previously established reference level (NMFS 2024). These conditions can result from exposure to a single pulse or from the accumulated effects of multiple pulses, in which case each pulse need not be as loud as a single pulse to have the same accumulated effect.

Acoustic threshold criteria used to evaluate the onset of AUD INJ from impulsive sound sources for marine mammal hearing groups in this consultation and for sea turtles is in Table 5. These acoustic thresholds are a dual metric for impulsive sounds, with one threshold based on peak sound pressure level (0-to-peak SPL) that does not include the duration of exposure. The other metric, the cumulative sound exposure level (SEL) criteria incorporates auditory weighting functions based upon a species group’s hearing sensitivity over the exposed frequency range and duration of exposure. The metric that results in a largest distance from the sound source (i.e., produces the largest field of exposure) is used in estimating total range to potential exposure and effect.

Table 5. Acoustic thresholds identifying the onset of Auditory Injury (AUD INJ) for marine mammals (NMFS 2024) and sea turtles (Accomando et al. 2025) exposed to impulsive sounds

Hearing Group	AUD INJ Onset (Received level)
Low-Frequency (LF) Cetaceans (Baleen Whales)	$L_{\mathrm{pk,flat:}}$ 222 dB $L_{\mathrm{E,LF,24h:}}$ 183 dB
High-Frequency (HF) Cetaceans (Sperm Whales)	$L_{\mathrm{pk,flat}}$: 230 dB $L_{\mathrm{E,MF,24h}}$: 193 dB
Sea Turtles	$L_{\mathrm{pk,flat}}$: 230 dB $L_{\mathrm{E,MF,24h}}$: 185 dB

$L_{\mathrm{pk,flat}}$=peak Sound Pressure Level (SPL)

LE, X, 24 Hour=Frequency Sound Exposure Level (SEL) Cumulated over 24 Hour
Note: Dual metric acoustic thresholds for impulsive sounds (peak and/or $\mathrm{SEL_{cum}}$): Use whichever results in the largest isopleth for calculating AUD INJ onset.

Note: Peak sound pressure (Lpk) has a reference value of 1 µPa, and cumulative sound exposure level (LE) has a reference value of 1 μPa^2s. In this table, thresholds are abbreviated to reflect American National Standards Institute standards (ANSI 2013). However, peak sound pressure is defined by ANSI as incorporating frequency weighting, which is not the intent for this technical guidance. Hence, the subscript "flat" is being included to indicate peak sound pressure should be flat weighted or unweighted within the generalized hearing range. The subscript associated with cumulative sound exposure level thresholds indicates the designated marine mammal auditory weighting function and that the recommended accumulation period is 24 hours. The cumulative sound exposure level thresholds could be exceeded in a multitude of ways (i.e., varying exposure levels and durations, duty cycle). When possible, it is valuable for action proponents to indicate the conditions under which these acoustic thresholds will be exceeded.

We do not anticipate that AUD INJ is a likely outcome for ESA-listed species, given the very small modeled radial distances to the threshold level sound for those species. Using NMFS's dual metric criteria (peak SPL and cumulative SEL), the greatest distance to the AUD INJ threshold was 157.5 m for low-frequency cetaceans (blue, fin, humpback, and sei whales), 13.4 m for high-frequency cetaceans (sperm whale), and 250.2 m for sea turtles.

It is unlikely that a marine mammal or sea turtle would remain close enough to the airgun array or sufficiently long enough to incur AUD INJ from cumulative exposure. The vessel and animals are both moving, the zone of acoustic influence is moving and is therefore minimized in time and space. Marine mammals and (to a lesser degree) sea turtles show some avoidance of the areas where received levels of airgun sound are high enough such that hearing impairment could potentially occur. The planned monitoring and mitigation measures are anticipated to further reduce the probability of ESA-listed species being exposed to sounds strong enough to induce severe effects (e.g., shutdowns, pre-start clearance and ramp-up procedures, vessel strike avoidance measures).

Exposure to seismic airgun sound at or above the thresholds for AUD INJ is not expected to occur and therefore effects from the survey are not anticipated to result in harm to ESA-listed species.

6.2 Response

Given the potential for exposure to stressors associated with the seismic airgun sound from the proposed geophysical survey, in this section, we describe the probable response or range of responses likely to result from that exposure for ESA-listed species. Our assessment considers the potential lethal, sub-lethal (or physiological), or behavioral responses that might reduce the fitness of individuals. Possible responses are considered in following categories:

- Hearing: TTS;
- Auditory interference (masking);
- Behavioral responses; and
- Physiological effects.

Response analyses will consider and weigh evidence of adverse consequences as well as evidence suggesting the absence of such consequences.

The estimated exposures to ESA harassment threshold levels of sound for ESA-listed marine mammals are in Table 4; sea turtles occurring in the ensonified area would be exposed to ESA harassment thresholds of sound (Section 6.1.2.2). Estimations assumed that no marine mammals or sea turtles will move away from the active airguns in response to increasing sound levels because we are not able to quantify the extent ESA-listed species will move away.

6.2.1 Temporary Threshold Shifts

Hearing threshold shifts can occur from exposure to sound from seismic airguns. TTS is the mildest form of hearing impairment that can occur during exposure to sound. TTS is an increase in the threshold of audibility at a specified frequency or portion of an individual's hearing range above a previously established reference level (NMFS 2024) that represents primarily tissue fatigue (Henderson et al. 2008). As opposed to PTS, TTS is temporary and reversible, and animals will recover hearing sensitivity. Therefore TTS is not AUD INJ and is considered harassment, not harm. Acoustic threshold criteria used to evaluate the onset of TTS from impulsive sound sources for marine mammal hearing groups in this consultation and for sea turtles is in Table 6.

Table 6. Acoustic thresholds identifying the onset of Temporary Threshold Shift (TTS) for marine mammals (NMFS 2024) and sea turtles (Accomando et al. 2025) exposed to impulsive sounds

Hearing Group	Temporary Threshold Shift (Received level)
Low-Frequency (LF) Cetaceans (Baleen Whales)	$L_{\text{pk,flat:}}$ 216 dB $L_{\text{E,LF,24h:}}$ 168 dB
High-Frequency (HF) Cetaceans (Sperm Whales)	$L_{\text{pk,flat}}$: 224 dB $L_{\text{E,MF,24h}}$: 178 dB
Sea Turtles	$L_{\text{pk,flat}}$: 224 dB $L_{\text{E,MF,24h}}$: 169 dB

$L_{\text{pk,flat}}$=peak Sound Pressure Level (SPL)

LE, X, 24 Hour=Frequency Sound Exposure Level (SEL) Cumulated over 24 Hour
Note: Dual metric acoustic thresholds for impulsive sounds (peak and/or SEL_{cum}): Use whichever results in the largest (most conservative for the ESA-listed species) isopleth for calculating TTS onset.

Note: Peak sound pressure (Lpk) has a reference value of 1 µPa, and cumulative sound exposure level (LE) has a reference value of 1 $\mu\text{Pa}^2\text{s}$. In this table, thresholds are abbreviated to reflect American National Standards Institute standards (ANSI 2013). However, peak sound pressure is defined by ANSI as incorporating frequency weighting, which is not the intent for this technical guidance. Hence, the subscript "flat" is being included to indicate peak sound pressure should be flat weighted or unweighted within the generalized hearing range. The subscript associated with cumulative sound exposure level thresholds indicates the designated marine mammal auditory weighting function and that the recommended accumulation period is 24 hours. The cumulative sound exposure level thresholds could be exceeded in a multitude of ways (i.e., varying exposure levels and durations, duty cycle). When possible, it is valuable for action proponents to indicate the conditions under which these acoustic thresholds will be exceeded.

As described in Section 6.1.3 above, the acoustic analysis and exposure estimates provided by NSF did not include estimates of exposure below the threshold for the onset of AUD INJ, but above the behavioral threshold that could have potential for TTS. Estimates of harassment exposure from the Permits Division do not distinguish between those individuals that are expected to experience TTS and those that will only exhibit a behavioral response. When TTS exposure information is absent, our effects analysis assumes that TTS could be possible for some portion of the individuals exposed to sound levels at or above the behavioral thresholds.

TTS can occur within closer distances from the source than those at which behavioral harassment is likely. TTS could also occur within a similar distance as harassment for sea turtles due to cumulative exposure during a 24-hour period. TTS of a sufficient degree can manifest as behavioral harassment, as reduced hearing sensitivity and the potential reduced opportunities to detect important signals (conspecific communication, predators, prey) may result in changes in behavior patterns that would not otherwise occur.

It seems unlikely that a marine mammal or sea turtle would remain close enough to the airgun array for sufficiently long enough to incur TTS from cumulative exposure. The vessel and animals are both moving, the overlap of airgun sound and ESA-listed animal occurrence sound will be limited in time and space. The sound from the airguns is expected to be an aversive stimulus, therefore deterring marine mammals and sea turtles from remaining in close proximity for extended durations.

The estimated radial distances to the acoustic thresholds for harassment from this survey are 3,526 m for marine mammals and for sea turtles at 763 m. ESA-listed marine mammal species with only one or just a few individuals estimated to be exposed to harassment (see Table 4) are unlikely to experience TTS. The proposed monitoring and mitigation measures (e.g., shutdowns, pre-start clearance, and ramp-up procedures) are expected to reduce the probability of ESA-listed species being exposed to sounds strong enough to induce TTS.

Olive ridleys are expected to be the most abundant sea turtle in the action area; they are also one of the smaller sea turtle species and therefore harder to see and implement mitigation. If there are ESA-listed animals, such as olive ridleys, exposed to sound levels that could induce TTS, we expect the TTS would be mild, temporary, and animals would recover quickly.

6.2.2 Marine Mammal Response

For species, we discuss responses in terms of physiological, physical, or behavioral effects to the species. These responses may rise to the level of *take* under the ESA. *Take* is defined as “to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct” (16 U.S.C. §1532(19)). We evaluate the probable responses to stressors by relying on the best scientific and commercial data available.

In the following subsections we consider potential responses of ESA-listed marine mammals exposed to the harassment from the seismic airgun sound, including auditory interference (masking), behavioral responses, and physiological effects. We use the best available scientific evidence to help evaluate if these responses will have meaningful consequences to the fitness of the exposed ESA-listed marine mammals.

6.2.2.1 Auditory Interference (Masking)

Interference, or masking, occurs when a sound is a similar frequency and similar to or louder than the sound an animal is trying to hear (Clark et al. 2009; Erbe et al. 2016). Masking can interfere with an individual’s ability to gather acoustic information about its environment, such as predators, prey, conspecifics, and other environmental cues (Richardson 1995). This can result in loss of environmental cues of predatory risk, mating opportunity, or foraging options (Francis and Barber 2013).

There is frequently overlap between airgun array sounds and vocalizations of ESA-listed marine mammals, particularly baleen whales. Low frequency sounds are broad and tend to have relatively constant bandwidth, whereas higher frequency bandwidths are narrower (NMFS 2006c). The proposed seismic survey could mask whale calls at some of the lower frequencies for these species. This could affect communication between individuals, affect their ability to receive information from their environment, or affect sperm whale echolocation (Evans 1998; NMFS 2006c). Any masking that might occur will likely be temporary because acoustic sources from the seismic surveys are not continuous and the research vessel will continue to transit through the area during the survey rather than remaining in a particular location. In addition, the proposed seismic survey activities on the *Langseth* are planned to occur over the course of approximately 24 days, with only seven days of airgun activity planned.

Most of the energy of sperm whale clicks is concentrated at 2–4 kHz and 10–16 kHz and, though the findings by Madsen et al. (2006) suggest frequencies of pulses from airgun arrays can overlap this range, the strongest spectrum levels of airguns are below 200 Hz (up to 188 Hz for proposed airgun array). Given the disparity between sperm whale echolocation and communication-related sounds with the dominant frequencies for seismic surveys, masking is not likely to be significant for sperm whales (NMFS 2006c). The proposed airguns will emit a 0.1-second pulse when fired approximately every 2.4-4.9 seconds. Sperm whale calls last 0.5-1 second, therefore, pulses are not expected to mask the vocalizations of ESA-listed sperm whales to a significant extent (Madsen et al. 2002b).

Overlap of the dominant low frequencies of airgun pulses with low-frequency baleen whale calls may pose a somewhat greater risk of masking. Nieukirk et al. (2012) analyzed 10 years of recordings from the Mid-Atlantic Ridge. When several seismic surveys were recorded simultaneously, whale sounds were masked and the airgun noise became the dominant component of background noise levels. We address the response of ESA-listed marine mammals stopping vocalizations because of airgun sound in the subsequent Behavioral Responses section.

Although sound pulses from airguns begin as short, discrete sounds, they can interact with the marine environment and lengthen through processes such as reverberation. This means that in some cases, such as in shallow water environments, airgun sound can become part of the acoustic background during the seismic survey. Few studies of how impulsive sound in the marine environment deforms from short bursts to lengthened waveforms exist, but can apparently add noticeably to acoustic background (Guerra et al. 2011), potentially interfering with the ability of animals to hear otherwise detectable sounds in their environment.

The sound localization abilities of marine mammals suggest that, if signal and sound come from different directions, masking will not be as severe as some studies may suggest (Richardson 1995). The dominant background noise may be highly directional if it comes from a particular anthropogenic source such as a ship or industrial site. Directional hearing may significantly reduce the masking effects of these sounds by improving the effective signal-to-sound ratio. In the cases of higher frequency hearing by the bottlenose dolphin (*Tursiops truncatus*), beluga whale (*Delphinapterus leucas*), and killer whale, empirical evidence confirms that masking depends strongly on the relative directions of arrival of sound signals and the masking sound (Bain 1993; Bain 1994; Dubrovskiy 2004). Toothed whales and probably other marine mammals as well, have additional capabilities besides directional hearing that can facilitate detection of sounds in the presence of background sound. There is evidence that some toothed whales can shift the dominant frequencies of their echolocation signals from a frequency range with a lot of ambient sound toward frequencies with less noise (Au 1974; Au 1975; Moore 1990; Thomas 1990; Romanenko 1992; Lesage 1999). A few marine mammal species increase the source levels or alter the frequency of their calls in the presence of elevated sound levels (Dahlheim 1987; Au 1993; Lesage 1993; Lesage 1999; Terhune 1999; Foote 2004; Parks 2007; Holt 2009; Parks 2009).

These examples of adaptations for reduced masking pertain mainly to the very high frequency echolocation signals of toothed whales. There is less information about the existence of corresponding mechanisms at moderate or low frequencies or in other types of marine mammals. For example, Zaitseva et al. (1980) found that, for the bottlenose dolphin, the angular separation between a sound source and a masking noise source had little effect on the degree of masking when the sound frequency is 18 kHz, in contrast to the pronounced effect at higher frequencies. Studies have noted directional hearing at frequencies as low as 0.5–2 kHz in several marine mammals, including killer whales (Richardson et al. 1995b). This ability may be useful in reducing masking at these frequencies.

In summary, high levels of sound generated by the proposed seismic survey activities may act to mask the detection of weaker biologically important sounds by some marine mammals considered in this Opinion. This masking is expected to be more prominent for baleen whales given the lower frequencies at which they hear best and produce calls. For toothed whales (e.g., sperm whales), which hear best at frequencies above the predominant ones produced by airguns and may have adaptations to allow them to reduce the effects of masking on higher frequency sounds such as echolocation clicks like other toothed whales mentioned above (e.g., belugas; Au et al. 1985). As such, toothed whales are less likely to experience masking during the time the airgun arrays are producing sound for the proposed actions.

6.2.2.2 Behavioral Responses

We expect the greatest response of marine mammals to airgun array sounds in terms of number of responses and overall impact to be in the form of changes in behavior. ESA-listed individuals may briefly respond to underwater sound by slightly changing their behavior or relocating a short distance, which can equate to harassment, but those responses are unlikely to result in meaningful consequences to the longer term fitness of the individual or at the population level. Displacement from important feeding or breeding areas over a prolonged period would likely be more significant for individuals and could affect the population depending on the extent of the feeding area and duration of displacement. This has been suggested for humpback whales along the Brazilian coast as a result of increased seismic survey activity (Parente et al. 2007).

Marine mammal responses to anthropogenic sound vary by species, state of maturity, prior exposure, current activity, reproductive state, time of day, and other factors (Ellison et al. 2012; Harris et al. 2018). This is reflected in a variety of aquatic, aerial, and terrestrial animal responses to anthropogenic noise that may ultimately have fitness consequences (NRC 2005a; Francis and Barber 2013; New et al. 2014; Costa et al. 2016; Fleishman et al. 2016). Although some studies are available that address responses of ESA-listed marine mammals considered in this Opinion directly, additional studies (such as bowhead and gray whales) are also considered relevant to help determine the responses that may result.

Animals generally respond to anthropogenic perturbations as they will predators, increasing vigilance, and altering habitat selection (Reep et al. 2011). There is increasing support that this prey-predator-like response is true for animals' response to anthropogenic sound (Harris et al. 2018). Habitat abandonment due to anthropogenic noise exposure has been found in terrestrial species (Francis and Barber 2013). Because of the similarities in hearing anatomy of terrestrial and marine mammals, we expect it possible for ESA-listed marine mammals to behave in a similar manner as terrestrial mammals when they detect a sound stimulus. For additional information on the behavioral responses marine mammals exhibit in response to anthropogenic noise, including non-ESA-listed marine mammal species, see the *Federal Register* notice of the proposed IHA (90 Fed. Reg. 19090), as well as several reviews (e.g., Southall et al. 2007c; Gomez et al. 2016).

Several studies have aided in assessing the various levels at which whales may modify or stop their calls in response to sounds from airguns. Whales continue calling while seismic surveys are operating locally (Richardson et al. 1986a; McDonald et al. 1993; McDonald et al. 1995; Greene Jr et al. 1999; Madsen et al. 2002b; Tyack et al. 2003; Nieukirk et al. 2004; Smultea et al. 2004; Jochens et al. 2006a). However, male humpback whales increasingly stopped vocal displays on Angolan breeding grounds as received seismic airgun levels increased (Cerchio 2014). Some blue, fin, and sperm whales stopped calling for short and long periods apparently in response to airguns (Bowles et al. 1994; McDonald et al. 1995; Clark and Gagnon 2006). Fin whales (presumably adult males) engaged in singing in the Mediterranean Sea moved out of an area where seismic survey airguns were operational, and for several days afterward (Castellote et al. 2012a).

Dunn and Hernandez (2009) tracked blue whales during a seismic survey on the R/V *Maurice Ewing* in 2007 and did not observe changes in call rates or find evidence of anomalous behavior that they could directly ascribe to the use of airguns at sound levels of approximately less than 145 dB re 1 μPa_{rms} (Wilcock et al. 2014). Blue whales may attempt to compensate for elevated ambient sound by calling more frequently during seismic surveys (Iorio and Clark 2009).

Bowhead whale calling rates were found to decrease during migration in the Beaufort Sea when seismic surveys were being conducted (Nations et al. 2009). Calling rates decreased when exposed to seismic airguns at estimated received levels of 116–129 dB re 1 μPa_{rms}, but did not change at received levels of 99–108 dB re 1 μPa_{rms} (Blackwell et al. 2013). A more recent study examining cumulative sound exposure found that bowhead whales began to increase call rates as soon as airgun sounds were detectable, but this increase leveled off at approximate 94 dB re 1

μPa^2-s over the course of 10 minutes (Blackwell et al. 2015). Once sound levels exceeded approximately 127 dB re 1 μPa^2-s over 10 minutes, call rates began to decline and at approximately 160 dB re 1 μPa^2-s over 10 minutes, bowhead whales appeared to cease calling all together (Blackwell et al. 2015).

Sperm whales, at least under some conditions, may be particularly sensitive to airgun sounds, as they have been documented to cease calling in association with airguns being fired hundreds of kilometers away (Bowles et al. 1994). Other studies have found no response by sperm whales to received airgun sound levels up to 146 dB re 1 µPa (peak-to-peak; (McCall Howard 1999; Madsen et al. 2002a).

For the species considered in this consultation, some exposed individual ESA-listed marine mammals may cease calling or otherwise alter their vocal behavior in response to the airgun array during the seismic survey activities. The effect is expected to be temporary and of short duration, because the research vessel is constantly moving when the airgun array is active. Animals may resume or modify calling at a short time later or at a location away from the airgun array once the acoustic stressor has diminished during the proposed seismic survey.

Studies of the responses of some baleen whales to airgun arrays have indicated responses to lower-amplitude sounds, but most studies support a threshold of approximately 160 dB re 1 μPa_{rms} (a level used in this Opinion to help evaluate effects for marine mammals) as the received sound level to cause behavioral responses other than vocalization changes (Richardson et al. 1995b). Activity of individuals seems to influence response (Robertson et al. 2013), as feeding individuals respond less than mother and calf pairs and migrating individuals (Malme et al. 1984b; Malme and Miles 1985; Richardson et al. 1995b; Miller et al. 1999; Richardson et al. 1999; Miller et al. 2005; Harris et al. 2007).

Feeding bowhead whales did not avoid vessels or cease feeding while seismic airgun surveys occurred 10–50 km (5.4–27 NM) away, apparently tolerating received sound levels up to 180 dB re 1 μPa_{rms} (Koski et al. 2008). Migrating bowhead whales show strong avoidance reactions to exposures to received sound levels of 120–130 dB re 1 μPa_{rms} at distances of 20–30 km (10.8–16.2 NM), but while feeding only changed dive and respiratory patterns, and then exhibited avoidance when received sound levels were higher (152–178 dB re 1 μPa_{rms}; (Richardson et al. 1986b; Ljungblad et al. 1988; Richardson et al. 1995b; Miller et al. 1999; Richardson et al. 1999; Miller et al. 2005; Harris et al. 2007). Nations et al. (2009) also found that bowhead whales were displaced during migration in the Beaufort Sea during active seismic surveys.

The available data indicate that most, if not all, baleen whale species exhibit avoidance of active seismic airguns (Gordon et al. 2003; Stone and Tasker 2006; Potter et al. 2007; Southall et al. 2007c; Barkaszi et al. 2012; Castellote et al. 2012b; NAS 2017; Stone et al. 2017). Despite the above observations and repeated exposures to seismic surveys, bowhead whales continue to return to summer feeding areas and appear to re-occupy displaced areas within a day (Richardson et al. 1986b). We do not know whether the individuals exposed in these ensonified areas are the same returning or if they tolerate repeat exposures, whether they may still experience a stress response. However, we expect the presence of the PSOs and the shutdown that will occur if a marine mammal were present in the EZ will lower the likelihood that marine mammals will be exposed to significant sound levels from the airgun array.

Gray whales respond similarly to seismic survey sounds as described for bowhead whales. Gray whales discontinued feeding and/or moved away at received sound levels of 163 dB re 1 μPa_{rms} (Malme et al. 1984b; Malme and Miles 1985; Malme et al. 1986; Malme et al. 1987; Würsig et al. 1999; Bain and Williams 2006; Gailey et al. 2007; Johnson et al. 2007a; Meier et al. 2007; Yazvenko et al. 2007). Migrating gray whales began to show changes in swimming patterns at approximately 160 dB re 1 μPa_{rms} and slight behavioral changes at 140–160 re 1 μPa_{rms} (Malme et al. 1984a; Malme and Miles 1985). As with bowhead whales, habitat continues to be used despite frequent seismic survey activity, but long-term effects have not been identified, if they are present at all (Malme et al. 1984a). Johnson et al. (2007b) reported that gray whales exposed to airgun sounds during seismic surveys off Sakhalin Island, Russia, did not experience any biologically significant or population level effects, based on subsequent research in the area from 2002 through 2005. Furthermore, when strict mitigation measures, such as those that will be required in the IHA by the Permits Division, are taken to avoid conducting seismic surveys during certain times of the year when most gray whales are expected to be present, gray whales may not exhibit any noticeable behavioral responses to seismic survey activities (Gailey et al. 2016). Given the similar conservation measures that would be implemented for these proposed actions, we expect some of the ESA-listed marine mammal species considered in this consultation will respond in a similar manner as gray whales.

Humpback whales exhibit a pattern of lower threshold responses when not occupied with feeding. Migrating humpbacks altered their travel path (at least locally) along Western Australia at received levels as low as 140 dB re 1 μPa_{rms} when females with calves were present, and showed an avoidance response at 7–12 km (3.8–6.5 NM) from the acoustic source (McCauley et al. 1998; McCauley et al. 2000b). A startle response occurred as low as 112 dB re 1 μPa_{rms}. Closest approaches were generally limited to 3–4 km (1.6–2.2 NM), although some individuals (mainly males) approached to within 100 m on occasion when sound levels were 179 dB re 1 μPa_{rms}. Changes in course and speed generally occurred at estimated received levels of 157–164 dB re 1 μPa_{rms}. Similarly, on the east coast of Australia, migrating humpback whales appear to avoid seismic airguns at distances of 3 km (1.6 NM) at levels of 140 dB re 1 μPa^2-s. A recent study examining the response of migrating humpback whales to a full 3,130 in^3 airgun array found that humpback whales exhibited no abnormal behaviors in response to the active airgun array and, while there were detectible changes in respiration and diving, these were similar to those observed when baseline groups (i.e., not exposed to active sound sources) were joined by another humpback whale (Dunlop et al. 2017). While some humpback whales were also found to reduce their speed and change course along their migratory route, overall these results suggest that the behavioral responses exhibited by humpback whales are unlikely to have significant biological consequences for fitness (Dunlop et al. 2017). Feeding humpback whales appear to be somewhat more tolerant. Humpback whales off the coast of Alaska startled at 150–169 dB re 1 μPa_{rms} and no clear evidence of avoidance was apparent at received levels up to 172 dB re 1 μPa_{rms} (Malme et al. 1984b; Malme et al. 1985). Potter et al. (2007) found that humpback whales on feeding grounds in the Atlantic Ocean did exhibit localized avoidance to airgun arrays. Among humpback whales on Angolan breeding grounds, no clear difference was observed in encounter rate or point of closest approach during seismic versus non-seismic periods (Weir 2008).

Observational data for specific baleen whale life histories (breeding and feeding grounds) in response to airguns are limited. Available data support a general avoidance response. Some fin and sei whale sighting data indicate similar sighting rates during seismic versus non-seismic periods, but sightings tended to be further away and individuals remained underwater longer (Stone 2003; Stone and Tasker 2006; Stone et al. 2017). Other studies have found at least small differences in sighting rates (lower during seismic survey activities), as well as whales being more distant from the seismic vessel during seismic survey activities (Moulton and Miller 2005a). When spotted at the average sighting distance, individuals will have likely been exposed to approximately 169 dB re 1 μPa_{rms} (Moulton and Miller 2005b).

Sperm whale response to airguns has thus far included mild behavioral disturbance such as temporarily disrupted foraging, avoidance, cessation of vocal behavior, or no reaction. Several studies have found sperm whales in the Atlantic Ocean to show little or no response (Davis et al. 2000; Stone 2003; Moulton and Miller 2005a; Madsen et al. 2006; Stone and Tasker 2006; Weir 2008; Miller et al. 2009; Stone et al. 2017). Detailed study of sperm whales in the Gulf of America and Gulf of Mexico suggests some alteration in foraging from less than 130–162 dB re 1 μPa peak-to-peak, although other behavioral reactions were not noted by several authors (Gordon et al. 2004; Gordon et al. 2006; Jochens et al. 2006a; Madsen et al. 2006; Winsor and Mate 2006). This has been contradicted by other studies, which found avoidance reactions by sperm whales in response to seismic activity (Mate et al. 1994; Jochens 2003; Jochens and Biggs 2004).

The intensity and the frequency of the disturbance created by the airgun arrays seems to have bearing on the effects to exposed sperm whales. The persistent, high-level disturbance caused by exposure to underwater noise associated with oil and gas activities in the Gulf of America was predicted to cause significant reductions in fitness, especially for reproductive female sperm whales due to lost foraging opportunities, to the point of starvation (Farmer et al. 2018a). An individual sperm whale's resilience to foraging disturbance depends on its size and daily energetic demands; pregnant and nursing sperm whales are thus most vulnerable (Farmer et al. 2018b). The amount of time between disturbances to foraging behavior matters because sperm whales need time to replenish lost reserves. Thus, intermittent disturbances to foraging behavior are less impactful than continuous disruption.

Miller et al. (2009) found sperm whales to be generally unresponsive to airgun exposure in the Gulf of America, although foraging behavior may have been affected based on changes in echolocation rate and slight changes in dive behavior. Displacement from the area was not observed. Winsor et al. (2017) found no evidence to suggest sperm whales avoid active airguns within distances of 50 km (27 NM). The lack of response by this species may in part be due to its higher range of hearing sensitivity and the low-frequency (generally less than 200 Hz) pulses produced by seismic airguns (Richardson et al. 1995b). However, sperm whales are exposed to considerable energy above 500 Hz during the course of seismic surveys (Goold and Fish 1998), so even though this species generally hears at higher frequencies, this does not mean that it cannot hear airgun sounds. Breitzke et al. (2008) found that source levels were approximately 30 dB re 1 µPa lower at 1 kHz and 60 dB re 1 µPa lower at 80 kHz compared to dominant frequencies during a seismic source calibration. Another odontocete, bottlenose dolphins, progressively reduced their vocalizations as an airgun array came closer and got louder (Woude 2013). Reactions of sperm whales to impulse noise likely vary depending on the activity at the time of exposure. For example, in the presence of abundant food or during breeding encounters, toothed whales sometimes are extremely tolerant of noise pulses (NMFS 2010b).

6.2.2.3 Physiological Effects

Individual marine mammals exposed to airguns (as well as other sound sources) could experience effects not readily observable such as stress (Romano et al. 2002) that may have adverse effects. Other possible responses to impulsive sound sources like airgun arrays include neurological effects, bubble formation, resonance effects, and other types of organ or tissue damage (Cox et al. 2006; Southall et al. 2007c; Zimmer and Tyack 2007; Tal et al. 2015), but similar to stress, these effects are not readily observable. Those more severe physical and physiological responses have been associated with explosives and/or mid-frequency tactical sonar, but not with seismic airguns. There have been no reported stranding events after NSF surveys. We do not expect ESA-listed marine mammals to experience any of these more severe physical and physiological responses as a result of exposure to the proposed seismic survey activities.

Stress is an adaptive response and does not normally place an animal at risk. Distress involves a stress response resulting in a biological consequence to the individual. The mammalian stress response involves the hypothalamic-pituitary-adrenal axis being stimulated by a stressor, causing a cascade of physiological responses, such as the release of the stress hormones cortisol, adrenaline (epinephrine), glucocorticosteroids, and others (Thomson and Geraci 1986; St. Aubin and Geraci 1988; St. Aubin et al. 1996; Gulland et al. 1999; Gregory and Schmid 2001; Busch and Hayward 2009). These hormones subsequently can cause short-term weight loss, the liberation of glucose into the blood stream, impairment of the immune and nervous systems, elevated heart rate, body temperature, blood pressure, and alertness, and other responses (Thomson and Geraci 1986; Kaufman and Kaufman 1994; Dierauf and Gulland 2001; Cattet et al. 2003; Elftman et al. 2007; Fonfara et al. 2007; Noda et al. 2007; Mancia et al. 2008; Busch and Hayward 2009; Dickens et al. 2010; Costantini et al. 2011). In some species, stress can also increase an individual's susceptibility to gastrointestinal parasitism (Greer et al. 2005). In highly stressful circumstances, or in species prone to strong "fight-or-flight" responses, more extreme consequences can result, including muscle damage and death (Cowan and Curry 1998; Cowan and Curry 2002; Herraez et al. 2007; Cowan 2008). The most widely-recognized indicator of vertebrate stress, cortisol, normally takes hours to days to return to baseline levels following a significantly stressful event, but other hormones of the hypothalamic-pituitary-adrenal axis may persist for weeks (Dierauf and Gulland 2001). Stress levels can vary by age, sex, season, and health status (St. Aubin et al. 1996; Gardiner and Hall 1997; Hunt et al. 2006; Keay et al. 2006; Romero et al. 2008). For example, stress is lower in immature North Atlantic right whales than adults and mammals with poor diets or undergoing dietary change tend to have higher fecal cortisol levels (Hunt et al. 2006; Keay et al. 2006).

Loud sounds generally increase stress indicators in mammals (Kight and Swaddle 2011). Romano et al. (2004) found beluga whales and bottlenose dolphins exposed to a seismic water gun (up to 228 dB re 1 μPa-m peak-to-peak) and single pure tones (up to 201 dB re 1 μPa) had increases in stress chemicals, including catecholamines, which could affect an individual's ability to fight off disease. During the time following September 11, 2001, shipping traffic and associated ocean noise decreased along the northeastern U.S. This decrease in ocean sound was associated with a significant decline in fecal stress hormones in North Atlantic right whales, providing evidence that chronic exposure to increased noise levels, although not acutely injurious, can produce stress (Rolland et al. 2012). These levels returned to baseline after 24 hours of traffic resuming.

As whales use hearing for communication and as a primary way to gather information about their environment, we assume that limiting these abilities, as is the case when masking occurs, will be stressful. We also assume that any individuals exposed to sound levels sufficient to trigger the onset of TTS will also experience some physiological stress response (NRC 2003a; NMFS 2006b). Finally, we assume that some individuals exposed at sound levels below those required to induce a TTS, but above the 160 dB re 1 μPa_{rms} threshold, may experience a stress response, which could be associated with an overt behavioral response. However, exposure to sounds from airgun arrays (or fisheries echosounder) are expected to be temporary so we expect any such stress responses to be short-term. Given the available data, animals will be expected to return to baseline state (e.g., baseline cortisol level) within hours to days, with the duration of the stress response depending on the severity of the exposure (i.e., we expect exposure resulting in some level of TTS will result in a longer duration response before returning to a baseline state as compared to exposure at lower sound levels).

Data specific to cetaceans are not readily available to assess other non-auditory physical and physiological responses to sound. However, based on studies of other vertebrates, exposure to loud sound may also adversely affect reproductive and metabolic physiology (reviewed in Kight and Swaddle 2011). Premature birth and indicators of developmental instability (possibly due to disruptions in calcium regulation) have been found in embryonic and neonatal rats exposed to loud sound. Studies of rats have shown that their small intestine leaks additional cellular fluid during loud sound exposure, potentially exposing individuals to a higher risk of infection (reflected by increases in regional immune response in experimental animals). In addition, exposure to 12 hours of loud sound may alter cardiac tissue in rats. In a variety of response categories, including behavioral and physiological responses, female animals appear to be more sensitive or respond more strongly than males. It is noteworthy that, although various exposures to loud sound appear to have adverse results, exposure to music largely appears to result in beneficial effects in diverse taxa. Clearly, the impacts of even loud sound are complex and not universally negative (Kight and Swaddle 2011). Given the available data, and the short duration of exposure to sounds generated by airgun arrays, we do not anticipate any effects to reproductive and metabolic physiology of ESA-listed marine mammals exposed to these sounds.

It is possible that an animal's prior exposure to sounds from seismic surveys will influence its future response. We have little information available to us as to what response individuals will have to future exposures to sources from seismic surveys compared to prior experience. If prior exposure produces a learned response, then this subsequent learned response will likely be similar to or less than prior responses to other stressors where the individual experienced a stress response associated with the novel stimuli and responded behaviorally as a consequence (such as moving away and reduced time budget for other activities like feeding that would otherwise be undertaken; (Andre 1997; André 1997; Gordon et al. 2006). Seismic survey activities can potentially lead to cetaceans habituating to sounds from airgun arrays, which may lead to additional energetic costs or reductions in foraging success (Nowacek et al. 2015). We do not believe sensitization will occur based upon the lack of severe responses previously observed in marine mammals exposed to sounds from seismic surveys, including those conducted by NSF in or near the action area. The proposed action will take place over approximately seven days of seismic activity, minimizing the likelihood that sensitization will occur. As stated before, we believe that exposed individuals will move away from the sound source, especially in the open ocean of the action area, where we expect species to be transiting.

6.2.2.4 Marine Mammal Strandings

There is some concern regarding the coincidence of marine mammal strandings and proximal seismic surveys. No conclusive evidence exists to causally link stranding events to seismic surveys. Suggestions that there was a link between seismic surveys and strandings of humpback whales in Brazil (Engel et al. 2004) were not well-founded (Iagc 2004; IWC 2007a). In September 2002, two goose-beaked whales stranded in the Gulf of California, Mexico. The R/V *Maurice Ewing* had been operating a 20-airgun array (8,490 in^3), 22 km (11.9 NM) offshore at the time that stranding occurred. The link between the stranding and the seismic surveys was inconclusive and not based on any physical evidence, as the individuals who happened upon the stranding were ill-equipped to perform an adequate necropsy (Taylor et al. 2004). Furthermore, the small numbers of animals involved and the lack of knowledge regarding the spatial and temporal correlation between the beaked whales and the sound source underlies the uncertainty regarding the linkage between sound sources from seismic surveys and beaked whale strandings (Cox et al. 2006). Numerous studies suggest that the physiology, behavior, habitat relationships, age, or condition of cetaceans may cause them to strand or might predispose them to strand when exposed to another phenomenon. These suggestions are consistent with the conclusions of numerous other studies that have demonstrated that combinations of dissimilar stressors commonly combine to kill an animal or dramatically reduce its fitness, even though one exposure without the other does not produce the same result (Fair and Becker 2000; Moberg 2000; Kerby et al. 2004; Romano et al. 2004; Creel 2005). At present, the factors from seismic survey airgun arrays that may contribute to marine mammal strandings are unknown and we have no evidence to lead us to believe that aspects of the airgun array proposed for use will cause marine mammal strandings.

The seismic survey will take place in the Eastern Tropical Pacific Ocean, and the closest approach to any coastline will be approximately 500 km (310.7 mi) from land (Clipperton Island). If exposed to seismic survey activities, we expect ESA-listed marine mammals will have sufficient space in the open ocean to move away from the sound source and will not be likely to experience exposure to the sound source to the point that animals would strand.

6.2.3 Sea Turtle Response

In the following subsections we consider potential responses of sea turtles exposed to the harassment from the seismic airgun sound, including behavioral responses and physiological effects. We use the best available scientific evidence to help evaluate if these responses will have meaningful consequences to the fitness of the exposed ESA-listed sea turtles.

We do not expect stranding response from sea turtles and there are no known documented instances of sea turtles stranding in association with anthropogenic sound. Interference that creates a masking effect is also not expected for sea turtles because they are not known to rely heavily on acoustics for life functions (Popper et al. 2014b; Nelms et al. 2016).

6.2.3.1 Behavioral Responses

There is limited information on how sea turtles will respond, but similar to ESA-listed marine mammals, it is likely that sea turtles will exhibit behavioral responses in the form of avoidance. There are some investigations of sea turtle responses to human activity for green and loggerhead (O'Hara and Wilcox 1990; McCauley et al. 2000a); leatherback, loggerhead, olive ridley, and 160 unidentified (hardshell species) sea turtles (Weir 2007). The work by O’Hara and Wilcox (1990) and McCauley et al. (2000a) reported behavioral changes of sea turtles in response to seismic airgun arrays. These studies provide a basis for our 175 dB re 1 μPa_{rms} threshold for determining when sea turtles could experience behavioral effects due to sound exposure, because at and above this level loggerhead turtles were observed to exhibit avoidance behavior, increased swimming speed, and erratic behavior. Loggerhead turtles have also been observed to move towards the surface upon exposure to an airgun (Lenhardt et al. 1983; Lenhardt 1994). In contrast, loggerhead turtles resting at the ocean surface were observed to startle and dive as an active seismic source approached them, with the responses decreasing with increasing distance from the source (Deruiter and Larbi Doukara 2012). Some of these animals may have reacted to the vessel's presence rather than the sound source (Deruiter and Larbi Doukara 2012). Monitoring reports from seismic surveys show that some sea turtles move away from approaching airgun arrays, although other sea turtles approach active airgun arrays within 10 m with minor behavioral responses (Holst et al. 2005c; Smultea et al. 2005; Holst et al. 2006; NMFS 2006c; NMFS 2006a; Holst and Smultea 2008a).

Observational evidence suggests that sea turtles are not as sensitive to sound as are marine mammals and behavioral changes are only expected when sound levels rise above received sound levels of 175 dB re 1 μPa_{rms}. If exposed at such sound levels, based on the available data, we anticipate some change in swimming patterns. Some sea turtles may approach the active airgun array, but we expect them to eventually turn away in order to avoid the active airgun array. The proposed action will consist of approximately seven days of seismic airgun activity, minimizing the likelihood of long-term behavioral changes by sea turtles. As such, we expect temporary displacement of exposed individuals from some portions of the action area while the *Langseth* transits through because of behavioral responses to sound sources.

6.2.3.2 Physiological Effects

There is a lack of evidence of seismic sound causing stress in sea turtles. However, animals often respond to anthropogenic stressors in a manner that resembles a predator-prey response (Harrington and Veitch 1992; Lima 1998; Gill et al. 2001; Frid and Dill 2002; Frid 2003; Beale and Monaghan 2004; Romero 2004; Harris et al. 2018). As predators generally induce a stress response in their prey (Lopez 2001; Dwyer 2004; Mateo 2007), we assume that sea turtles may experience a stress response if exposed to loud sounds from airgun arrays. We expect that breeding adult females may experience a lower stress response, as female green, hawksbill, and loggerhead turtles appear to have a physiological mechanism to reduce or eliminate hormonal responses to stress (predator attack, high temperature, and capture) to maintain reproductive capacity at least during their breeding season; a mechanism not shared with males (Jessop et al. 2000; Jessop 2001; Jessop et al. 2004). Individuals may experience a stress response at levels lower than approximately 175 dB re 1 μPa_{rms}, but data are lacking to evaluate this possibility. Therefore, we follow the best available evidence identifying a behavioral response as the point at which we also expect some level of stress response.

6.2.4 Prey Species

Seismic surveys could have indirect, adverse effects on ESA-listed marine mammals, and sea turtles by affecting their prey (including larval stages) through lethal or sublethal damage, stress responses, or alterations in their behavior or distribution. Prey items of the ESA-listed marine mammals and sea turtles, such as fishes, cephalopods, and various zooplankton, could be impacted. A review by Carroll et al. (2017) summarized the available information on the impacts seismic surveys have on fishes and invertebrates. In many cases, species-specific information on the prey of ESA-listed marine mammals and sea turtles is not available. Until more specific information becomes available, we expect that the prey of ESA-listed marine mammals and sea turtles will respond to sound associated with the proposed action in a similar manner to those fishes and invertebrates described below (information derived from Carroll et al. (2017) unless otherwise noted).

Like with marine mammals and sea turtles, it is possible that seismic surveys can cause physical and physiological responses, including direct mortality, in fishes and invertebrates. In fishes, such responses appear to be highly variable, and depend on the nature of the exposure to seismic survey activities, as well as the species in question. Current data indicate that possible physical and physiological responses include hearing threshold shifts, barotraumatic ruptures, stress responses, organ damage, and/or mortality. For invertebrates, research is more limited, but the available data suggest that exposure to seismic survey activities can result in anatomical damage and mortality in some cases. In crustaceans and bivalves, there are mixed results with some studies suggesting that seismic surveys do not result in meaningful physiological and/or physical effects, while others indicate such effects may be possible under certain circumstances. Furthermore, even within studies there are sometimes differing results depending on what aspect of physiology one examines (e.g., Fitzgibbon et al. 2017). In some cases, the discrepancies likely relate to differences in the contexts of the studies. For example, in a relatively uncontrolled field study, Parry et al. (2002) did not find significant differences in mortality between oysters that were exposed to a full seismic airgun array and those that were not, but another study by Day et al. (2017) in a more controlled setting did find significant differences in mortality between scallops exposed to a single airgun and a control group that received no exposure. However, the increased mortality documented by Day et al. (2017) was not significantly different from the expected natural mortality. All available data on echinoderms suggests they exhibit no physical or physiological response to exposure to seismic survey activities. Based on the available data, we assume that some fishes and invertebrates that serve as prey for ESA-listed marine mammals and sea turtles may experience physical and physiological effects, including mortality, but in most cases, such effects are only expected at relatively close distances to the sound source.

There has been research that suggests seismic airgun arrays may lead to a significant reduction in zooplankton, including copepods. McCauley et al. (2017) found that the use of a single airgun (approximately 150 in^3) led to a decrease in zooplankton abundance by over 50% and a two- to three-fold increase in dead adult and larval zooplankton when compared to control scenarios. In addition, effects were found out to 1.2 km (0.6 NM); the maximum distance to which sonar equipment used in the study was able to detect changes in abundance. McCauley et al. (2017) noted that for seismic activities to have a significant impact on zooplankton at an ecological scale, the spatial or temporal scale of the seismic activity must be large in comparison to the ecosystem in question. In particular, 3-D seismic surveys, which involve the use of multiple overlapping tracklines to extensively and intensively survey a particular area, are of concern (McCauley et al. 2017). This is in part because, in order for such activities to have a measurable effect, they need to outweigh the naturally fast turnover rate of zooplankton (McCauley et al. 2017). The proposed action takes place over a broad spatial area, with the tracklines spaced far apart and will last for only seven days, meaning that we do not believe that the spatial or temporal scale of the seismic survey is large in relation to the marine environment Eastern Tropical Pacific Ocean.

However, Fields et al. (2019) has demonstrated different results through a series of control experiments using seismic blasts from two airguns (260 in^3) during 2009 and 2010 on the zooplankton *Calanus finmarchicus*. Their data show that seismic blasts have limited effects on the mortality of *C. finmarchicus* within 10 m of the seismic airguns, but there was no measurable impact at greater distances. The study also found significantly higher immediate mortality at distances greater than 5 m from the airgun and a higher cumulative mortality (seven days after exposure) at a distance between 10–20 m from the airgun, and observed nor sublethal effects, but did see changes in gene expression (Fields et al. 2019). Furthermore, Fields et al. (2019) demonstrated that shots from seismic airguns had no effect on the escape response of *C. finmarchicus*. They conclude that the effects of shots from seismic airguns are much less than reported by McCauley et al. (2017).

Given the results from each of these studies, it is difficult to fully assess the exact impact seismic airgun arrays may have on the instantaneous or long-term survivability of zooplankton/krill that are exposed. The airgun array volume proposed in this consultation versus the aforementioned studies (90 in^3 versus 150 or 260 in^3) suggests that any copepod or other zooplankton directly exposed to the proposed seismic survey array (underneath or within 5 m) would be exposed to less energy and likely suffer less mortality than described by either of those studies.

Seismic surveys are less likely to have significant effects over a broad area on zooplankton because of their fast growth and high turnover rate. (see Richardson et al. 2017 for simulations based on the results of McCauley et al. 2017 that suggest ocean circulation greatly reduce the impact of seismic surveys on zooplankton at the population level). While the proposed seismic survey may temporarily alter copepod or krill abundance in the action area, we expect such effects to be temporary because of the design of the survey (i.e., survey lines will not be repeatedly shot in a given area as in the lawnmower pattern described in Richardson et al. 2017), the high turnover rate of zooplankton, and ocean circulation that will minimize any effects.

Some evidence has been found for mortality in fishes with a swim bladder resulting from exposure to airguns in close-range exposure to high amplitudes (Falk and Lawrence 1973; Kostyuchenko 1973; Holliday et al. 1987; La Bella et al. 1996; D'Amelio 1999; McCauley et al. 2000b; McCauley et al. 2000c; Bjarti 2002; Hassel et al. 2003; McCauley et al. 2003; Popper et al. 2005). Lethal effects, if any, are expected within a few meters of the airgun array (Dalen and Knutsen 1986; Buchanan et al. 2004).

There are reports showing sublethal effects to some fish species from airgun arrays. Several species at various life stages have been exposed to high-intensity sound sources (220–242 dB re 1 µPa) at close distances, with some cases of injury (Booman et al. 1996; McCauley et al. 2003). Low-intensity (less than 120 dB re 1 µPa) noise may also have effects to larval and embryonic fishes as well. Fry in tanks exposed to high water pump noise (118 dB re 1 µPa) suffered greater mortality than did fry in quieter control tanks (103 dB re 1 µPa; (Banner and Hyatt 1973). The hearing ability of juvenile snapper held in aquaculture tanks was impaired (10 dB reduction) after two weeks of exposure to sound levels of 120 dB re 1 µPa (Caiger et al. 2012). Effects from TTS were not found in whitefish at received levels of approximately 175 dB re 1 µPa^2-s, but pike did show 10–15 dB of hearing loss with recovery within one day (Popper et al. 2005). Caged pink snapper (*Pelates spp.*) have experienced PTS when exposed over 600 times to received sound levels of 165–209 dB re 1 µPa peak-to-peak. Exposure to airguns at close range were found to produce balance issues in exposed fry (Dalen and Knutsen 1986). Exposure of monkfish (*Lophius* spp.) and capelin (*Mallotus villosus*) eggs at close range to airguns did not produce differences in mortality compared to control groups (Payne 2009). Salmonid swim bladders were reportedly damaged by received sound levels of approximately 230 dB re 1 µPa (Falk and Lawrence 1973).

The prey of ESA-listed marine mammals and sea turtles may also exhibit behavioral responses if exposed to active seismic airgun arrays. Based on the available data, as reviewed by Carroll et al. (2017), considerable variation exists in how fishes behaviorally respond to seismic survey activities, with some studies indicating no response and other noting startle or alarm responses and/or avoidance behavior. However, no effects to foraging or reproduction have been documented. An observed response by fishes to airgun sound is a startle or distributional response, where fish react momentarily by changing orientation or swimming speed, or change their vertical distribution in the water column (Fewtrell 2013a; Davidsen et al. 2019). We expect that, if fish detect the sound and perceive it as a threat or some other signal that induces them to leave the area, they are capable of moving away from the sound source (e.g., airgun array) if it causes them discomfort. We expect fishes will return to the area after the sound passes and be available as prey for marine mammals and sea turtles.

Although received sound levels were not reported, caged *Pelates* spp., pink snapper, and trevally (*Caranx ignobilis*) generally exhibited startle, displacement, and/or grouping responses upon exposure to airguns (Fewtrell 2013a). These responses generally persisted for several minutes, although subsequent exposures of the same individuals did not necessarily elicit a response (Fewtrell 2013a). Startle responses were observed in rockfish at received airgun levels of 200 dB re 1 µPa 0-to-peak and alarm responses at greater than 177 dB re 1 µPa 0-to-peak (Pearson et al. 1992). Fish also tightened schools and shifted their distribution downward. Normal position and behavior resumed 20– 60 minutes after firing of the airgun ceased. A downward shift was also noted by Skalski et al. (1992) at received seismic sounds of 186–191 re 1 µPa 0-to-peak. Caged European sea bass (*Dichentrarchus labrax*) showed elevated stress levels when exposed to airguns, but levels returned to normal after three days (Skalski 1992). These fish also showed a startle response when the seismic survey vessel was as much as 2.5 km (1.3 NM) away; this response increased in severity as the vessel approached and sound levels increased, but returned to normal after about two hours following cessation of airgun activity.

Whiting (*Merlangius merlangus*) exhibited a downward distributional shift upon exposure to 178 dB re 1 µPa 0-to-peak sound from airguns, but habituated to the sound after one hour and returned to normal depth (sound environments of 185–192 dB re 1 µPa) despite airgun activity (Chapman and Hawkins 1969). Whiting may also flee from sounds from airguns (Dalen and Knutsen 1986). Hake (*Merluccius* spp.) may re-distribute downward (La Bella et al. 1996). Lesser sand eels (*Ammodytes tobianus*) exhibited initial startle responses and upward vertical movements before fleeing from the seismic survey area upon approach of a vessel with an active source (Hassel et al. 2003; Hassel et al. 2004).

McCauley et al. (2000; 2000b) found small fish show startle responses at lower levels than larger fish in a variety of fish species and generally observed responses at received sound levels of 156–161 dB re 1 µPa$_{rms}$, but responses tended to decrease over time suggesting habituation. As with previous studies, caged fish showed increases in swimming speeds and downward vertical shifts. Pollock (*Pollachius* spp.) did not respond to sounds from airguns received at 195–218 dB re 1 µPa 0-to-peak, but did exhibit continual startle responses and fled from the acoustic source when visible (Wardle et al. 2001). Blue whiting (*Micromesistius poutassou*) and mesopelagic fishes were found to re-distribute 20–50 m deeper in response to airgun ensonification and a shift away from the seismic survey area was also found (Slotte et al. 2004). Startle responses were infrequently observed from salmonids receiving 142–186 dB re 1 µPa peak-to-peak sound levels from an airgun (Thomsen 2002). Cod (*Gadus* spp.) and haddock (*Melanogrammus aeglefinus*) likely vacate seismic survey areas in response to airgun activity and estimated catchability decreased starting at received sound levels of 160–180 dB re 1 µPa 0-to-peak (Dalen and Knutsen 1986; Løkkeborg 1991; Engås et al. 1993; Løkkeborg and Soldal 1993; Turnpenny et al. 1994; Engås et al. 1996).

Increased swimming activity in response to airgun exposure on fish, as well as reduced foraging activity, is supported by data collected by Lokkeborg et al. (2012). Bass did not appear to vacate during a shallow-water seismic survey with received sound levels of 163–191 dB re 1 µPa 0-to-peak (Turnpenny and Nedwell 1994). Similarly, European sea bass apparently did not leave their inshore habitat during a four- to five-month seismic survey (Pickett et al. 1994). La Bella et al. (1996) found no differences in trawl catch data before and after seismic survey activities and echosurveys of fish occurrence did not reveal differences in pelagic biomass. However, fish kept in cages did show behavioral responses to approaching operating airguns.

Data on the behavioral response of invertebrates suggests that some species may exhibit a startle response, but most studies do not suggest strong behavioral responses. For example, a recent study by Charifi et al. (2017) found that oysters appear to close their valves in response to low frequency sinusoidal sounds. In addition, Day et al. (2017) recently found that when exposed to seismic airgun array sounds, scallops exhibit behavioral responses such as flinching, but none of the observed behavioral responses were considered to be energetically costly.

Squid are important prey, especially for sperm whales but also for sea turtles, and there are some studies of squid responses to operating airguns. Squid exhibited both startle and avoidance responses to airgun exposure at received sound levels of 174 dB re 1 μPa_{rms} by first ejecting ink and then moving rapidly away from the area (McCauley et al. 2000b; McCauley et al. 2000c; Fewtrell 2013b). The authors also noted some movement upward. During ramp-up, squid did not discharge ink but alarm responses occurred when received sound levels reached 156–161 dB re 1 μPa_{rms}. There are some reported observations of lethal effects in squid (*Loligo vulgaris*) at levels of 246– 252 dB after 3-11 minutes (Moriyasu et al. 2004). Guerra et al. (2004) suggested that giant squid mortalities were associated with seismic surveys based upon coincidence of carcasses with the seismic surveys in time and space, as well as pathological information from the carcasses. (André et al. 2011) exposed four cephalopod species (*Loligo vulgaris*, *Sepia officinalis*, *Octopus vulgaris*, and *Ilex coindetii*) to two hours of continuous sound from 50–400 Hz at 157 ± 5 dB re 1 µPa. They reported lesions to the sensory hair cells of the statocysts of the exposed animals that increased in severity with time, suggesting that cephalopods are particularly sensitive to low-frequency sound. The received sound pressure level was 157 ± 5 dB re 1 µPa, with peak levels at 175 dB re 1 µPa.

The overall response of fishes and squids is to exhibit startle responses and undergo vertical and horizontal movements away from the sound field. As with marine mammals and sea turtles, behavioral responses by fishes and invertebrates may also be associated with some level of stress response.

Based on the available data, we anticipate seismic survey activities will result in temporary and minor reduction in availability of prey for ESA-listed species near the active airgun array. This may be due to changes in prey distributions (i.e., due to avoidance) or abundance (i.e., due to mortality) or both. These disruptions are expected to be temporary as prey will re-distribute and re-colonize back into the action area after seismic survey activities have passed or concluded. We do not expect this to have a meaningful impact on ESA-listed marine mammals or sea turtles. ESA-listed marine mammals and sea turtles are not expected to closely approach the airgun array when active, and as such will not be in areas from which prey have been temporarily displaced or otherwise affected, and as highly mobile predators may follow their prey out of the ensonified area.

6.3 Summary of Effects Analysis

In this section, we combine the exposure analysis and response analysis to produce estimates of the amount and type of take caused directly or indirectly by the proposed action. This summary of the anticipated effects of the action considers all consequences caused by the proposed action.

The following subsections state the anticipated effects of the action for each ESA-listed species that will be adversely affected by the proposed geophysical survey.

6.3.1 Marine Mammal Summary

Table 4 estimates the number of each ESA-listed species of marine mammals expected to be exposed to underwater sound from the seismic airguns at or above the 160 dB re 1 μPa$_{\text{rms}}$ harassment threshold for marine mammals. Exposed individuals could be either sex and vary in age. No calves are expected to be in the action area. The number of exposed individuals for each species is small because they are expected to be sparsely distributed through the proposed action area and the density of ESA-listed marine mammals is expected to be low. The survey will take place offshore and the ESA-listed cetaceans are not known to aggregate in the action area. Most individuals are likely to be migrating through and some possibly foraging but the action area is not considered a valuable feeding area.

Severe impacts, such as injury or mortality, are not expected. Sound above the AUD INJ threshold are predicted to be relatively small areas (See Harm, Section 6.1.3) and the required mitigation and monitoring measures will further reduce any probability of adverse responses.

Harassment is expected to occur as behavioral disruptions, with ESA-listed marine mammals likely being deterred from approaching the area ensonified with active airgun sound. Interference created by the airgun sound could result in some masking of ESA-listed marine mammal vocalizations, which is more likely for baleen whales than for the sperm whale. These effects are expected to be temporary as the airguns are a moving sound source in a large offshore area and only proposed to be used for seven days total, with behavior returning to a baseline state shortly after the sound source becomes inactive or leaves the area.

6.3.2 Sea Turtle Summary

As described earlier, we are not able to quantify the amount of sea turtle exposure and are relying on the extent of the ensonified area as a surrogate. We expect East Pacific DPS of green turtles, hawksbill turtles, leatherback turtles, North Pacific Ocean DPS loggerhead turtles, and olive ridley turtles, to be exposed to the airgun array within 175 dB re 1 μPa (rms) ensonified areas during the seismic survey activities and exhibit responses in the form of ESA behavioral harassment or TTS. Exposed individuals could be either sex and vary in age. Sea turtle hatchlings are expected to be in the action area for all species except possibly for North Pacific Ocean loggerhead sea turtles. The number of exposed individuals for each species is small because the density of sea turtles is expected to be low offshore relative to nearshore. Most individuals are likely to be migrating through and some could be foraging but the action area is not known to be a valuable feeding area.

Severe impacts, such as injury or mortality, are not expected. Sound above the AUD INJ threshold are predicted to be relatively small areas (See Harm, Section 6.1.3) and the required mitigation and monitoring measures will further reduce any probability.

Harassment is expected to occur as behavioral disruptions, with sea turtles likely avoiding the area ensonified with active airgun sound. Sea turtles are considered less sensitive to underwater sound than marine mammals and any harassment is expected to be brief as the airguns are a moving sound source in a large offshore area and only proposed to be used for twenty days total, with behavior returning to a baseline state shortly after the sound source becomes inactive or leaves the area.

7 CUMULATIVE EFFECTS

Cumulative effects are defined in regulations as "those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation" (50 CFR §402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7(a)(2) of the ESA.

We assessed the action area of this consultation for any non-Federal activities that are reasonably certain to occur. The past and ongoing impact of existing actions was described in the Environmental Baseline (Section 5).

After reviewing publicly available notices to identify projects that are reasonably certain to occur in the action area, we have identified the following actions to analyze in this section: deep-sea mining in the Clarion Clipperton Zone. While this area is of high interest for mineral extraction, activities must be authorized by the International Seabed Authority. Significant activity related to deep-sea mining are unlikely during the proposed action.

8 INTEGRATION AND SYNTHESIS

This Opinion includes a jeopardy analysis for the ESA-listed threatened and endangered species that are likely to be adversely affected by the action. Section 7(a)(2) of the Act and its implementing regulations require every Federal agency, in consultation with and with the assistance of the Secretary (16 U.S.C. §1532(15)), to insure that any action it authorizes, funds, or carries out, in whole or in part, in the United States or upon the high seas, is not likely to jeopardize the continued existence of any listed species. The jeopardy analysis and destruction or adverse modification analysis, therefore, rely upon the regulatory definitions of *jeopardize the continued existence of* and *destruction or adverse modification*.

Jeopardize the continued existence of means "to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 CFR §402.02). *Recovery*, used in that definition, means "improvement in the status of listed species to the point at which listing is no longer appropriate under the criteria set out in section 4(a)(1) of the Act" (50 CFR §402.02).

The Integration and Synthesis is the final step in our jeopardy and adverse modification analyses. In this section, we add the effects of the action (Section 6) to the environmental baseline (Section

5) and the cumulative effects (Section 7), taking into account the status of the species, critical habitat, and recovery planning (Section 4), to formulate the agency's biological opinion as to whether the NSF and NMFS can insure their proposed actions, is not likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminish the value of designated or proposed critical habitat as a whole for the conservation of the species.

8.1 Jeopardy Analysis

The jeopardy analysis assesses the proposed geophysical survey and IHA's effects on ESA-listed species' survival and recovery. The following sections summarize the relevant information in this Opinion for each individual species considered.

8.1.1 Marine Mammals

Only a very small number of each ESA-listed marine mammal species considered in this Opinion (Table 4) is expected to be exposed to underwater sound from the seismic airguns at or above the marine mammal harassment threshold. Based on the ESA-listed marine mammal population numbers (see Population Dynamics for each LAA species in Section 4.2), the estimated harassment exposures are all less than 1% for each population.

The most likely result of disruptions caused by seismic airgun sound is harassment with behavioral responses that may include avoidance, interruptions in communication or foraging, and some level of stress. The disruptive sound and responses are expected to be temporary as the airguns are a moving sound source in a large offshore area and only proposed to be used for twenty days total, with individuals being able to return to their activities in the action area shortly after the exposure has ended. Substantive behavioral reactions, such as disruption of critical life functions, displacement, or avoidance of important habitat to noise exposure are considered more likely to be significant if they last more than 24 hours, or recur on subsequent days (Southall et al. 2007a). Behavioral reactions are not expected to last more than 24 hours or recur on subsequent days such that an animal's fitness could be impacted. The temporary responses are not expected to alter an individual's growth, survival, or reproductive fitness. Therefore, the action is not expected to have adverse consequences on the viability of the populations those individuals belong to or ability of the species those populations comprise to recover.

8.1.2 Sea Turtles

Individual adult or juvenile sea turtles within the extent of the ensonified area (3,289.2 km^2) are expected to be exposed to underwater sound from the seismic airguns at or above the sea turtle harassment threshold. Based on the sea turtle population numbers and distribution in the region (see Population Dynamics for each LAA species in Section 4.2), the estimated harassment exposures are expected to be a low proportion for each population.

The most likely result of disruptions caused by seismic airgun sound is harassment with behavioral responses that may include avoidance, interruptions in foraging and some level of stress. The disruptive sound and responses are expected to be temporary as the airguns are a moving sound source in a large offshore area and only proposed to be used for twenty days total. The temporary responses are not expected to alter an individual's growth, survival, or reproductive fitness. The fitness of individual sea turtles is not expected to be impacted since sea turtles should be able to return to their activities in the action area shortly after the exposure has ended. Considering the lack of consequence to individual sea turtle fitness, the action is not expected to have adverse consequences on the viability of the populations those individuals belong or ability of the species those populations comprise to recover.

9 CONCLUSION

After reviewing and analyzing the current status of the listed species, the environmental baseline within the action area, the consequences of the proposed geophysical survey and IHA and associated activities, and cumulative effects, it is NMFS's opinion that the proposed actions, are not likely to jeopardize the continued existence of blue whale, fin whale, sei whale, Central America DPS humpback whale, sperm whale, leatherback sea turtle, East Pacific DPS green sea turtle, hawksbill sea turtle, olive ridley sea turtle (Mexico's Pacific Coast Breeding Colonies), and North Pacific Ocean DPS loggerhead sea turtle.

Section 4.1.2 determined the likelihood of exposure was discountable or a response would be insignificant and, therefore, this action may affect, but is not likely to adversely affect giant manta ray, oceanic whitetip shark, and Eastern Pacific DPS scalloped hammerhead shark.

10 INCIDENTAL TAKE STATEMENT

In those cases where the Service concludes that an action (or the implementation of any RPAs) and the resultant incidental take of listed species will not violate section 7(a)(2), and, in the case of marine mammals, where the taking is authorized pursuant to section 101(a)(5) of the Marine Mammal Protection Act of 1972, the Service will provide with the biological opinion a statement concerning incidental take that, among other things, specifies the impact of the incidental take of the affected species, i.e., an incidental take statement.

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. "Incidental take" is defined by regulation as takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or applicant (50 CFR §402.02). Section 7(b)(4) and section 7(o)(2) of the ESA, as well as in regulation at 50 CFR §402.14(i)(6) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of the ITS.

When an action is reasonably certain to result in incidental take of ESA-listed marine mammals, section 7(b)(4) of the ESA requires that such taking be authorized under section 101(a)(5) of the MMPA in order for the Secretary to issue an ITS for ESA-listed marine mammals and that the ITS specify the measures necessary to comply with section 101(a)(5) of the MMPA. As part of the proposed action, the Permits and Conservation Division proposes to issue regulations for the issuance of an IHA. Accordingly, the terms of this ITS and the exemption from Section 9 of the ESA become effective only upon the issuance of the 101(a)(5) authorization.

10.1 Amount or Extent of Take

In this Opinion, NMFS determined that incidental take of ESA-listed blue, fin, sei, sperm and humpback whale (Central America DPS) by harassment, shown in Table 7, is reasonably certain to occur.

Table 7. Take by harassment anticipated for ESA-listed marine mammals from the proposed actions

Species	Individuals Taken by Harassment
Blue Whale	2
Fin Whale	2
Sei Whale	2
Humpback Whale – Central America DPS	2
Sperm Whale	8

We anticipate noise from seismic survey activities is reasonably likely to result in the incidental take of ESA-listed green, hawksbill, leatherback, loggerhead, and olive ridley turtles by harassment.

Where it is not practical to quantify the number of individuals that are expected to be taken by the action, a surrogate (e.g., similarly affected species, habitat, ecological conditions, and sound pressure thresholds) may be used to express the amount or extent of anticipated take if we: 1) describe the causal link between the surrogate and take of the listed species, 2) explain why it is not practical to express the amount or extent of anticipated take or to monitor take-related impacts in terms of individuals of the listed species, and 3) set a clear standard for determining when the level of anticipated take has been exceeded (50 CFR 402. §14(i)(1)(i)). Because there are no reliable estimates of green (North Pacific DPS), hawksbill, leatherback, loggerhead (East Pacific Ocean DPS), and olive ridley sea turtle population densities in the action area, it is not practical to develop numerical estimates of exposure for these species.

NMFS is not able to estimate the number of endangered or threatened sea turtles that might be "taken" by the proposed seismic airgun activities because such estimates are impossible to produce with current levels of knowledge. In other words, numerical values cannot be practically obtained for these species. Although we cannot estimate the amount of take of individual sea turtles, we can estimate the extent of habitat affected by the seismic airgun transmissions, which is used as a proxy for the take of endangered or threatened sea turtles herein. Any anticipated take of endangered or threatened sea turtles that occurs will be in the form of harassment. Mortality and/or PTS is not reasonably expected to occur in sea turtles.

We are relying on the extent of the 175 dB re 1 μPa (rms) ensonified area (3,289.2 km^2). A green, hawksbill, leatherback, loggerhead, or olive ridley sea turtle within the 175 dB re 1 μPa (rms) during airgun array operations will be affected by the stressor, and expected to respond in a manner that constitutes take. The take will last for the duration of the exposure—that is, the amount of time the sea turtle spends in the 175 dB re 1 μPa (rms) ensonified area. Depending on the vessel speed during acquisition, a sea turtle could be exposed for up to five minutes.

10.2 Reasonable and Prudent Measures

"Reasonable and prudent measures" are measures that are necessary or appropriate to minimize the impact of incidental take on the species (50 CFR §402.02). These measures "cannot alter the basic design, location, scope, duration, or timing of the action and may involve only minor changes" (50 CFR §402.14(i)(2)). The conservation measures in Section 2.2 are a part of the proposed action and are not presented in detail again here. NMFS believes the following RPMs are necessary and appropriate:

1. The Permits Division must ensure that the NSF and L-DEO implement a program to avoid/minimize and report the potential effects of seismic survey activities as well as the effectiveness of conservation measures incorporated as part of the IHA and possible renewal for the incidental taking of ESA-listed marine mammals (blue whales, fin whales, sei whales, Central America DPS of humpback whales, and sperm whales) pursuant to section 101(a)(5)(D) of the MMPA. In addition, the NMFS Permits Division must ensure that the provisions of the final IHA and possible renewal are carried out, and to inform us if take is exceeded.
2. The NSF, in coordination with L-DEO, must implement a program to avoid/minimize and report the potential effects of seismic survey activities, as well as the effectiveness of conservation measures for the incidental taking of ESA threatened and endangered sea turtles (East Pacific DPS of greens, hawksbills, leatherbacks, North Pacific Ocean DPS of loggerheads, and Mexico's Pacific Coast Breeding Colonies of olive ridleys).

10.3 Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the ESA, the NSF and the Permits Division must comply (or must ensure that any applicant complies) with the following terms and conditions that implement the reasonable and prudent measures. The NSF and the Permits

Division or any applicant has a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this ITS (16 U.S.C. § 1536(b)(4)(iv) and 50 CFR §402.14(i)(4)).

The following terms and conditions implement the reasonable and prudent measures:

1. A copy of the draft comprehensive report on all seismic survey activities and monitoring results must be provided to the NMFS Endangered Species Division within 90 days of the completion of the high-energy seismic survey, or expiration of the IHA, whichever comes sooner. The report should be sent to nmfs.hq.esa.consultations@noaa.gov, and the subject line of the e-mail should include “NSF East Pacific Rise Seismic Survey Draft Report” and consultation tracking number OPR-2025-02269.
    a. The report must contain the elements required in the IHA for reporting the effects on marine mammals.
    b. For sea turtles, the report must detail the number and type of each species taken, the time and date of each taking, the manner of taking, the effects of the taking (e.g., individual response), description of mitigation that occurred, and any other relevant information pertaining to effects of the action to sea turtles.
2. Any reports of injured or dead ESA-listed species must be provided by the NSF or Permits Division to the chief of the ESA Interagency Cooperation Division immediately (within 24 hours) by e-mail at tanya.dobrzynski@noaa.gov and nmfs.hq.esa.consultations@noaa.gov. The subject line of the e-mail should include “report of injured or dead ESA-listed species” and consultation tracking number OPR-2025-02269.

11 CONSERVATION RECOMMENDATIONS

Conservation recommendations are “suggestions … regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information” (50 CFR §402.02).

The following conservation recommendations should be considered by the NSF and the Permits Division to minimize or avoid effects to threatened and endangered species associated with this action or contribute to the development of information:

1. We recommend that the NSF promote and fund research examining the potential effects of seismic surveys on ESA-listed marine mammal, sea turtle, fish, and marine invertebrate species.
2. We recommend that the NSF and L-DEO develop a more robust propagation model that incorporates environmental variables into estimates of how far sound levels reach from airgun arrays.
3. We recommend that the NSF and L-DEO model potential impacts to ESA-listed species, validate assumptions, through refinements of current models and use of other relevant

models, validate assumptions used in effects analyses, and seek information and high quality data for use in such efforts.

4. We recommend that the NSF and L-DEO conduct a sound source verification in the study area (and future locations) to validate predicted and modeled isopleth distances to ESA harm and harassment thresholds and incorporate the results of that study into buffer and exclusion zones prior to starting seismic survey activities.
5. We recommend that the Permits Division develop a flow chart with decision points for mitigation and monitoring measures to be included in future MMPA incidental take authorizations for seismic surveys.
6. We recommend NSF and L-DEO use as well as NMFS Permits Division require in MMPA incidental take authorizations) pedestal-mounted Big-Eye binoculars (e.g., 25 by 150, 2.7° view angle, individual ocular focus, height control) for optimal visual monitoring by PSOs.
7. We recommend the NSF and L-DEO use (and the Permits Division require in MMPA incidental take authorizations) thermal imaging cameras, in addition to reticled binoculars (Big-Eye and handheld) and the naked eye, for use during daytime and nighttime visual observations and test their effectiveness at detecting ESA-listed species.
8. We recommend the NSF and L-DEO use (and the Permits Division require in MMPA incidental take authorizations) clinometers or geometers, such as those described in Hansen et al. 2020, to accurately measure lateral distances from the research vessel to ESA-listed species for potential implementation of conservation measures (e.g., shutdown procedure) during daytime and nighttime visual observations.
9. We recommend the NSF and L-DEO (and the Permits Division require in MMPA incidental take authorizations) limit the shifts of visual PSOs to no more than two consecutive hours followed by at least a one hour break to prevent fatigue and increase effectiveness at detecting marine mammals and other ESA-listed species.
10. We recommend the NSF and L-DEO use the Marine Mammal Commission's recommended method for estimating the number of cetaceans in the vicinity of seismic surveys based on the number of groups detected for post-seismic survey activities take analysis and use in monitoring reports.
11. We recommend the Permits Division require the monitoring report include estimates of the number and nature of exposures that occurred within estimated harassment and harm zones based on PSO observations and including an estimate of those that were not detected, in consideration of both the characteristics and behaviors of the species of marine mammal that affect detectability as well as the environmental factors that affect detectability.
12. We recommend the NSF, L-DEO, and the Permits Division work to make the data collected as part of the required monitoring and reporting available to the public and scientific community in an easily accessible online database that can be queried to aggregate data across PSO reports. Access to such data, which may include sightings as

well as responses to seismic survey activities, will not only help us understand the biology of ESA-listed species (e.g., their range), it will inform future consultations and incidental take authorizations/permits by providing information on the effectiveness of the conservation measures and the impact of seismic survey activities on ESA-listed species and/or designated critical habitat.

13. We recommend the NSF and Permits Division consider using the potential standards for towed array PAM in the *Towed Array Passive Acoustic Operations for Bioacoustic Applications: ASA/JNCC Workshop summary March 14-18, 2016 Scripps Institution of Oceanography, La Jolla, California, USA* (Thode 2017).
14. We recommend the NSF and L-DEO utilize real-time visual sighting and acoustic detection services such as the WhaleAlert application, another whale alert system for marine mammals, or the Ocean Alert mobile application for marine megafauna (e.g., marine mammals, sea turtles, and sharks). We recognize that the research vessel may not have reliable internet access during operations offshore, but nearshore, where many ESA-listed species can be found, we anticipate internet access may be better. Monitoring such systems will help plan seismic survey activities and transits to avoid locations with recent ESA-listed species sightings, and may also be valuable during other activities to alert others of ESA-listed species within the area, which they can then avoid. For more detailed information on the WhaleAlert application and Ocean Alert mobile application visit the website.
15. We recommend the NSF and L-DEO submit their monitoring data (i.e., visual sightings) by PSOs to the Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations online database so that it can be added to the aggregate marine mammal, seabird, sea turtle, and fish observation data from around the world.
16. We recommend the NSF and SIO coordinate with government agencies (e.g. Bureau of Ocean Energy Management, U.S. Navy), academic institutions, and/or the private sector that may be conducting long-term passive acoustic monitoring and/or tagging studies to potentially determine received sound levels and responses of protected species and their prey from the seismic survey activities in the action area.
17. We recommend the NSF and L-DEO measure ambient noise levels in the seismic survey areas to help better understand the total ensonified area from acoustic sources (e.g., vessel noise, airgun array operations) to determine the extent of the action area in future ESA section 7 consultations.
18. We recommend the vessel operator and other relevant vessel personnel (e.g., crew members) on the *Langseth* take the U.S. Navy's marine species awareness training available online at: https://www.youtube.com/watch?v=KKo3r1yVBBA in order to detect ESA-listed species and relay information to PSOs.

In order for NMFS Office of Protected Resources Interagency Cooperation Division to be kept informed of actions minimizing or avoiding adverse effects on ESA-listed species or their critical habitat, NSF and the Permits Division should notify the Interagency Cooperation Division of any conservation recommendations implemented in the final action. Notice can be provided to nmfs.hq.esa.consultations@noaa.gov with the ECO number for this consultation (from the signature page) in the subject line.

12 REINITIATION OF CONSULTATION

This concludes formal consultation on NSF's proposed marine geophysical survey by the *Langseth* in the Eastern Tropical Pacific Ocean and the Permits Division's related issuance of an IHA for the L-DEO pursuant to section 101(a)(5)(D) of the MMPA.. Consistent with 50 CFR §402.16(a), reinitiation of consultation is required and shall be requested by the Federal agency, where discretionary Federal agency involvement or control over the action has been retained or is authorized by law and:

1. If the amount or extent of incidental taking specified in the ITS is exceeded;
2. If new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not previously considered;
3. If the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the Opinion; or
4. If a new species is listed or critical habitat designated that may be affected by the identified action.

If the amount of tracklines, location of tracklines, number of seismic survey days, acoustic characteristics of the airgun arrays, timing of the high-energy seismic survey, or any other aspect of the proposed action changes in such a way (e.g., increased beyond the 25% contingency, greater estimates of sound propagation, increases in the airgun array sound source levels) that the incidental take of ESA-listed species can be greater than estimated in the ITS of this Opinion, then one or more of the reinitiation triggers above may be met and reinitiation of consultation may be necessary.

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14 APPENDIX A

INCIDENTAL HARASSMENT AUTHORIZATION

The Lamont-Doherty Earth Observatory of Columbia University (L-DEO: the “Holder of the Authorization” or "Holder") is hereby authorized under section 101(a)(5)(D) of the Marine Mammal Protection Act (MMPA; 16 U.S.C. 1371(a)(5)(D)) to incidentally harass marine mammals, under the following conditions:

1. This incidental harassment authorization (IHA) is effective for one year upon written notification from the Holder to NMFS, but not beginning later than one year from the date of issuance or extending beyond two years from the date of issuance.
2. This IHA is valid only for geophysical survey activity of the East Pacific Rise in the Eastern Tropical Pacific Ocean, as specified in L-DEO’s IHA application.
3. General Conditions

(a) A copy of this IHA must be in the possession of L-DEO, the vessel operator, the lead protected species observer (PSO), and any other relevant designees of L-DEO operating under the authority of this IHA.

(b) The species and/or stocks authorized for taking are listed in Table 1. Authorized take, by Level A and Level B harassment only, is limited to the species and numbers listed in Table 1.

(c) The taking by serious injury or death of any of the species listed in Table 1 or any taking of any other species of marine mammal is prohibited and may result in the modification, suspension, or revocation of this IHA. Any taking exceeding the authorized numbers listed in Table 1 is prohibited and may result in the modification, suspension, or revocation of this IHA.

(d) During use of the acoustic source, if any marine mammal species or stock not listed in Table 1 appear within or enter the Level B harassment zone (Table 3) the acoustic source must be shut down.

(e) L-DEO must ensure that relevant vessel personnel and the PSO team participate in a joint onboard briefing led by the vessel operator and lead PSO to ensure that responsibilities, communication procedures, marine mammal monitoring protocols, operational procedures, and IHA requirements are clearly understood.

4. Mitigation Requirements
    a. L-DEO must use independent, dedicated, trained visual and acoustic PSOs, meaning that the PSOs must be employed by a third-party observer provider, must not have tasks other than to conduct observational effort, collect data, and communicate with and instruct relevant vessel crew with regard to the presence of marine mammals and mitigation requirements (including brief alerts regarding maritime hazards), and must have successfully completed an approved PSO training course appropriate for their designated task (visual or acoustic). Individual PSOs may perform acoustic and visual PSO duties (though not at the same time).
    b. At least one visual and two acoustic PSOs must have a minimum of 90 days at-sea experience working in those roles, respectively, during a deep penetration seismic survey, with no more than 18 months elapsed since the conclusion of the at-sea experience.
    c. Visual Observation
        i. During survey operations (e.g., any day on which use of the airgun array is planned to occur and whenever the airgun array is in the water, whether activated or not), a minimum of two PSOs must be on duty and conducting visual observations at all times during daylight hours (i.e., from 30 minutes prior to sunrise through 30 minutes following sunset).
        ii. Visual monitoring of the exclusion and buffer zones must begin no less than 30 minutes prior to ramp-up and must continue until one hour after use of the airgun array ceases or until 30 minutes past sunset.
        iii. iVisual PSOs must coordinate to ensure 360° visual coverage around the vessel from the most appropriate observation posts, and must conduct

    visual observations using binoculars and the naked eye while free from distractions and in a consistent, systematic, and diligent manner.

    iv. Visual PSOs must immediately communicate all observations to the acoustic PSO(s) on duty, including any determination by the PSO regarding species identification, distance, and bearing and the degree of confidence in the determination.
    v. During good conditions (e.g., daylight hours; Beaufort sea state (BSS) 3 or less), visual PSOs must conduct observations when the airgun array is not operating for comparison of sighting rates and behavior with and without use of the airgun array and between acquisition periods, to the maximum extent practicable.
    vi. Visual PSOs may be on watch for a maximum of four consecutive hours followed by a break of at least one hour between watches and may conduct a maximum of 12 hours of observation per 24-hour period. Combined observational duties (visual and acoustic but not at same time) may not exceed 12 hours per 24-hour period for any individual PSO.

d. Acoustic Monitoring
    i. The Holder must use a towed passive acoustic monitoring system (PAM) which must be monitored by, at a minimum, one on-duty acoustic PSO beginning at least 30 minutes prior to ramp-up and at all times during use of the airgun array.
    ii. When both visual and acoustic PSOs are on duty, all detections must be immediately communicated to the remainder of the on-duty PSO team for potential verification of visual observations by the acoustic PSO or of acoustic detections by visual PSOs.
    iii. Acoustic PSOs may be on watch for a maximum of four consecutive hours followed by a break of at least one hour between watches and may conduct a maximum of 12 hours of observation per 24-hour period. Combined observational duties may not exceed 12 hours per 24-hour period for any individual PSO.
    iv. Survey activity may continue for 30 minutes when the PAM system malfunctions or is damaged, while the PAM operator diagnoses the issue. If the diagnosis indicates that the PAM system must be repaired to solve the problem, operations may continue for an additional 10 hours without acoustic monitoring during daylight hours only under the following conditions:
        1. Sea state is less than or equal to BSS 4;
        2. With the exception of delphinids, no marine mammals detected solely by PAM in the applicable shutdown zone in the previous two hours;

3. NMFS is notified via email as soon as practicable with the time and location in which operations began occurring without an active PAM system; and
4. Operations with an active airgun array, but without an operating PAM system, do not exceed a cumulative total of 10 hours in any 24-hour period.

e. Shutdown zones and buffer zones
    i. Except as provided in 4(e)(ii), the PSOs must establish and monitor a 500-m shutdown zone and additional 500-m buffer zone (total 1000 m). The 1000-m zone must serve to focus observational effort but not limit such effort; observations of marine mammals beyond this distance shall also be recorded as described in 5(d) below and/or trigger shutdown as described in 4(g)(iii) below, as appropriate. The shutdown zone encompasses the area at and below the sea surface out to a radius of 500 m from the edges of the airgun array, rather than being based on the center of the array or around the vessel itself. The buffer zone encompasses the area at and below the sea surface from the edge of the shutdown zone, out to a radius of 1000 meters from the edges of the airgun array (500–1000 m). During use of the airgun array, occurrence of marine mammals within the buffer zone (but outside the shutdown zone) must be communicated to the operator to prepare for the potential shutdown of the airgun array. PSOs must monitor the shutdown zone and buffer zone for a minimum of 30 minutes prior to ramp-up (i.e., pre-start clearance). ii. An extended 1500 m shutdown zone must be established for all beaked whales, a large whale with a calf, and groups of six or more large whales. No buffer zone is required.

f. Pre-start clearance and Ramp-up
    i. A ramp-up procedure must be followed at all times as part of the activation of the airgun array, except as described under 4(f)(viii).
    ii. The operator must notify a designated PSO of the planned start of ramp-up as agreed upon with the lead PSO. The notification time should not be less than 60 minutes prior to the planned ramp-up in order to allow the PSOs time to monitor the shutdown and buffer zone for 30 minutes prior to the initiation of ramp-up.
    iii. Ramp-ups shall be scheduled so as to minimize the time spent with the source activated prior to reaching the designated run-in.
    iv. One of the PSOs conducting the pre-start clearance observations must be notified again immediately prior to initiating ramp-up procedures and the operator must receive confirmation from the PSOs to proceed.

v. Ramp-up must not be initiated if any marine mammal is within the shutdown or buffer zone. If a marine mammal is observed within the shutdown zone or the buffer zone during the 30 minute pre-start clearance period, ramp-up may not begin until the animal(s) has been observed exiting the zone or until an additional time period has elapsed with no further sightings (15 minutes for small odontocetes, and 30 minutes for mysticetes and all other odontocetes).

vi. Ramp-up must begin by activating a single airgun of the smallest volume in the array and must continue in stages by doubling the number of active elements at the commencement of each stage, with each stage of approximately the same duration. Duration must not be less than 20 minutes. The operator must provide information to the PSO documenting that appropriate procedures were followed.

vii. PSOs must monitor the shutdown and buffer zones during ramp-up, and ramp-up must cease and the source must be shut down upon visual observation or acoustic detection (other than delphinids) of a marine mammal within the shutdown zone. Once ramp-up has begun, observations of marine mammals within the buffer zone do not require shutdown, but such observation must be communicated to the operator to prepare for the potential shutdown.

viii. Where operational planning cannot reasonably avoid such circumstances ramp-up may occur at times of poor visibility, including nighttime, if appropriate acoustic monitoring has occurred with no detections in the 30 minutes prior to beginning ramp-up. Airgun array activation may only occur at times of poor visibility where operational planning cannot reasonably avoid such circumstances.

ix. If the airgun array is shut down for brief periods (i.e., less than 30 minutes) for reasons other than that described for shutdown (e.g., mechanical difficulty), it may be activated again without ramp-up if PSOs have maintained constant observation and no detections of marine mammals have occurred within the applicable shutdown zone. For any longer shutdown, pre-start clearance observation and ramp-up are required.

x. Testing of the airgun array involving all elements requires ramp-up. Testing limited to individual source elements or strings does not require ramp-up but does require pre-start clearance watch.

g. Shutdown requirements

i. Any PSO on duty has the authority to delay the start of survey operations or to call for shutdown of the airgun array.

ii. The operator must establish and maintain clear lines of communication directly between PSOs on duty and crew controlling the airgun array to ensure that shutdown commands are conveyed swiftly while allowing PSOs to maintain watch.

iii. When the airgun array is active (i.e., anytime one or more airguns is active, including during ramp-up) and (1) a marine mammal (excluding delphinids of the species described in 4(g)(iv)) appears within or enters the shutdown zone and/or (2) a marine mammal is detected acoustically and localized within the shutdown zone, the airgun array must be shut down. When shutdown is called for by a PSO, the airgun array must be immediately deactivated. Any dispute regarding a PSO shutdown must be resolved after deactivation.

iv. The shutdown requirement described in 4(g)(iii) shall be waived small dolphins of the following genera: *Delphinus, Lagenodelphis, Stenella, Steno,* and *Tursiops.*

   1. If a dolphin of these genera is visually and/or acoustically detected and localized within the shutdown zone, no shutdown is required unless the PSO confirms the individual to be of a genus other than those listed above, in which case a shutdown is required.
   2. If there is uncertainty regarding identification, visual PSOs may use best professional judgement in making the decision to call for a shutdown. Upon implementation of shutdown, the source may be reactivated after the marine mammal(s) has been observed exiting the applicable shutdown zone(*i.e.*, animal is not required to fully exit the buffer zone where applicable)or following a clearance period (15 minutes for small odontocetes, and 30 minutes for mysticetes and all other odontocetes)with no further observation Shutdown of the array is required upon observation of a species for which authorization has not been granted ora species for which authorization has been granted but the authorized number of takes has been met, approaching or observed within any harassment zone (*see* Table 2 and Table 3).

4. Vessel strike avoidance
   a. Vessel operators and crew must maintain a vigilant watch for all marine mammals and slow down, stop their vessel, or alter course, as appropriate and regardless of vessel size, to avoid striking any marine mammals. A visual observer aboard the vessel must monitor a vessel strike avoidance zone around the vessel (separation distances stated below). Visual observers monitoring the vessel strike avoidance zone may be third-party observers (i.e., PSOs) or crew members, but crewmembers responsible for these duties must be provided sufficient training to

1) distinguish marine mammals from other phenomena and 2) broadly to identify a marine mammal to taxonomic group (i.e., as a large whale, or other marine mammal).

  i. Vessel speeds must be reduced to 10 kt or less when mother/calf pairs,
  ii. The vessel must maintain a minimum separation distance of 100 m from sperm whales and all baleen whales.
  iii. The vessel must, to the maximum extent practicable, attempt to maintain a minimum separation distance of 50 m from all other marine mammals, with an understanding that at times this may not be possible (e.g., for animals that approach the vessel).
  iv. When marine mammals are sighted while a vessel is underway, the vessel must take action as necessary to avoid violating the relevant separation distance (e.g., attempt to remain parallel to the animal's course, avoid excessive speed or abrupt changes in direction until the animal has left the area). If marine mammals are sighted within the relevant separation distance, the vessel must reduce speed and shift the engine to neutral, not engaging the engines until animals are clear of the area. This does not apply to any vessel towing gear or any vessel that is navigationally constrained.

5. Monitoring Requirements
   a. The operator must provide PSOs with bigeye reticle binoculars (e.g., 25 x 150; 2.7 view angle; individual ocular focus; height control) of appropriate quality solely for PSO use. These must be pedestal-mounted on the deck at the most appropriate vantage point that provides for optimal sea surface observation, PSO safety, and safe operation of the vessel.
   b. The operator must work with the selected third-party observer provider to ensure PSOs have all equipment (including backup equipment) needed to adequately perform necessary tasks, including accurate determination of distance and bearing to observed marine mammals. Such equipment, at a minimum, must include: i. PAM must include a system that has been verified and tested by an experienced acoustic PSO that will be using it during the trip for which monitoring is required.

  v. Reticle binoculars (e.g., 7 x 50) of appropriate quality (at least one per PSO, plus backups).
  vi. Global Positioning Unit (GPS; plus backup).

        vii. Digital single-lens reflex cameras of appropriate quality that capture photographs and video (plus backup).
        viii. Compass (plus backup)
        ix. Radios for communication among vessel crew and PSOs (at least one per PSO, plus backups).
        x. Any other tools necessary to adequately perform necessary PSO tasks.

5. Protected Species Observers (PSOs, Visual and Acoustic) Qualifications
    a. PSOs must have successfully completed an acceptable PSO training course appropriate for their designated task (visual or acoustic). Acoustic PSOs are required to complete specialized training for operating PAM systems and are encouraged to have familiarity with the vessel with which they will be working.
        i. NMFS must review and approve PSO resumes.
        ii. One visual PSO with experience as shown in 4(b) shall be designated as the lead for the PSO team. The lead must coordinate duty schedules and roles for the PSO team and serve as primary point of contact for the vessel operator. (Note that the responsibility of coordinating duty schedules and roles may instead be assigned to a shore-based, third-party monitoring coordinator.) To the maximum extent practicable, the lead PSO must devise the duty schedule such that experienced PSOs are on duty with those PSOs with appropriate training but who have not yet gained relevant experience.
        iii. PSOs must successfully complete relevant training, including completion of all required coursework and passing (80% or greater) a written and/or oral examination developed for the training program.
        iv. PSOs must have successfully attained a bachelor’s degree from an accredited college or university with a major in one of the natural sciences, a minimum of 30 semester hours or equivalent in the biological sciences, and at least one undergraduate course in math or statistics.
        v. The educational requirements may be waived if the PSO has acquired the relevant skills through alternate experience. Requests for such a waiver must be submitted to NMFS and must include written justification. Requests must be granted or denied (with justification) by NMFS within one week of receipt of submitted information. Alternate experience that may be considered includes, but is not limited to (1) secondary education and/or experience comparable to PSO duties; (2) previous work experience conducting academic, commercial, or government-sponsored marine mammal surveys; or (3) previous work experience as a PSO; the PSO should demonstrate good standing and consistently good performance of PSO duties.
    b. Data Collection

i. PSOs must use standardized electronic data collection forms. PSOs must record detailed information about any implementation of mitigation requirements, including the distance of animals to the airgun array and description of specific actions that ensued, the behavior of the animal(s), any observed changes in behavior before and after implementation of mitigation, and if shutdown was implemented, the length of time before any subsequent ramp-up of the airgun array. If required mitigation was not implemented, PSOs should record a description of the circumstances.

ii. At a minimum, the following information must be recorded:

1. Vessel name, vessel size and type, maximum speed capability of vessel;
2. Dates (MM/DD/YYYY) of departures and returns to port with port name;
3. PSO names and affiliations, PSO ID (initials or other identifier);
4. Date (MM/DD/YYYY) and participants of PSO briefings (as discussed in General Requirement);
5. Visual monitoring equipment used (description);
6. PSO location on vessel and height (meters) of observation location above water surface;
7. Watch status (description);
8. Dates (MM/DD/YYYY) and times (Greenwich Mean Time/UTC) of survey on/off effort and times (GMC/UTC) corresponding with PSO on/off effort;
9. Vessel location (decimal degrees) when survey effort began and ended and vessel location at beginning and end of visual PSO duty shifts;
10. Vessel location (decimal degrees) at 30-second intervals if obtainable from data collection software, otherwise at a practical regular interval;
11. Vessel heading (compass heading) and speed (knots) at beginning and end of visual PSO duty shifts and upon any change;
12. Water depths in meters(if obtainable from data collection software);
13. Environmental conditions while on visual survey (at beginning and end of PSO shift and whenever conditions changed significantly), including BSS and any other relevant weather conditions including cloud cover, fog, sun glare, and overall visibility to the horizon;
14. Factors that may have contributed to impaired observations during each PSO shift change or as needed, as environmental conditions

changed (e.g., describe vessel traffic, equipment malfunctions); and

15. Vessel/survey activity information and describe changes thereof, such as airgun array power output while in operation, number and volume of airguns operating in the array, tow depth of the array, and any other notes of significance (i.e., pre-start clearance, ramp-up, shutdown, testing, shooting, ramp-up completion, end of operations, streamers, etc.).

iii. Upon visual observation of any marine mammals, the following information must be recorded:

1. Sighting ID (numeric);
2. Watch status (sighting made by PSO on/off effort, opportunistic, crew, alternate vessel/platform);
3. Location of PSO/observer (description);
4. Vessel activity at the time of the sighting (*e.g.*, deploying, recovering, testing, shooting, data acquisition, other);
5. PSO who sighted the animal/ID;
6. Time/date of sighting (GMT/UTC, MM/DD/YYYY);
7. Initial detection method (description);
8. Sighting cue (description);
9. Vessel location at time of sighting (decimal degrees);
10. Water depth (meters);
11. Direction of vessel's travel (compass direction);
12. Speed, in knots, of the vessel from which the observation was made;
13. Direction of animal's travel relative to the vessel (description, compass heading);
14. Bearing to sighting (degrees);
15. Identification of the animal (*e.g.*, genus/species, lowest possible taxonomic level, or unidentified) and the composition of the group if there is a mix of species;
16. Species reliability to indicate confidence in identification (1=unsure/possible, 2=probable, 3=definite/sure, 9=unknown/not recorded);
17. Estimated distance to the animal (meters) and method of estimating distance;
18. Estimated number of animals (high/low/best numeric estimate);
19. Estimated number of animals by cohort (adults, yearlings, juveniles, calves, group composition, etc.);

20. Description (as many distinguishing features as possible of each individual seen, including length, shape, color, pattern, scars or markings, shape and size of dorsal fin, shape of head, and blow characteristics);
21. Detailed behavior observations (*e.g.*, number of blows/breaths, number of surfaces, breaching, spy-hopping, diving, feeding, traveling; as explicit and detailed as possible; note any observed changes in behavior);
22. Animal's closest point of approach (CPA in meters) and/or closest distance from any element of the airgun array;
23. Description of any actions implemented in response to the sighting (*e.g.*, delays, shutdown, ramp-up) and time and location of the action.
24. Photos (Yes/No);
25. Photo Frame Numbers (list of numbers); and
26. Conditions at a time of sighting (*e.g.*. visibility, BSS)

c. If a marine mammal is detected while using the PAM system, the following information must be recorded: 1. An acoustic encounter identification number, and whether the detection was linked with a visual sighting;
   - (a) Date (MM/DD/YYYY) and time (GMT/UTC) when first and last heard;
   - (b) Types and nature of sounds heard (e.g., clicks, whistles, creaks, burst pulses, continuous, sporadic, strength of signal); and
   - (c) Any additional information recorded such as water depth of the hydrophone array, bearing of the animal to the vessel (if determinable), species or taxonomic group (if determinable), spectrogram screenshot, and any other notable information.

3. Reporting
   - (a) L-DEO must submit a draft comprehensive report to NMFS on all activities and monitoring results within 90 days of the completion of the survey or expiration of the IHA, whichever comes sooner. A final report must be submitted within 30 days following resolution of any comments on the draft report. If no comments are received from NMFS within 30 calendar days of receipt of the draft report, the report shall be considered final. The draft report must include the following:
     1. Summary of all activities conducted and sightings of marine mammals near the activities;
     2. Summary of all data required to be collected (see condition 5(d));
     3. Full documentation of methods, results, and interpretation pertaining to all monitoring;

        4. Summary of dates and locations of survey operations (including (1) the number of days on which the airgun array was active and (2) the percentage of time and total time the array was active during daylight vs. nighttime hours (including dawn and dusk)) and all marine mammal sightings (dates, times, locations, activities, associated survey activities);
        5. Geo-referenced time-stamped vessel tracklines for all time periods during which airguns were operating. Tracklines should include points recording any change in airgun status (e.g., when the airguns began operating, when they were turned off, or when they changed from full array to single gun or vice versa);
        6. GIS files in ESRI shapefile format and UTC date and time, latitude in decimal degrees, and longitude in decimal degrees. All coordinates must be referenced to the WGS84 geographic coordinate system; and
        7. Raw observational data.
    b. Reporting Injured or Dead Marine Mammals (i) Discovery of Injured or Dead Marine Mammal – In the event that personnel involved in the survey activities covered by the authorization discover an injured or dead marine mammal, L-DEO must report the incident to the Office of Protected Resources (OPR at *PR.ITP.MonitoringReports@noaa.gov*) as soon as feasible. The report must include the following information: 1. Time, date, and location (latitude/longitude) of the first discovery (and updated location information if known and applicable);
        - Species identification (if known) or description of the animal(s) involved;
        - Condition of the animal(s), including carcass condition if the animal is dead;
        - Observed behaviors of the animal(s), if alive;
        - If available, photographs or video footage of the animal(s); and
        - General circumstances under which the animal was discovered.

6. Vessel Strike – In the event of a ship strike of a marine mammal by any vessel involved in the activities covered by the authorization, L-DEO must report the incident to OPR as soon as feasible. The report must include the following information:
        1. Time, date, and location (latitude/longitude) of the incident;
        2. Species identification (if known) or description of the animal(s) involved;
        3. Vessel's speed during and leading up to the incident;
        4. Vessel's course/heading and what operations were being conducted (if applicable);
        5. Status of all sound sources in use;

        6. Description of avoidance measures/requirements that were in place at the time of the strike and what additional measures were taken, if any, to avoid strike;
        7. Environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover, visibility) immediately preceding the strike;
        8. Estimated size and length of animal that was struck;
        9. Description of the behavior of the marine mammal immediately preceding and following the strike;
        10. If available, description of the presence and behavior of any other marine mammals immediately preceding the strike;
        11. Estimated fate of the animal (e.g., dead, injured but alive, injured and moving, blood or tissue observed in the water, status unknown, disappeared); and
        12. To the extent practicable, photographs or video footage of the animal(s).
3. This Authorization may be modified, suspended or revoked if the holder fails to abide by the conditions prescribed herein (including, but not limited to, failure to comply with monitoring or reporting requirements), or if NMFS determines: (1) the authorized taking is likely to have or is having more than a negligible impact on the species or stocks of affected marine mammals, or (2) the prescribed measures are likely not or are not effecting the least practicable adverse impact on the affected species or stocks and their habitat.
4. Renewals
    b. On a case-by-case basis, NMFS may issue a one-time, one-year Renewal IHA following notice to the public providing an additional 15 days for public comments when (1) up to another year of identical, or nearly identical, activities are planned or (2) the specified activities would not be completed by the time this IHA expires and a Renewal would allow for completion of the activities, provided all of the following conditions are met:
        i. A request for renewal is received no later than 60 days prior to the needed Renewal IHA effective date (the Renewal IHA expiration date cannot extend beyond one year from expiration of this IHA).
        ii. The request for renewal must include the following:
            i. An explanation that the activities to be conducted under the requested Renewal IHA are identical to the activities analyzed for this IHA, are a subset of the activities, or include changes so minor that the changes do not affect the previous analyses, mitigation and monitoring requirements, or take estimates (with the exception of reducing the type or amount of take).

(ii) A preliminary monitoring report showing the results of the required monitoring to date and an explanation showing that the monitoring results do not indicate impacts of a scale or nature not previously analyzed or authorized.

iii. Upon review of the request for Renewal, the status of the affected species or stocks, and any other pertinent information, NMFS determines that there are no more than minor changes in the activities, the mitigation and monitoring measures will remain the same and appropriate, and the findings made in support of this IHA remain valid.

Table 1. Authorized take numbers, by species

Species	Authorized Level B Take
Humpback whale	2
Minke whale	1
Bryde's whale	6
Fin whale	2
Sei whale	2
Blue whale	2
Sperm whale	8
Goose-beaked whale	12
Longman's beaked whale	20
Mesoplodon Beaked whales1	5
Risso's dolphin	66
Rough-toothed dolphin	70
Bottlenose dolphin	149
Pantropical spotted dolphin	1,057
Spinner dolphin	1,295
Striped dolphin	1,179
Common dolphin	580
Fraser's dolphin	395

Short-finned pilot whale	126
Killer whale	7
False killer whale	27
Pygmy killer whale	26
Melon-headed whale	200
Kogia spp.2	2

APPENDIX E: INCIDENTAL HARASSMENT AUTHORIZATION

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
1315 East-West Highway
Silver Spring, Maryland 20910

INCIDENTAL HARASSMENT AUTHORIZATION

The Lamont-Doherty Earth Observatory of Columbia University (L-DEO) (the “Holder of the Authorization” or "Holder") is hereby authorized under section 101(a)(5)(D) of the Marine Mammal Protection Act (MMPA; 16 U.S.C. 1371(a)(5)(D)) to incidentally harass marine mammals, under the following conditions:

1. This incidental harassment authorization (IHA) is effective for 1 year upon written notification from the Holder to NMFS, but not beginning later than 1 year from the date of issuance or extending beyond 2 years from the date of issuance.

2. This IHA is valid only for geophysical survey activity of the East Pacific Rise in the Eastern Tropical Pacific Ocean, as specified in L-DEO’s IHA application.

3. <u>General Conditions</u>

    (a) A copy of this IHA must be in the possession of L-DEO, the vessel operator, the lead protected species observer (PSO), and any other relevant designees of L-DEO operating under the authority of this IHA.

    (b) The species and/or stocks authorized for taking are listed in Table 1. Authorized take, by Level A and Level B harassment only, is limited to the species and numbers listed in Table 1.

    (c) The taking by serious injury or death of any of the species listed in Table 1 or any taking of any other species of marine mammal is prohibited and may result in the modification, suspension, or revocation of this IHA. Any taking exceeding the authorized numbers listed in Table 1 is prohibited and may result in the modification, suspension, or revocation of this IHA.

    (d) During use of the acoustic source, if any marine mammal species or stock not listed in Table 1 appear within or enter the Level B harassment zone (Table 3) the acoustic source must be shut down.

    (e) L-DEO must ensure that relevant vessel personnel and the PSO team participate in a joint onboard briefing led by the vessel operator and lead PSO to ensure that responsibilities, communication procedures, marine mammal monitoring protocols, operational procedures, and IHA requirements are clearly understood.

4. Mitigation Requirements

a. L-DEO must use independent, dedicated, trained visual and acoustic PSOs, meaning that the PSOs must be employed by a third-party observer provider, must not have tasks other than to conduct observational effort, collect data, and communicate with and instruct relevant vessel crew with regard to the presence of marine mammals and mitigation requirements (including brief alerts regarding maritime hazards), and must have successfully completed an approved PSO training course appropriate for their designated task (visual or acoustic). Individual PSOs may perform acoustic and visual PSO duties (though not at the same time).

b. At least one visual and two acoustic PSOs must have a minimum of 90 days at-sea experience working in those roles, respectively, during a deep penetration seismic survey, with no more than 18 months elapsed since the conclusion of the at-sea experience.

c. Visual Observation

  i. During survey operations (e.g., any day on which use of the airgun array is planned to occur and whenever the airgun array is in the water, whether activated or not), a minimum of two PSOs must be on duty and conducting visual observations at all times during daylight hours (i.e., from 30 minutes prior to sunrise through 30 minutes following sunset).

  ii. Visual monitoring of the exclusion and buffer zones must begin no less than 30 minutes prior to ramp-up and must continue until one hour after use of the airgun array ceases or until 30 minutes past sunset.

  iii. Visual PSOs must coordinate to ensure 360° visual coverage around the vessel from the most appropriate observation posts, and must conduct visual observations using binoculars and the naked eye while free from distractions and in a consistent, systematic, and diligent manner.

  iv. Visual PSOs must immediately communicate all observations to the acoustic PSO(s) on duty, including any determination by the PSO regarding species identification, distance, and bearing and the degree of confidence in the determination.

  v. During good conditions (e.g., daylight hours; Beaufort sea state (BSS) 3 or less), visual PSOs must conduct observations when the airgun array is not operating for comparison of sighting rates and behavior with and without use of the airgun array and between acquisition periods, to the maximum extent practicable.

  vi. Visual PSOs may be on watch for a maximum of four consecutive hours followed by a break of at least one hour between watches and may conduct a maximum of 12 hours of observation per 24-hour period. Combined observational duties (visual and acoustic but not at same time) may not exceed 12 hours per 24-hour period for any individual PSO.

d. Acoustic Monitoring

  i. The Holder must use a towed passive acoustic monitoring system (PAM) which must be monitored by, at a minimum, one on-duty acoustic PSO beginning at least 30 minutes prior to ramp-up and at all times during use of the airgun array.

  ii. When both visual and acoustic PSOs are on duty, all detections must be immediately communicated to the remainder of the on-duty PSO team for potential verification of visual observations by the acoustic PSO or of acoustic detections by visual PSOs.

  iii. Acoustic PSOs may be on watch for a maximum of four consecutive hours followed by a break of at least one hour between watches and may conduct a maximum of 12 hours of observation per 24-hour period. Combined observational duties may not exceed 12 hours per 24-hour period for any individual PSO.

  iv. Survey activity may continue for 30 minutes when the PAM system malfunctions or is damaged, while the PAM operator diagnoses the issue. If the diagnosis indicates that the PAM system must be repaired to solve the problem, operations may continue for an additional 10 hours without acoustic monitoring during daylight hours only under the following conditions:

    1. Sea state is less than or equal to BSS 4;

    2. With the exception of delphinids, no marine mammals detected solely by PAM in the applicable shutdown zone in the previous two hours;

    3. NMFS is notified via email as soon as practicable with the time and location in which operations began occurring without an active PAM system; and

    4. Operations with an active airgun array, but without an operating PAM system, do not exceed a cumulative total of 10 hours in any 24-hour period.

e. Shutdown zones and buffer zones

  i. Except as provided in 4(e)(ii), the PSOs must establish and monitor a 500-m shutdown zone and additional 500-m buffer zone (total 1000 m). The 1000-m zone must serve to focus observational effort but not limit such effort; observations of marine mammals beyond this distance shall also be recorded as described in 5(d) below and/or trigger shutdown as described in 4(g)(iii) below, as appropriate. The shutdown zone encompasses the area at and below the sea surface out to a radius of 500 m from the edges of the airgun array (rather than being based on the center of the array or around the vessel itself) (0–500 m). The buffer zone encompasses the area at and below the sea surface from the edge of the shutdown zone, out to a radius of 1000 meters from the edges of the airgun array (500–1000 m). During use of the airgun array, occurrence of marine mammals within the buffer zone (but outside the shutdown zone) must be communicated to the operator to prepare for the potential shutdown of the airgun array. PSOs must monitor the shutdown zone and buffer zone for a minimum of 30 minutes prior to ramp-up (i.e., pre-start clearance).

ii. An extended 1500 m shutdown zone must be established for all beaked whales, a large whale with a calf, and groups of six or more large whales. No buffer zone is required.

f. Pre-start clearance and Ramp-up

i. A ramp-up procedure must be followed at all times as part of the activation of the airgun array, except as described under 4(f)(viii).

ii. The operator must notify a designated PSO of the planned start of ramp-up as agreed upon with the lead PSO. The notification time should not be less than 60 minutes prior to the planned ramp-up in order to allow the PSOs time to monitor the shutdown and buffer zone for 30 minutes prior to the initiation of ramp-up.

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

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

v. Ramp-up must not be initiated if any marine mammal is within the shutdown or buffer zone. If a marine mammal is observed within the shutdown zone or the buffer zone during the 30 minute pre-start clearance period, ramp-up may not begin until the animal(s) has been observed exiting the zone or until an additional time period has elapsed with no further sightings (15 minutes for small odontocetes, and 30 minutes for mysticetes and all other odontocetes).

vi. Ramp-up must begin by activating a single airgun of the smallest volume in the array and must continue in stages by doubling the number of active elements at the commencement of each stage, with each stage of approximately the same duration. Duration must not be less than 20 minutes.

The operator must provide information to the PSO documenting that appropriate procedures were followed.

vii. PSOs must monitor the shutdown and buffer zones during ramp-up, and ramp-up must cease and the source must be shut down upon visual observation or acoustic detection (other than delphinids) of a marine mammal within the shutdown zone. Once ramp-up has begun, observations of marine mammals within the buffer zone do not require shutdown, but such observation must be communicated to the operator to prepare for the potential shutdown.

viii. Where operational planning cannot reasonably avoid such circumstances ramp-up may occur at times of poor visibility, including nighttime, if appropriate acoustic monitoring has occurred with no detections in the 30 minutes prior to beginning ramp-up. Airgun array activation may only occur at times of poor visibility where operational planning cannot reasonably avoid such circumstances.

ix. If the airgun array is shut down for brief periods (i.e., less than 30 minutes) for reasons other than that described for shutdown (e.g., mechanical difficulty), it may be activated again without ramp-up if PSOs have maintained constant observation and no detections of marine mammals have occurred within the applicable shutdown zone. For any longer shutdown, pre-start clearance observation and ramp-up are required.

x. Testing of the airgun array involving all elements requires ramp-up. Testing limited to individual source elements or strings does not require ramp-up but does require pre-start clearance watch.

g. Shutdown requirements

i. Any PSO on duty has the authority to delay the start of survey operations or to call for shutdown of the airgun array.

ii. The operator must establish and maintain clear lines of communication directly between PSOs on duty and crew controlling the airgun array to ensure that shutdown commands are conveyed swiftly while allowing PSOs to maintain watch.

iii. When the airgun array is active (i.e., anytime one or more airguns is active, including during ramp-up) and (1) a marine mammal (excluding delphinids of the species described in 4(g)(iv)) appears within or enters the shutdown zone and/or (2) a marine mammal is detected acoustically and localized within the shutdown zone, the airgun array must be shut down. When shutdown is called for by a PSO, the airgun array must be immediately deactivated. Any dispute regarding a PSO shutdown must be resolved after deactivation.

iv. The shutdown requirement described in 4(g)(iii) shall be waived small dolphins of the following genera: *Delphinus, Lagenodelphis, Stenella, Steno,* and *Tursiops.*

   1. If a dolphin of these genera is visually and/or acoustically detected and localized within the shutdown zone, no shutdown is required unless the PSO confirms the individual to be of a genus other than those listed above, in which case a shutdown is required.

   2. If there is uncertainty regarding identification, visual PSOs may use best professional judgement in making the decision to call for a shutdown.

v. Upon implementation of shutdown, the source may be reactivated after the marine mammal(s) has been observed exiting the applicable shutdown zone (*i.e.*, animal is not required to fully exit the buffer zone where applicable) or following a clearance period (15 minutes for small odontocetes, and 30 minutes for mysticetes and all other odontocetes) with no further observation of the marine mammal(s).

vi. Shutdown of the array is required upon observation of a species for which authorization has not been granted or a species for which authorization has been granted but the authorized number of takes has been met, approaching or observed within any harassment zone (*see* table 2 and table 3).

h. Vessel strike avoidance

i. Vessel operators and crew must maintain a vigilant watch for all marine mammals and slow down, stop their vessel, or alter course, as appropriate and regardless of vessel size, to avoid striking any marine mammals. A visual observer aboard the vessel must monitor a vessel strike avoidance zone around the vessel (separation distances stated below). Visual observers monitoring the vessel strike avoidance zone may be third-party observers (i.e., PSOs) or crew members, but crew members responsible for these duties must be provided sufficient training to 1) distinguish marine mammals from other phenomena and 2) broadly to identify a marine mammal to taxonomic group (i.e., as a large whale, or other marine mammal).

ii. Vessel speeds must be reduced to 10 knots or less when mother/calf pairs, pods, or large assemblages of cetaceans are observed near a vessel.

iii. The vessel must maintain a minimum separation distance of 100 m from sperm whales and all baleen whales.

iv. The vessel must, to the maximum extent practicable, attempt to maintain a minimum separation distance of 50 m from all other marine mammals, with an understanding that at times this may not be possible (e.g., for animals that approach the vessel).

        v. When marine mammals are sighted while a vessel is underway, the vessel must take action as necessary to avoid violating the relevant separation distance (e.g., attempt to remain parallel to the animal's course, avoid excessive speed or abrupt changes in direction until the animal has left the area). If marine mammals are sighted within the relevant separation distance, the vessel must reduce speed and shift the engine to neutral, not engaging the engines until animals are clear of the area. This does not apply to any vessel towing gear or any vessel that is navigationally constrained.

5. Monitoring Requirements

    a. The operator must provide PSOs with bigeye reticle binoculars (e.g., 25 x 150; 2.7 view angle; individual ocular focus; height control) of appropriate quality solely for PSO use. These must be pedestal-mounted on the deck at the most appropriate vantage point that provides for optimal sea surface observation, PSO safety, and safe operation of the vessel.

    b. The operator must work with the selected third-party observer provider to ensure PSOs have all equipment (including backup equipment) needed to adequately perform necessary tasks, including accurate determination of distance and bearing to observed marine mammals. Such equipment, at a minimum, must include:

        i. PAM must include a system that has been verified and tested by an experienced acoustic PSO that will be using it during the trip for which monitoring is required.

        ii. Reticle binoculars (e.g., 7 x 50) of appropriate quality (at least one per PSO, plus backups).

        iii. Global Positioning Unit (GPS) (plus backup).

        iv. Digital single-lens reflex cameras of appropriate quality that capture photographs and video (plus backup).

        v. Compass (plus backup)

        vi. Radios for communication among vessel crew and PSOs (at least one per PSO, plus backups).

        vii. Any other tools necessary to adequately perform necessary PSO tasks.

    c. Protected Species Observers (PSOs, Visual and Acoustic) Qualifications

        i. PSOs must have successfully completed an acceptable PSO training course appropriate for their designated task (visual or acoustic). Acoustic PSOs are required to complete specialized training for operating PAM systems and are encouraged to have familiarity with the vessel with which they will be working.

ii. NMFS must review and approve PSO resumes.

iii. One visual PSO with experience as shown in 4(b) shall be designated as the lead for the PSO team. The lead must coordinate duty schedules and roles for the PSO team and serve as primary point of contact for the vessel operator. (Note that the responsibility of coordinating duty schedules and roles may instead be assigned to a shore-based, third-party monitoring coordinator.) To the maximum extent practicable, the lead PSO must devise the duty schedule such that experienced PSOs are on duty with those PSOs with appropriate training but who have not yet gained relevant experience.

iv. PSOs must successfully complete relevant training, including completion of all required coursework and passing (80 percent or greater) a written and/or oral examination developed for the training program.

v. PSOs must have successfully attained a bachelor's degree from an accredited college or university with a major in one of the natural sciences, a minimum of 30 semester hours or equivalent in the biological sciences, and at least one undergraduate course in math or statistics.

vi. The educational requirements may be waived if the PSO has acquired the relevant skills through alternate experience. Requests for such a waiver must be submitted to NMFS and must include written justification. Requests must be granted or denied (with justification) by NMFS within one week of receipt of submitted information. Alternate experience that may be considered includes, but is not limited to (1) secondary education and/or experience comparable to PSO duties; (2) previous work experience conducting academic, commercial, or government-sponsored marine mammal surveys; or (3) previous work experience as a PSO; the PSO should demonstrate good standing and consistently good performance of PSO duties.

d. Data Collection

i. PSOs must use standardized electronic data collection forms. PSOs must record detailed information about any implementation of mitigation requirements, including the distance of animals to the airgun array and description of specific actions that ensued, the behavior of the animal(s), any observed changes in behavior before and after implementation of mitigation, and if shutdown was implemented, the length of time before any subsequent ramp-up of the airgun array. If required mitigation was not implemented, PSOs should record a description of the circumstances.

ii. At a minimum, the following information must be recorded:

1. Vessel name, vessel size and type, maximum speed capability of vessel;

2. Dates (MM/DD/YYYY) of departures and returns to port with port name;

3. PSO names and affiliations, PSO ID (initials or other identifier);

4. Date (MM/DD/YYYY) and participants of PSO briefings (as discussed in General Requirement);

5. Visual monitoring equipment used (description);

6. PSO location on vessel and height (meters) of observation location above water surface;

7. Watch status (description);

8. Dates (MM/DD/YYYY) and times (Greenwich Mean Time/UTC) of survey on/off effort and times (GMC/UTC) corresponding with PSO on/off effort;

9. Vessel location (decimal degrees) when survey effort began and ended and vessel location at beginning and end of visual PSO duty shifts;

10. Vessel location (decimal degrees) at 30-second intervals if obtainable from data collection software, otherwise at a practical regular interval;

11. Vessel heading (compass heading) and speed (knots) at beginning and end of visual PSO duty shifts and upon any change;

12. Water depths (meters) (if obtainable from data collection software);

13. Environmental conditions while on visual survey (at beginning and end of PSO shift and whenever conditions changed significantly), including BSS and any other relevant weather conditions including cloud cover, fog, sun glare, and overall visibility to the horizon;

14. Factors that may have contributed to impaired observations during each PSO shift change or as needed as environmental conditions changed (description) (e.g., vessel traffic, equipment malfunctions); and

15. Vessel/survey activity information (and changes thereof) (description), such as airgun array power output while in operation, number and volume of airguns operating in the array, tow depth of the array, and any other notes of significance (i.e., pre-start clearance, ramp-up, shutdown, testing, shooting, ramp-up completion, end of operations, streamers, etc.).

iii. Upon visual observation of any marine mammals, the following information must be recorded:

1. Sighting ID (numeric);
2. Watch status (sighting made by PSO on/off effort, opportunistic, crew, alternate vessel/platform);
3. Location of PSO/observer (description);
4. Vessel activity at the time of the sighting (*e.g.*, deploying, recovering, testing, shooting, data acquisition, other);
5. PSO who sighted the animal/ID;
6. Time/date of sighting (GMT/UTC, MM/DD/YYYY);
7. Initial detection method (description);
8. Sighting cue (description);
9. Vessel location at time of sighting (decimal degrees);
10. Water depth (meters);
11. Direction of vessel's travel (compass direction);
12. Speed (knots) of the vessel from which the observation was made;
13. Direction of animal's travel relative to the vessel (description, compass heading);
14. Bearing to sighting (degrees);
15. Identification of the animal (*e.g.*, genus/species, lowest possible taxonomic level, or unidentified) and the composition of the group if there is a mix of species;
16. Species reliability (an indicator of confidence in identification) (1=unsure/possible, 2=probable, 3=definite/sure, 9=unknown/not recorded);
17. Estimated distance to the animal (meters) and method of estimating distance;
18. Estimated number of animals (high/low/best) (numeric);

19. Estimated number of animals by cohort (adults, yearlings, juveniles, calves, group composition, etc.);

20. Description (as many distinguishing features as possible of each individual seen, including length, shape, color, pattern, scars or markings, shape and size of dorsal fin, shape of head, and blow characteristics);

21. Detailed behavior observations (*e.g.*, number of blows/breaths, number of surfaces, breaching, spyhopping, diving, feeding, traveling; as explicit and detailed as possible; note any observed changes in behavior);

22. Animal's closest point of approach (CPA) (meters) and/or closest distance from any element of the airgun array;

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

24. Photos (Yes/No);

25. Photo Frame Numbers (list of numbers); and

26. Conditions at a time of sighting (*e.g.*. visibility, BSS)

iv. If a marine mammal is detected while using the PAM system, the following information must be recorded:

1. An acoustic encounter identification number, and whether the detection was linked with a visual sighting;

2. Date (MM/DD/YYYY) and time (GMT/UTC) when first and last heard;

3. Types and nature of sounds heard (e.g., clicks, whistles, creaks, burst pulses, continuous, sporadic, strength of signal); and

4. Any additional information recorded such as water depth of the hydrophone array, bearing of the animal to the vessel (if determinable), species or taxonomic group (if determinable), spectrogram screenshot, and any other notable information.

6. Reporting

(a) L-DEO must submit a draft comprehensive report to NMFS on all activities and monitoring results within 90 days of the completion of the survey or expiration of the IHA, whichever comes sooner. A final report must be submitted within 30 days following resolution of any comments on the draft report. If no comments are received from NMFS within 30 calendar days of receipt of the draft report, the report shall be considered final. The draft report must include the following:

(i) Summary of all activities conducted and sightings of marine mammals near the activities;

(ii) Summary of all data required to be collected (see condition 5(d));

(iii) Full documentation of methods, results, and interpretation pertaining to all monitoring;

(iv) Summary of dates and locations of survey operations (including (1) the number of days on which the airgun array was active and (2) the percentage of time and total time the array was active during daylight vs. nighttime hours (including dawn and dusk)) and all marine mammal sightings (dates, times, locations, activities, associated survey activities);

(v) Geo-referenced time-stamped vessel tracklines for all time periods during which airguns were operating. Tracklines should include points recording any change in airgun status (e.g., when the airguns began operating, when they were turned off, or when they changed from full array to single gun or vice versa);

(vi) GIS files in ESRI shapefile format and UTC date and time, latitude in decimal degrees, and longitude in decimal degrees. All coordinates must be referenced to the WGS84 geographic coordinate system; and

(vii) Raw observational data.

(b) Reporting Injured or Dead Marine Mammals

(i) Discovery of Injured or Dead Marine Mammal – In the event that personnel involved in the survey activities covered by the authorization discover an injured or dead marine mammal, L-DEO must report the incident to the Office of Protected Resources (OPR) (*PR.ITP.MonitoringReports@noaa.gov*) as soon as feasible. The report must include the following information:

1. Time, date, and location (latitude/longitude) of the first discovery (and updated location information if known and applicable);

2. Species identification (if known) or description of the animal(s) involved;

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

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

5. If available, photographs or video footage of the animal(s); and

6. General circumstances under which the animal was discovered.

(ii) Vessel Strike – In the event of a ship strike of a marine mammal by any vessel involved in the activities covered by the authorization, L-DEO must report the incident to OPR as soon as feasible. The report must include the following information:

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

2. Species identification (if known) or description of the animal(s) involved;

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

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

5. Status of all sound sources in use;

6. Description of avoidance measures/requirements that were in place at the time of the strike and what additional measures were taken, if any, to avoid strike;

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

8. Estimated size and length of animal that was struck;

9. Description of the behavior of the marine mammal immediately preceding and following the strike;

10. If available, description of the presence and behavior of any other marine mammals immediately preceding the strike;

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

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

7. This Authorization may be modified, suspended or revoked if the holder fails to abide by the conditions prescribed herein (including, but not limited to, failure to comply with monitoring or reporting requirements), or if NMFS determines: (1) the authorized taking is likely to have or is having more than a negligible impact on the species or stocks of affected marine mammals, or (2) the prescribed measures are likely not or are not

effecting the least practicable adverse impact on the affected species or stocks and their habitat.

8. Renewals

On a case-by-case basis, NMFS may issue a one-time, one-year Renewal IHA following notice to the public providing an additional 15 days for public comments when (1) up to another year of identical, or nearly identical, activities are planned or (2) the specified activities would not be completed by the time this IHA expires and a Renewal would allow for completion of the activities, provided all of the following conditions are met:

(a) A request for renewal is received no later than 60 days prior to the needed Renewal IHA effective date (the Renewal IHA expiration date cannot extend beyond one year from expiration of this IHA).

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

  (i) An explanation that the activities to be conducted under the requested Renewal IHA are identical to the activities analyzed for this IHA, are a subset of the activities, or include changes so minor that the changes do not affect the previous analyses, mitigation and monitoring requirements, or take estimates (with the exception of reducing the type or amount of take).

  (ii) A preliminary monitoring report showing the results of the required monitoring to date and an explanation showing that the monitoring results do not indicate impacts of a scale or nature not previously analyzed or authorized.

(c) Upon review of the request for Renewal, the status of the affected species or stocks, and any other pertinent information, NMFS determines that there are no more than minor changes in the activities, the mitigation and monitoring measures will remain the same and appropriate, and the findings made in support of this IHA remain valid.

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Kimberly Damon-Randall,
Director, Office of Protected Resources,
National Marine Fisheries Service

Table 1. Authorized take numbers, by species

Species	Authorized Level B Take
Humpback whale	2
Minke whale	1
Bryde's whale	6
Fin whale	2
Sei whale	2
Blue whale	2
Sperm whale	8
Goose-beaked whale	12
Longman's beaked whale	20
Mesoplodon Beaked whales[1]	5
Risso's dolphin	66
Rough-toothed dolphin	70
Bottlenose dolphin	149
Pantropical spotted dolphin	1,057
Spinner dolphin	1,295
Striped dolphin	1,179
Common dolphin	580
Fraser's dolphin	395
Short-finned pilot whale	126
Killer whale	7
False killer whale	27
Pygmy killer whale	26
Melon-headed whale	200
Kogia spp.[2]	2

[1] Includes Blainville's beaked whale, ginkgo-toothed beaked whale, Deraniyagala's beaked whale, pygmy beaked whale.

[2] Includes pygmy sperm whale and dwarf sperm whale.

Table 2. Modeled Radial Distances (m) to Isopleths Corresponding to Level A Harassment Thresholds.

Airgun Configuration	Level A harassment zone (m)		
	LF cetaceans	HF cetaceans	VHF cetaceans
2 strings, 18 airgun array (3,300 in^3)	157.5	13.4	164.6

Table 3. Modeled Radial Distance (m) to Isopleth Corresponding to Level B Harassment Threshold.

Airgun Configuration	Water Depth (m)	Level B harassment zone (m)
2 strings, 18 airgun array ($3,300 in^3$)	>1000m	3,526