NATIONAL MARINE FISHERIES SERVICE
ENDANGERED SPECIES ACT SECTION 7
BIOLOGICAL OPINION

Title: Biological Opinion on the Lamont-Doherty Earth Observatory's Marine Geophysical Survey by the R/V *Marcus G. Langseth* off Western Mexico in the Eastern Tropical Pacific Ocean and National Marine Fisheries Service Permits and Conservation Division's Issuance of an Incidental Harassment Authorization pursuant to Section 101(a)(5)(D) of the Marine Mammal Protection Act

Consultation Conducted By: Endangered Species Act Interagency Cooperation Division, Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce

Action Agency: National Science Foundation and National Oceanic Atmospheric Administration National Marine Fisheries Service-Office of Protected Resources-Permits and Conservation Division

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1 INTRODUCTION

The Endangered Species Act of 1973, as amended (ESA; 16 U.S.C. 1531 et seq.) establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat they depend on. Section 7(a)(2) of the ESA requires Federal agencies to insure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their designated critical habitat. Federal agencies must do so in consultation with National Marine Fisheries Service (NMFS) for threatened or endangered species (ESA-listed), or designated critical habitat that may be affected by the action that are under NMFS jurisdiction (50 C.F.R. §402.14(a)). If a Federal action agency determines that an action "may affect, but is not likely to adversely affect" endangered species, threatened species, or designated critical habitat and NMFS concur with that determination for species under NMFS jurisdiction, consultation concludes informally (50 C.F.R. §402.14(b)).

Section 7(b)(3) of the ESA requires that at the conclusion of consultation, NMFS provides an opinion stating whether the Federal agency's action is likely to jeopardize ESA-listed species or destroy or adversely modify designated critical habitat. If NMFS determines that the action is likely to jeopardize listed species or destroy or adversely modify critical habitat, NMFS provides a reasonable and prudent alternative that allows the action to proceed in compliance with section 7(a)(2) of the ESA. If an incidental take is expected, section 7(b)(4) requires NMFS to provide an incidental take statement that specifies the impact of any incidental taking and includes necessary or appropriate reasonable and prudent measures to minimize such impacts and terms and conditions to implement the reasonable and prudent measures. The statement must specify measures that are necessary to comply with section 101(a)(5) of the Marine Mammal Protection Act for incidental take of listed marine mammals. Incidental take that occurs consistent with the ITS is exempted from the take prohibitions of Section 9 of the ESA.

The Federal action agencies for this consultation are the National Science Foundation (NSF) and the NMFS's 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 seismic survey in and around the Guerrero Gap off western Mexico, in the Eastern Tropical Pacific Ocean to take place in spring 2022, in support of an NSF-funded collaborative research project led by Columbia University's Lamont-Doherty Earth Observatory (L-DEO). The second is the NMFS Permits Division's proposal to issue an incidental harassment authorization (IHA) authorizing non-lethal "takes" by Level A and Level B harassment (as defined by the Marine Mammal Protection Act [MMPA]) of marine mammals incidental to the planned seismic survey, pursuant to section 101 (a)(5)(D) of the MMPA, 16 U.S.C. § 1371(a)(5)(D).

This consultation, opinion, and incidental take statement, were completed in accordance with ESA section 7, associated implementing regulations (50 C.F.R. §§402.01-402.17), and agency policy and guidance. This consultation was conducted by the NMFS Office of Protected

Resources Endangered Species Act Interagency Cooperation Division (hereafter referred to as "we" or "our").

This document represents our opinion on the effects of the proposed actions on endangered and threatened marine mammals, sea turtles, and fishes and designated and proposed critical habitat for those species. A complete record of this consultation is on file at the NMFS Office of Protected Resources in Silver Spring, Maryland.

1.1 Background

The NSF is proposing to fund and conduct a marine seismic survey for scientific research purposes and data collection in the Guerrero Gap in the Eastern Tropical Pacific Ocean off the coast of Mexico in the spring of 2022. The NSF, as the research funding and action agency, has a mission to "promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense…" The proposed seismic survey will collect data in support of a research proposal that has been reviewed under the NSF merit review process and identified as a NSF program priority. In conjunction with this action, the Permits Division proposes the issuance of an IHA pursuant to the MMPA requirements for incidental takes of marine mammals that could occur during the NSF 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.

The principal investigators worked with the NSF and L-DEO to consider potential times to carry out the proposed seismic surveys. Key factors taken into consideration included environmental conditions (i.e., the seasonal presence of marine mammals, sea turtles, and sea birds), weather conditions, equipment, and optimal timing for other proposed seismic surveys using the R/V *Marcus G. Langseth*.

1.2 Consultation History

This opinion is based on information provided in the NSF draft environmental analysis prepared pursuant to Executive Order 12114, L-DEO's MMPA IHA application, the Permits Division's notice of a proposed IHA prepared pursuant to the MMPA, and information from previous, recent NSF seismic surveys (NMFS 2021). Our communication with the NSF and Permits Division regarding this consultation is summarized as follows:

- **October 15, 2020:** The NSF submitted a request for a species list.
- **August 18, 2021:** The NSF submitted the draft initiation package to the ESA Interagency Cooperation Division for review.
- **September 17, 2021:** The ESA Interagency Cooperation Division returned questions on the draft environmental analysis to the NSF. The NSF responded with answers on September 21, 2021.
- **September 21, 2021:** The ESA Interagency Cooperation Division determined the initiation package was complete and initiated consultation with NSF.

- **January 10, 2022:** The Permits Division submitted their initiation package to the ESA Interagency Cooperation Division for review. The ESA Interagency Cooperation Division reviewed the package, determined it was complete, and initiated consultation on the same date.
- **January 12, 2022**: The notice for the proposed IHA published in the Federal Register, beginning the 30-day public comment period.
- **February 9-17, 2022**: The Permits Division shared information received from local experts through public comments concerning the potential occurrence of Central America humpback whales in the action area. As a result, the Permits Division and NSF notified the ESA Interagency Cooperation Division of changes in their proposed actions - the Permits Division to include area and timing restrictions for the survey to avoid exposure of Central America humpback whales in their final IHA (if issued), and NSF to conduct their survey in accordance to such restrictions. These changes to the proposed actions were incorporated into the Biological Opinion.
- **March 11, 2022**: The Permits Division shared a draft of the final IHA with the ESA Interagency Cooperation Division.

2 THE ASSESSMENT FRAMEWORK

Section 7(a)(2) of the ESA requires Federal agencies, in consultation with NMFS, to insure that their actions are not likely to jeopardize the continued existence of endangered or threatened species; or adversely modify or destroy their designated critical habitat.

"Jeopardize the continued existence of" means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of an ESA-listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 C.F.R. §402.02).

"Destruction or adverse modification" means a direct or indirect alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species (50 C.F.R. §402.02).

The final designations of critical habitat for green, leatherback, and loggerhead turtles used the term primary constituent element or essential features. The new critical habitat regulations (81 FR 7414; February 11, 2016) replace this term with physical and biological features. The shift in terminology does not change the approach used in conducting a "destruction or adverse modification" analysis, which is the same regardless of whether the original designation identified primary constituent elements, physical or biological features, or essential features. In this opinion, we use the term physical or biological features to mean primary constituent elements or essential features, as appropriate for the specific designated critical habitat.

An ESA section 7(a)(2) opinion involves the following steps:

Description of the Proposed Action (Section 3): We describe the proposed action and those aspects (or stressors) of the proposed action that may have effects on the physical, chemical, and biotic environment. This section also includes the conservation measures that NSF has incorporated up front into the project to minimize and avoid the effects to ESA-listed species and designated critical habitat.

Potential Stressors (Section 4): We identify and describe the stressors that could occur as a result of the proposed actions and affect ESA-listed species and designated critical habitat.

Action Area (Section 5): We describe the action area with the spatial extent of the stressors from the action. 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.

Endangered Species Act-Listed Species and Proposed or Designated Critical Habitat Present in the Action Area (Section 6): We identify the ESA-listed species and designated critical habitat that are likely to co-occur with the stressors produced by the proposed action in space and time.

We identify those *Species and Critical Habitat Not Likely to be Adversely Affected* (Section 7). We include a section (Section 7.1) for stressors that are not likely to adversely affect the species or designated critical habitat that are not analyzed further in this opinion. We also include a section that identifies species and critical habitats (Section 7.2) not likely to be adversely affected by the proposed action and its stressors.

Status of Species and Critical Habitat Likely to be Adversely Affected (Section 8): We examine the status of each species and critical habitat that are likely to be adversely affected by the proposed action.

*Environmental Baseline (*Section 9): We describe the environmental baseline in the action area as the condition of the listed species and designated critical habitat in the action area, without the consequences to the listed species or designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process. The consequences to listed species from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline.

Effects of the Action (Section 10): Effects of the action are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action. These are broken into analyses of exposure, response, and risk, as described below for the species that are likely to be adversely affected by the action.

Exposure, Response, and Risk Analyses (Section 10.3, 10.3.2, and 10.4): We identify the number, age (or life stage), and sex of ESA-listed individuals that are likely to be exposed to the stressors and the populations or subpopulations to which those individuals belong. We also identify the unit(s) of designated critical habitat that are likely to be exposed. This is our exposure analysis. We evaluate the available evidence to determine how individuals of those ESA-listed species are likely to respond given their probable exposure. We also consider how designated critical habitat in terms of changes in function. This is our response analysis (Section 10.3.2). We assess the consequences of these responses of individuals that are likely to be exposed to the populations those individuals represent, and the species those populations comprise. We also assess the consequences of responses of critical habitat to the critical habitat unit(s) and how changes in function may affect the conservation value of designated critical habitat. This is our risk analysis (Section 10.4).

Cumulative Effects (Section 11): Cumulative effects are the effects to ESA-listed species and designated critical habitat of future state or private activities that are reasonably certain to occur within the action area (50 C.F.R. §402.02). Effects from future Federal actions that are unrelated to the proposed action are not considered because they require separate ESA section 7 compliance.

Integration and Synthesis (Section 12): With full consideration of the status of the species and the designated critical habitat, we consider the effects of the action within the action area on populations or subpopulations and on the physical and biological features essential to the conservation of the species when added to the environmental baseline and the cumulative effects to determine whether the action could reasonably be expected to:

- Reduce appreciably the likelihood of survival and recovery of ESA-listed species in the wild by reducing its numbers, reproduction, or distribution, and state our conclusion as to whether the action is likely to jeopardize the continued existence of such species; and/or
- Appreciably diminish the value of designated critical habitat for the conservation of an ESA-listed species, and state our conclusion as to whether the action is likely to destroy or adversely modify designated critical habitat.

The results of our jeopardy and destruction and adverse modification analyses are summarized in the *Conclusion* (Section 13). If, in completing the last step in the analysis, we determine that the action under consultation is likely to jeopardize the continued existence of ESA-listed species or destroy or adversely modify designated critical habitat, then we must identify Reasonable and Prudent Alternative(s) to the action, if any, or indicate that to the best of our knowledge there are no reasonable and prudent alternatives (see 50 C.F.R. §402.14(h)(2)).

An *Incidental Take Statement* (Section 14) is included for those actions for which incidental take of ESA-listed species is reasonably certain to occur (see 50 C.F.R. §402.14(g)(7), §402.14(i)). The ITS specifies the amount or extent of take, reasonable and prudent measures to minimize the impact of the take, measures for marine mammals that are necessary to comply with section

101(a)(5) of the MMPA and applicable regulations with regard to such taking, and terms and conditions to implement the reasonable and prudent measures (ESA section 7 (b)(4); 50 C.F.R. §402.14(i)).

We also provide discretionary *Conservation Recommendations* (Section 15) that may be implemented by the action agency (50 C.F.R. §402.14(j)). Finally, we identify the circumstances in which the action agency is required to request *Reinitiation of Consultation* (Section 16) (50 C.F.R. §402.16).

2.1 Evidence Available for the Consultation

To comply with our obligation to use the best scientific and commercial data available, we collected information identified through searches of Google Scholar and literature cited sections of peer reviewed articles, species listing documentation, and reports published by government and private entities. This opinion is based on our review and analysis of various information sources, including:

- Information submitted by the NSF and the Permits Division;
- Government reports (including NMFS biological opinions and stock assessment reports);
- NOAA technical memos; and
- Peer-reviewed scientific literature.

These resources were used to identify information relevant to the potential stressors and responses of ESA-listed species and designated critical habitat under NMFS' jurisdiction that may be affected by the proposed action to draw conclusions on risks the action may pose to the continued existence of these species and the value of designated critical habitat for the conservation of ESA-listed species.

3 DESCRIPTION OF THE PROPOSED 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 upon the high seas.

Two proposed Federal actions were evaluated in this consultation. The first is the NSF's (along with researchers from the L-DEO of Columbia University, University of Texas Institute of Geophysics, and Northern Arizona University, and in collaboration with researchers from the National Autonomous University of Mexico and Kyoto University) proposal to sponsor and conduct a high-energy marine seismic survey on the R/V *Marcus G. Langseth* in the Eastern Tropical Pacific Ocean in and around the Guerrero Gap of the Middle America Trench off the coast of western Mexico in the spring (mid-May to July) of 2022. The R/V *Marcus G. Langseth* is operated by the L-DEO of Columbia University under an existing cooperative agreement.

The principal investigators are Drs. A. Becel (L-DEO), B. Boston (L-DEO), A. Arnulf (University of Texas), and D.J. Shillington (Northern Arizona University). Researchers from the

National Autonomous University of Mexico (Dr. M. Cruz-Atienza) and Kyoto University (Dr. Y. Ito) will also be collaborating with the principal investigators.

The second Federal action is Permits Division's issuance of an IHA authorizing non-lethal MMPA "takes" by Level A and B harassment pursuant to section 101(a)(5)(D) of the MMPA incidental to the NSF's high-energy marine seismic survey in the Eastern Tropical Pacific Ocean.

The proposed NSF action includes a two-dimensional high-energy seismic survey in the Exclusive Economic Zone (EEZ) of Mexico, including International Waters (i.e., the high seas). This project involves the acquisition and analysis of two-dimensional seismic data from the Guerrero Gap and neighboring segments at the Middle America subduction zone, offshore Mexico. This area is one of the best-known examples in the world of along-strike variations in slip behavior of the plate boundary. The seismic data would allow the principal investigators to provide constraints on the properties and geometry of the subduction zone faults, including the abundance and distribution of fluids in both the incoming oceanic plate and within the subduction zone. Results from this project would be valuable for understanding the role of fluids (e.g., seawater) in influencing the contrasting slip behavior both at this subduction zone and other subduction zones worldwide. This project has broad implications for earthquake hazard assessment in the subduction zone off Mexico and would also provide prime constraints on Earth's water budget.

The information presented here is based primarily on the draft environmental analysis, IHA application, the *Federal Register* notice of the proposed IHA, and the draft IHA provided by the NSF and Permits Division as part of their initiation packages, as well as the revised draft final IHA (Appendix A; Section 17).

3.1 National Science Foundation's and Lamont-Doherty Earth Observatory of Columbia University's Proposed Activities

The NSF proposes to fund and conduct a seismic survey in the Eastern Tropical Pacific Ocean on the Research Vessel (R/V) *Marcus G. Langseth* (operated by the L-DEO). A 36-airgun array will be deployed as an energy source. A multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler will be operated during the survey, and ocean-bottom seismometers will collect data.

3.1.1 Seismic Survey Overview

The survey will take place in international waters (i.e., the high seas), the Mexican EEZ (370.4 kilometers [200 nautical miles]), and in the territorial seas of Mexico, in waters depths of approximately 100 to 5,560 meters (328 to 18,242 feet).

All planned seismic data acquisition activities will be conducted by the NSF and researchers, with onboard assistance by technical staff and the marine operations group. The research vessel will be self-contained, and the scientific party and crew will live aboard the vessel for the entire seismic survey.

The R/V *Marcus G. Langseth* is tentatively planned to depart port in mid-May 2022, and return to port in July 2022. The proposed survey consists of eight multi-channel seismic lines, of which six are coincident ocean bottom seismometer refraction lines that are located perpendicular to the margin; these six lines would therefore be acquired twice. The first part of the action involves R/V *Marcus G. Langseth* deploying ocean bottom seismometers along the refraction lines that will be used to record the seismic data. Ocean bottom seismometers are deployed using a boom over the side of the vessel. After the ocean bottom seismometers are placed, the seismic survey activities will begin. Ocean bottom seismometers will be retrieved and re-deployed on subsequent refraction lines before seismic operations resume on that line.

The seismic survey will consist of a total of approximately 48 days, including approximately 20 days of airgun array operations, approximately 19 days of equipment deployment and retrieval, and approximately three days of transit, with six days of contingency time for poor weather, etc. The R/V *Marcus G. Langseth* will depart and return to port in Manzanillo, Mexico. Some minor deviation from the dates is possible, depending on logistics and weather.

The NSF will use conventional seismic survey methodology and the procedures will be similar to those used during previous seismic surveys. Seismic survey protocols generally involve a predetermined set of tracklines. The seismic acquisition or sound source vessel travels down a linear trackline for some distance until a line of data is acquired, then turns and acquires data on a different trackline.

A maximum of approximately 3,600 kilometers (1,944 nautical miles) of tracklines will be surveyed in the Eastern Tropical Pacific Ocean (see Figure 1). The location of the tracklines may shift from what is depicted in Figure 1 depending on factors such as mechanical issues, poor data quality, weather, etc.

There will be additional airgun array operations in the seismic survey area associated with turns, airgun array testing, and repeat coverage of any areas where initial data quality is considered sub-standard by the project scientists due to equipment failure or shutdowns and ramp-ups for protected species.

3.1.2 Vessel Specifications

The seismic survey will involve one source vessel, the U.S.-flagged R/V *Marcus G. Langseth*. The R/V *Marcus G. Langseth* is owned by the NSF and operated by Columbia University's L-DEO under an existing Cooperative Agreement. The R/V *Marcus G. Langseth* has a length of 72 meters (235 feet), a beam of 17 meters (56 feet), and a maximum draft of 5.9 meters (19.4 feet). It is 2,842 gross tons. Its propulsion system consists of two diesel Bergen BRG-6 engines, each producing 3,550 horsepower, and an 800 horsepower bow thruster. The R/V *Marcus G. Langseth*'s design is that of a seismic research vessel, with a particularly quiet propulsion system to avoid interference with the seismic signals. During the two-dimensional seismic survey, the vessel speed will be approximately 7.8 kilometers per hour (4.2 knots) and approximately 8.3 kilometers per hour (4.5 knots) during the three-dimensional seismic survey. When not towing seismic survey gear, the R/V *Marcus G. Langseth* typically cruises at 18.5 kilometers per hour (10 knots) and has a range of approximately 13,500 kilometers (7,289.4 nautical miles). No chase vessel will be used during seismic survey activities. The R/V *Marcus G. Langseth* will also serve as the platform from which vessel-based protected species observers (PSOs) (acoustic and visual) will listen and watch for animals (e.g., marine mammals and sea turtles).

3.1.3 Airgun Array and Acoustic Receiver Description

The energy source for the seismic survey was chosen by the NSF to be the lowest practical to meet the scientific objectives.

During the seismic survey, the R/V *Marcus G. Langseth* will deploy an airgun array (i.e., a certain number of airguns of varying sizes in a certain arrangement) as an energy source. An airgun is a device used to emit acoustic energy pulses downward through the water column and into the seafloor, and generally consists of a steel cylinder that is charged with high-pressure air. Release of the compressed air into the water column generates a signal that reflects (or refracts) off the seafloor and/or sub-surface layers having acoustic impedance contrast. When fired, a brief (approximately 0.1 second) pulse of sound is emitted by all airguns nearly simultaneously. The airguns are silent during the intervening periods with the array typically fired on a fixed distance (or shot point) interval. The return signal is recorded by a listening device (e.g., receiving system) and later analyzed with computer interpretation and mapping systems used to depict the sub-surface. In the proposed action, the receiving system will consist of the towed hydrophone array, and the ocean bottom seismometers.

The R/V *Marcus G. Langseth* will deploy a 15-kilometer towed hydrophone streamer and an airgun array to conduct the two-dimensional multi-channel seismic survey. Ocean bottom seismometers would be deployed, retrieved, and then re-deployed during the survey. The ocean bottom seismometers would receive and store the returning acoustic signals; data will be analyzed later after the devices are retrieved.

The airgun array for the two-dimensional seismic survey will consist of 36 Bolt airguns (plus four spares) with a total discharge volume of 108,154.6 cubic centimeters (6,600 cubic inches [in^3]) (Table 1). The airguns will be configured as four identical linear arrays or “strings”. The four airgun strings will be towed behind the R/V *Marcus G. Langseth* and will be distributed across an area approximately 24 meters (78.7 feet) by 16 meters (52.5 feet). The shot interval will be approximately 16 to 17 seconds (approximately every 37.5 meters [123 feet]). The firing pressure of the airgun array will be approximately 1,900 pounds per square inch (psi) (plus or minus 100 psi). The four airgun strings will be towed approximately 30 meters (98 feet) behind the vessel at a tow depth of 12 meters (39.4 feet). Other source array specifications such as source output (underwater decibels referenced to one micro Pascal at one meter [root mean squared; dB re 1μPa-m]), pulse duration, and dominant frequency components in Table 1.

It is expected that the airgun array will be active 24 hours per day during the seismic survey, where airgun operations will occur during daylight hours only). Airguns will operate continually during the seismic survey period except for unscheduled shutdowns.

Table 1. Source array and survey specifications for the proposed two-dimensional seismic survey off Mexico in the Eastern Pacific Ocean.

Source array specifications	
Energy source	36 Bolt 40 to 360-in^3 air guns 4 strings
Source output (downward)-36 air gun array	Zero to peak = 258 dB re 1 μPa-m Peak to peak = 264 dB re 1 μPa-m
Air discharge volume	~ 6,600-in^3
Pulse duration	0.1 second
Shot interval	37.5 m
Dominant frequency components	2 to 188 hertz
Tow depth	12-meters
Sound source velocity (tow speed)	4.2 knots (7.8 kilometers per hour)

The receiving system will consist of a single 15-kilometer (8.1 nautical miles) long towed hydrophone streamer (for the two-dimensional seismic survey), and ocean bottom seismometers. A longer hydrophone streamer, like the one proposed for this action, provides opportunities to suppress unwanted energy that interferes with imaging targets, allows for accurate measurements of seismic velocities, and provides a large amount of data redundancy for enhancing seismic images during data processing. As the airgun array is towed along the tracklines, the hydrophone streamer will receive the returning acoustic signals and transfer the data to the onboard processing system. The ocean bottom seismometers will receive and store the returning acoustic signals internally for later analysis.

During the seismic survey, the R/V *Marcus G. Langseth* will deploy up to 33 ocean bottom seismometers (Figure 1). The ocean bottom seismometers would be placed along the refraction lines (see Figure 1). The 33 ocean bottom seismometers will be deployed, retrieved, serviced, and then deployed again for the next refraction survey line, at 124 sites in total. Ocean bottom seismometers placed every 10 or 12 kilometers (6.2 or 7.5 miles) Ocean bottom seismometers have a height and diameter of 1 meter, and an 80-kilogram (176.4 pound) steel anchor.

To retrieve an ocean bottom seismometer placed on the sea floor, an acoustic release transponder (pinger) transmits a signal to the instrument at a frequency of 8 to 11 kilohertz (kHz) and a response is received at a frequency of 11.5 to 13 kHz (operator selectable) to activate and release the instrument. The transmitting beam pattern is 55 degrees. The sound source level is approximately 93 decibels. The pulse duration is two milliseconds (±10 percent) and the pulse repetition rate is one per second (±50 microseconds). The transponder will trigger the burn-wire assembly that releases the instrument from the anchor on the sea floor and the device floats to the surface. The anchor for the ocean bottom seismometer is scuttled and left on the sea floor.

3.1.4 Multibeam Echosounder and Sub-bottom Profiler

Along with operations of the airgun array, three additional acoustical data acquisition systems will operate during the seismic survey from the R/V *Marcus G. Langseth*. The Kongsberg EM 122 multi-beam echosounder and Knudsen Chirp 3260 sub-bottom profiler will map the ocean floor during the seismic survey. The multi-beam echosounder and sub-bottom profiler sound sources will operate continuously from the R/V *Marcus G. Langseth*, including simultaneously with the airgun array, but not during transit to and from the seismic survey area.

3.1.4.1 Multibeam Echosounder

The ocean floor will be mapped with the Kongsberg EM122 multi-beam echosounder. The multi-beam echosounder is a hull-mounted system operating at 10.5 to 13 (usually 12) kHz. The transmitting beamwidth is one or two degrees fore-aft and 150 degrees (maximum) athwartship (i.e., perpendicular to the ship's line of travel). The maximum sound source level is 242 dB re: 1 µPa-m. Each ping consists of eight (in water greater than 1,000 meters [3,281 feet]) or four (in water less than 1,000 meters [3,281 feet]) successive fan-shaped transmissions, each ensonifying a sector that extends one degree fore-aft. Continuous-wave signals increase from 2 to 15 milliseconds long in water depths up to 2,600 meters (8,530 feet) and frequency modulated chirp signals up to 100 milliseconds long are used in water greater than 2,600 meters (8,530 feet). The successive transmissions span an overall cross-track angular extent of about 150 degrees, with two millisecond gaps between the pings for successive sectors.

3.1.4.2 Sub-bottom Profiler

The ocean floor will also be mapped with the Knudsen 3260 sub-bottom profiler. The sub-bottom profiler is normally operated to provide information about the near sea floor sedimentary features and the bottom topography that is mapped simultaneously by the multi-beam echosounder. The beam is transmitted as a 27-degree cone, which is directed downward by a 3.5-kHz transducer in the hull of the R/V *Marcus G. Langseth*. The nominal power output is 10 kilowatts, but the actual maximum radiated power is 3 kilowatts or 222 dB re: 1 µPa at 1 meter 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 sub-bottom profiler is capable of reaching depths of 10,000 meters (32,808.4 feet).

3.1.5 Proposed Conservation Measures

The NSF and L-DEO are obligated to enact mitigation measures to have their 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 or adverse effects on their designated critical habitats. Monitoring is used to observe or check the progress of the mitigation over time and can also be used to ensure that any measures implemented to reduce or avoid adverse effects on ESA-listed species are successful.

If a final IHA is issued, Permits Division would likely require, and the NSF and L-DEO will implement, the mitigation and monitoring measures listed below pertaining to marine mammals. The NSF and L-DEO included conservation measures that would apply to sea turtles, and those measures are included in this section as well. For sea turtles, the NSF included conservation measures as part of its proposed action, namely an exclusion zone, vessel avoidance procedures, and shut down procedures. These mitigation and monitoring measures are required during the seismic survey to reduce the potential for injury to or harassment of marine mammals and sea turtles. Additional details for each likely mitigation and monitoring measure are described in subsequent sections of this opinion, specifically:

- Proposed exclusion and buffer zones;
- Shut-down procedures;
- Ramp-up procedures;
- Visual monitoring by NMFS-approved PSOs;
- Passive acoustic monitoring (PAM);
- Vessel strike avoidance measures; and
- Additional mitigation measures.

Additional details on the other proposed MMPA mitigation and monitoring measures (e.g., shut-down and ramp-up procedures) can be found in Permits Division *Federal Register* notice of proposed incidental harassment authorization and request for comments on proposed incidental authorization and possible renewal (87 FR 1992; January 12, 2022) and Appendix A (Section 17).

3.1.5.1 Proposed Exclusion and Buffer Zones—Ensonified Area

If a final IHA is issued, the Permits Division would require, and the NSF and L-DEO would implement, exclusion zones around the R/V *Marcus G. Langseth* to minimize any potential adverse effects of the sound from the airgun array on MMPA and ESA-listed marine mammals. The NSF included measures for sea turtles as part of its proposed action. The exclusion zones are 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 exclusion zones are based upon modeled sound levels at various distances from the R/V *Marcus G. Langseth*, and correspond to the respective species' sound thresholds for potential injury and behavioral effects to MMPA and ESA-listed species.

3.1.5.2 Ensonified Area

The L-DEO model results are used to determine the 160 dB re: 1 µPa (rms) radius for single 40 cubic inch airgun array and 36 airgun array in shallow (less than 100 meters (328 feet) deep), intermediate (100 to 1,000 meters deep), and deep water (greater than 1,000 meters [3,280.8 feet]). This sound level was chosen because it corresponds to the distance at which Level B harassment under the MMPA occurs. Received sound levels were predicted by L-DEO’s model (Diebold et al. 2010), which uses ray tracing for the direct wave traveling from the airgun array to the receiver and its associated source ghost (i.e., reflection at the air-water interface in the vicinity of the airgun array), in a constant-velocity half-space (infinite homogeneous ocean layer, unbounded by a seafloor).

Measurements have not been reported for the single 40 cubic inch airgun array. The L-DEO model results are used to determine the 160 dB re: 1 µPa (rms) radius for the single 40 cubic inch airgun array at a tow depth of 12 meters (39.4 feet) in shallow, intermediate, and deep water. The estimated distances to the 160 dB re: 1 µPa (rms) isopleths for the single 40 cubic inch airgun array and 36-airgun array are in Table 2.

Table 2. Predicted distances to which sound levels of 160 dB re: 1 µPa (rms) for impulsive sources will be received from the single 40 cubic inch airgun and the 36-airgun array in shallow, intermediate, and deep water depths for marine mammals during the propos

Source	Volume (in^3)	Water Depth (m)	Predicted Distance to Threshold (160 dB re: 1 µPa [rms]) (m)
1 Airgun	40	<100	1,041
		100 to 1,000	647
		>1,000	431
36 Airguns	6,600	<100	25,494
		100 to 1,000	10,100
		>1,000	6,733

in^3=cubic inches
m=meters

The NSF will implement an exclusion zone for sea turtles. An exclusion zone of 150 meters will be used as a shutdown distance for sea turtles (see Section 10.3.1.3 below). This distance is practicable for PSOs to implement shutdowns, and is sufficiently large to prevent sea turtles from being exposed to sound levels that could result in the onset of permanent threshold shift (PTS) in hearing as a result of auditory injury and therefore harm under the ESA. The buffer zone will correspond to the predicted 175 dB re: 1 μPa (rms) behavioral harassment threshold distances (constituting harassment under the ESA) to which sound source levels will be received from the single airgun array and 36 airgun array in shallow, intermediate, and deep water depths described in Table 3.

Table 3. Predicted distances to which sound levels of 175 dB re: 1 μPa (rms) will be received from the single 40 cubic inch airgun and the 36-airgun array in shallow, intermediate, and deep-water depths for sea turtles during the proposed seismic survey in the Eastern Tropical Pacific Ocean.

Source	Volume (in^3)	Water Depth (m)	Predicted Distance to Threshold (175 dB re: 1 μPa [rms]) (m)
1 Airgun	40	<100	170
		100 to 1,000	116
		>1,000	77
36 Airguns	6,600	<100	4,123
		100 to 1,000	2,796
		>1,000	1,864

in^3=cubic inches

m=meters

Note: The NSF and L-DEO will use a 150 meter exclusion zone in all water depths for the 36 airgun array as the shut-down distance for sea turtles.

3.1.5.3 Establishment of Proposed Exclusion and Buffer Zones

An exclusion zone is a defined area within which occurrence of an animal triggers mitigation action intended to reduce the potential for certain outcomes (e.g., auditory injury, disruption of critical behaviors). For marine mammals, PSOs will establish a default (minimum) exclusion zone with a 500 meter (1,640.4 feet) radius for visual monitoring for the 36-airgun array. The 500 meter (1,640.4 feet) exclusion zone will be based on the radial distance from any element of the airgun array (rather than being based on the center of the airgun array or around the vessel itself). With certain exceptions (described below), if a marine mammal appears within, enters, or appears on course to enter this zone, the airgun array will be powered-down or shut-down, depending on the circumstance. As stated earlier, for sea turtles, NSF will establish an exclusion zone of 150 meters (492 feet), with the buffer zone corresponding to the distance to the 175 dB threshold.

The buffer zone means an area beyond the exclusion zone to be monitored for the presence of marine mammals and sea turtles that may enter the exclusion zone. The buffer zone encompasses the area at and below the sea surface from the edge of the zero to 150-meter (zero to 492 feet; for sea turtles), zero to 500-meter (zero to 1,640.4 feet; for marine mammals) exclusion zone, out to a radius of 1,000 meters (3,280.8 feet) from the edges of the airgun array (500 to 1,000 meters [1,640.4 to 3,280.8 feet]).

The 500 meter (1,640.4 feet) exclusion zone for marine mammals is intended to be precautionary in the sense that it will be expected to contain sound exceeding the injury criteria for all cetacean hearing groups (based on the dual criteria of the cumulative sound exposure level (SEL_{cum}) and peak sound pressure level (SPL); see Table 8 in Response Analysis), while also providing a consistent, reasonably observable zone within which PSOs will typically be able to conduct effective observations. Additionally, a 500 meter (1,640.4 feet) exclusion zone is expected to minimize the likelihood that marine mammals will be exposed to levels likely to result in more severe behavioral responses. Although significantly greater distances may be observed from an elevated platform under good conditions, the Permits Division believes that 500 meters (1,640.4 feet) is likely regularly attainable for PSOs using the naked eye during typical conditions.

The NSF's draft environmental analysis and L-DEO's incidental harassment authorization application have a detailed description of the modeling for the R/V *Marcus G. Langseth*'s airgun arrays, as well as the resulting isopleths to thresholds for the various marine mammal hearing groups and sea turtles (Tables 2 and 3). Predicted distances to PTS threshold isopleths, which vary based on marine mammal hearing groups, were calculated based on modeling performed by L-DEO using the NUCLEUS software program and the NMFS User Spreadsheet (https://www.fisheries.noaa.gov/action/user-manual-optional-spreadsheet-tool-2018-acoustic-technical-guidance; Table 4). For a discussion on how we evaluated and adopted the NSF and L-DEO's analysis, see Section 10.3.1.

Table 4. Predicted distances to permanent threshold shift thresholds for impulsive sources for various marine mammal hearing groups and sea turtles that could be received from the 36-airgun arrays during the proposed seismic survey in the Eastern Tropical Pacific Ocean.

Threshold	Low Frequency Cetaceans (m)	Mid Frequency Cetaceans (m)	High Frequency Cetaceans (m)	Phocid Pinnipeds (m)	Otariid Pinnipeds (m)	Sea Turtles (m)
Source – 36 Airgun Array, 50-meter shot interval						
SEL_{cum}	320.2	0	1.0	10.4	0	15.4
Peak SPL_{flat}	38.9	13.6	268.3	43.7	10.6	10.6

m=meters

3.1.5.4 Shutdown Procedures

The shutdown of the airgun array requires the immediate deactivation of all individual elements of the airgun array. PSOs will be required to delay the start of seismic survey activities or to call for shutdown of the airgun array if a marine mammal or sea turtle is detected within the applicable exclusion zone. The operator must also establish and maintain clear lines of communication directly between PSOs on duty and crew controlling the airgun array to ensure that shutdown commands are conveyed swiftly while allowing PSOs to maintain watch. When both visual and acoustic PSOs are on duty, all detections will be immediately communicated to the remainder of the on-duty PSO team for potential verification of visual observations by the acoustic PSO or of acoustic detections by visual PSOs. When the airgun array is active (i.e., anytime one or more airgun is active, including during ramp-up) and (1) a marine mammal appears within or enters the applicable exclusion zone and/or (2) a marine mammal (other than delphinds) is detected acoustically and localized within the applicable exclusion zone, the airgun array will be shut-down. When shutdown is called for by a PSO, the airgun array will be immediately deactivated and any dispute resolved only following deactivation. Additionally, shut-down will occur whenever PAM alone (without visual sighting), confirms presence of marine mammal(s) or sea turtle(s) in the exclusion zone. If the acoustic PSO cannot confirm presence within the exclusion zone, visual PSOs will be notified but shutdown is not required.

Following a shutdown, the airgun array activity will not resume until the animal has cleared the exclusion zone – the 500-meter (1,640.4 feet) exclusion zone in the case of marine mammals or 150-meter exclusion zone in the case of sea turtles. For marine mammals, the animal will be considered to have cleared the 500 meter exclusion zone if the marine mammal is visually observed to have departed the 500 meter exclusion zone, or it has not been seen within the 500 meter exclusion zone, or if has not been seen within the 500 meter exclusion zone for 15 minutes in the case of small odontocetes and pinnipeds, or 30 minutes in the case of mysticetes and large odontocetes, including sperm whales. For sea turtles, the animal is considered to have cleared the 150-meter exclusion zone if it is visually observed to have departed the 150-meter exclusion zone, or it has not been seen in the 150-meter exclusion zone for 15 minutes.

In addition to the shutdown procedures described above, the Permits Division's MMPA incidental harassment authorization will require shutdowns if:

- Any large whale (defined as a sperm whale or any mysticete [baleen whale]) species with a calf (defined as an animal less than two-thirds the body size of an adult observed to be in close association with an adult) is observed at any distance.
- An aggregation of six or more large whales is observed at any distance.

3.1.5.5 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. Ramp-up begins by first activating a single airgun of the smallest volume, followed by doubling the number of active elements in stages until the full complement of an airgun array are active. Each stage will be approximately the same duration, and the total duration will not be less than approximately 20 minutes. The intent of pre-clearance observation (30 minutes) is to ensure no protected species are observed within the buffer zone prior to the beginning of ramp-up. During pre-clearance is the only time observations of protected species in the buffer zone will prevent operations (i.e., the beginning of ramp-up). The intent of ramp-up is to warn protected species of pending seismic survey activities and to allow sufficient time for those animals to leave the immediate vicinity. A ramp-up procedure, involving a step-wise increase in the number of airguns firing and total airgun array volume until all operational airguns are activated and the full volume is achieved, is required at all times as part of the activation of the airgun array. All operators must adhere to the following pre-clearance and ramp-up requirements:

- The operator must notify a designated PSO of the planned start of ramp-up as agreed upon with the lead PSO; the notification time will not be less than 60 minutes prior to the planned ramp-up in order to allow the PSO time to monitor the exclusion and buffer zones for 30 minutes prior to the initiation of ramp-up (pre-clearance);
- Ramp-ups will be scheduled so as to minimize the time spent with the airgun array activated prior to reaching the designated run-in;
- One of the PSOs conducting pre-clearance observations must be notified again immediately prior to initiating ramp-up procedures and the operator must receive confirmation from the PSO to proceed;
- Ramp-up may not be initiated if any marine mammals or sea turtle is within the applicable exclusion or buffer zone. If a marine mammal or sea turtle is observed within the applicable exclusion zone or the buffer zone during the 30 minute pre-clearance period, ramp-up may not begin until the animal(s) has been observed exiting the zones or until an additional time period has elapsed with no further sightings (15 minutes for small odontocetes and sea turtles) and 30 minutes for all other species (e.g. marine mammals).
- Ramp-up will begin by activating a single airgun array of the smallest volume in the airgun array and will continue in stages by doubling the number of active elements at the commencement of each stage, with each stage of approximately the same duration. Duration will not be less than 20 minutes. The operator must provide information to the PSO documenting that appropriate documenting that appropriate procedures were followed;
- PSOs must monitor the exclusion and buffer zones during ramp-up, and ramp-up must cease and the airgun array must be shutdown upon observation of a marine mammal or sea turtle within the applicable exclusion zone. Once ramp-up has begun, observations of marine mammals within the buffer zone do not require shut-down, but such observation will be communicated to the operator to prepare for the potential shut-down;
- Ramp-up may occur at times of poor visibility, including nighttime, if appropriate acoustic monitoring has occurred with no detections in the 30 minutes prior to beginning

ramp-up. Airgun array activation may only occur at times of poor visibility where operational planning cannot reasonably avoid such circumstances;

- If the airgun array is shut-down for brief periods (i.e., less than 30 minutes) for reasons other than that described for shut-down (e.g., mechanical difficulty), it may be activated again without ramp-up if PSOs have maintained constant visual and/or PAM and no visual or acoustic detections of marine mammals or sea turtles have occurred within the applicable exclusion zone. For any longer shutdown, pre-clearance observation and ramp-ups are required. For any shut-down at night or in periods of poor visibility (e.g., Beaufort sea state 4 or greater), ramp-up is required, but if the shut-down period was brief and constant observation was maintained, pre-clearance watch of 30 minutes is not required; and
- Testing of the airgun array involving all elements requires ramp-up. Testing limited to individual elements or strings of the airgun array does not require ramp-up but does require pre-clearance of 30 minutes.

3.1.5.6 Vessel-based Visual Mitigation Monitoring

Visual monitoring requires the use of trained PSOs to scan the ocean surface visually for the presence of marine mammals or sea turtles. The area to be scanned visually includes primarily the exclusion zone (0 to 500 meters), but also the buffer zone. As described above, the buffer zone is an area beyond the exclusion zone to be monitored for the presence of marine mammals and sea turtles that may enter the exclusion zone. During pre-clearance monitoring (i.e., before ramp-up begins), the buffer zone also acts as an extension of the exclusion zone in that observations of marine mammals and sea turtles within the buffer zone will also prevent airgun array operations from beginning (i.e., ramp-up). Visual monitoring of the exclusion zone and adjacent waters is intended to establish and, when visual conditions allow, maintain zones around the sound source that are clear of marine mammals and sea turtles, thereby reducing or eliminating the potential for injury and minimizing the potential for more severe behavioral reactions for animals occurring close to the vessel. Visual monitoring of the buffer zone is intended to (1) provide additional protection to naïve marine mammals that may be in the area during pre-clearance; and (2) during use of the airgun array, aid in establishing and maintaining the exclusion zone by alerting the visual PSO and crew of marine mammals and sea turtles that are outside of, but may approach and enter, the exclusion zone.

The NSF and L-DEO must use at least five dedicated, trained, NMFS-approved PSOs. The PSOs must have no tasks other than to conduct observational effort, record observational data, and communicate with and instruct relevant vessel crew with regard to the presence of marine mammals and sea turtles and mitigation requirements. The PSO resumes shall be provided to NMFS for approval.

At least one of the visual and two of the acoustic PSOs aboard the vessel must have a minimum of 90 days at-sea experience working in those roles, respectively, during a deep penetration (i.e., high-energy) seismic survey, with no more than 18 months elapsed since the conclusion of the at-sea experience. One visual PSO with such experience shall be designated as the lead for the entire PSO team. The lead PSO shall serve as the primary point of contact for the vessel operator and ensure all PSO requirements per the MMPA incidental harassment authorization and the Incidental Take Statement are met. To the maximum extent practicable, the experienced PSOs will be scheduled to be on duty with those PSOs with appropriate training but who have not yet gained relevant experience.

During seismic survey activities (e.g., any day on which use of the airgun array is planned to occur, and whenever the airgun array is in the water, whether activated or not), a minimum of two visual PSOs must be on duty and conducting visual observations at all times during daylight hours (i.e., from 30 minutes prior to sunrise through 30 minutes following sunset) and 30 minutes prior to and during nighttime ramp-ups of the airgun array. Visual monitoring of the exclusion and buffer zones must begin no less than 30 minutes prior to ramp-up and must continue until one hour after use of the airgun array ceases or until 30 minutes past sunset. Visual PSOs shall coordinate to ensure 360-degree visual coverage around the vessel from the most appropriate observation posts, and shall conduct visual observations using binoculars and the naked eye while free from distractions and in a consistent, systematic, and diligent manner.

The PSOs will establish and monitor the buffer and exclusion zones. During use of the airgun array (i.e., anytime the airgun array is active, including ramp-up), occurrences of marine mammals and sea turtles within the buffer zone (but outside the exclusion zone) will be communicated to the operator to prepare for the potential shutdown for the airgun array.

Visual PSOs will immediately communicate all observations to the on-duty acoustic PSO(s), including any determination by the PSO regarding species identification, distance, and bearing and the degree of confidence in the determination. Any observations of marine mammals and sea turtles by crewmembers will be relayed to the PSO team. During good conditions (e.g., daylight hours, Beaufort sea state three or less), visual PSOs will conduct observations when the airgun array is not operating for comparison of sighting rates and behavior with and without use of the airgun array and between acquisition periods, to the maximum extent practicable. Visual PSOs may be on watch for a maximum of four consecutive hours followed by a break of at least one hour between watches and may conduct a maximum of 12 hours of observation per 24-hour period. Combined observational duties (visual and acoustic, but not at the same time) may not exceed 12 hours per 24-hour period for any individual PSO.

3.1.5.7 Passive Acoustic Monitoring

PAM means the use of trained personnel operators herein referred to as acoustic PSOs to operate passive acoustic monitoring equipment to acoustically detect the presence of marine mammals. PAM involves acoustically detecting marine mammals, regardless of distance from the airgun array, as localization of animals may not always be possible. PAM is intended to further support visual monitoring (during daylight hours) in maintaining an exclusion zone around the airgun array that is clear of marine mammals. In cases where visual monitoring is not effective (e.g., due to weather, nighttime), PAM may be used to allow certain activities to occur, as further detailed below.

PAM will take place in addition to the visual monitoring program. Visual monitoring typically is not effective during periods of poor visibility or at night, and even with good visibility, is unable to detect marine mammals when they are below the surface or beyond visual range. PAM can be used in addition to visual observations to improve detection, identification, and localization of cetaceans. The passive acoustic monitoring will serve to alert visual PSOs (if on duty) when vocalizing cetaceans are detected. It is only useful when marine mammals call, but it can be effective either by day or night, and does not depend on good visibility. It will be monitored in real time so that the visual PSOs can be advised when cetaceans are detected.

The R/V *Marcus G. Langseth* will use a towed passive acoustic monitoring system, which must be monitored by 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. Acoustic PSOs may be on watch for a maximum of four consecutive hours followed by a break of at least one hour between watches and may conduct a maximum of 12 hours of observation per 24-hour period for any individual PSO.

Seismic survey activities may continue for 30 minutes when the PAM system malfunctions or is damaged, while the PAM operator diagnoses the issue. If the diagnosis indicates that the PAM system must be repaired to solve the problem, operations may continue for an additional five hours without PAM during daylight hours only under the following conditions:

- Beaufort sea state is less than or equal to four;
- No marine mammals (excluding delphinids) detected solely by PAM in the applicable exclusion zone in the previous two hours;
- NMFS is notified via email as soon as practicable with the time and location in which operations began occurring without an active PAM system; and
- Operations with an active airgun array, but without an operating PAM system, do not exceed a cumulative total of four hours in any 24-hour period.

3.1.5.8 Vessel Strike Avoidance

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

- The vessel operator (R/V *Marcus G. Langseth*) 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 and regardless of vessel size, to avoid striking any marine mammal and sea turtle during seismic survey activities as well as transits. A single marine mammal at the surface may indicate the presence of submerged animals in the vicinity of the vessel; therefore, precautionary measures should be exercised when an animal is observed. A visual observer aboard the vessel will monitor a vessel strike avoidance zone around the vessel, to ensure the potential for vessel strike is minimized, according to the parameters stated below. Visual observers monitoring the vessel strike avoidance zone can be either third-party PSOs or crew members, but crew members responsible for these duties will be provided sufficient training to distinguish marine mammals and sea turtles from other phenomena and broadly to identify marine mammals and sea turtles to broad taxonomic group (i.e., as a large whale or other marine mammal).

- Vessel speeds must be reduced to 18.5 kilometers per hour (10 knots) or less when mother/calf pairs, pods, or large assemblages of marine mammals are observed near the vessel.
- The vessel (R/V *Marcus G. Langseth*) will maintain a minimum separation distance of 100 meter (328.1 feet) from large whales (i.e., all baleen whales and sperm whales).
- The vessel will maintain a minimum separation distance of 50 meter (164 feet) from all other marine mammals and sea turtles, with an exception made for animals that approach the vessel.
- When marine mammals 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 towing gear.

3.1.5.9 Mitigation for Central America Humpback Whale DPS

To prevent exposure of Central America DPS humpback whales in habitat during a time when they are breeding, calving, and nursing, the NSF will not conduct seismic survey activities in the nearshore portions (i.e., survey tracklines) of the action area until after May 1st. The Permits Division will include this restriction in the final IHA, if issued. Based on local data, humpback whales generally have left the action area by late spring (Audley 2022).

We define "nearshore lines" as those where the ensonified area comes within 33.4 kilometers of shore, 33.4 kilometers being the maximum distance from shore of a humpback sighting in the action area (Audley 2022). For example, the 264-kilometer line running parallel to shore off Guerrero (known as MCS04, about 30.4 kilometers from shore) is characterized as being “nearshore”. We also consider the connector lines and portions of lines landward of this line (MCS04) as being nearshore, as well as portions of the contingency sites (i.e,. the three “crosses", one off Guerrero near MCS04, and two crosses northwest of that line, off Colima and Michoacán) (Figure 1).

No portion of the tracklines occur in waters less than 100 meters deep. However, due to the proximity of the tracklines to shore, and the size of the ensonified area for intermediate water depths (10.1 kilometers), the ensonified area for tracklines in those areas could extend into likely humpback whale nearshore habitat areas.

3.1.6 National Marine Fisheries Service's Proposed Activities

On August 18, 2021, Permits Division received a request from the NSF and L-DEO for an incidental harassment authorization under the MMPA to take marine mammals incidental to conducting a high-energy marine seismic survey over the Guerrero Gap off the coast of Mexico in the Eastern Tropical Pacific. On December 15, 2021, Permits Division deemed the NSF and L-DEO's application for an MMPA incidental harassment authorization to be adequate and complete. The NSF and L-DEO's request is for take of a small number of 30 species of marine mammals by MMPA Level A and Level B harassment. Neither the NSF, L-DEO, nor Permits Division expects serious injury or mortality to result from the proposed activities; therefore, an MMPA incidental harassment authorization is appropriate. The incidental harassment authorization will be valid for a period of one year from the date of issuance. The Permits Division proposes to issue the incidental harassment authorization by April 30, 2022, so that the NSF and L-DEO's will have the incidental harassment authorization prior to the start of the proposed activities.

3.1.7 National Marine Fisheries Service's Proposed Incidental Harassment Authorization

The Permits Division is proposing to issue an incidental harassment authorization authorizing non-lethal "takes" by MMPA Level A and Level B harassment of marine mammals incidental to the planned seismic survey. These incidental takes under MMPA are the equivalent of incidental take by harass (Level B) and harm (Level A) under ESA. For the ESA-listed marine mammals, only Level B harassment would be authorized in the IHA. The incidental harassment authorization, if issued, will be valid for a period of one year from the date of issuance. The incidental harassment authorization, if issued, will authorize the incidental harassment of the following threatened and endangered marine mammal species: blue whale (*Balaenoptera musculus*), fin whale (*Balaenoptera physalus*), Central America distinct population segment (DPS) of humpback whale (*Megaptera novaeangliae*), sei whale (*Balaenoptera borealis*), sperm whale (*Physeter macrocephalus*), and Guadalupe fur seal (*Arctocephalus townsendi*). The proposed incidental harassment authorization identifies requirements that the NSF must comply with as part of its authorization, which were discussed in the last section.

On January 11, 2022, Permits Division published a notice of proposed incidental harassment authorization and request for comments on proposed incidental harassment authorization and possible renewal in the *Federal Register* (87 FR 1992). The public comment period closed on February 12, 2022. Appendix A, Section 17, contains the draft final incidental harassment authorization.

4 POTENTIAL STRESSORS

The proposed action involves multiple activities, each of which can create stressors. Stressors are any physical, chemical, or biological entity that may directly or indirectly induce an adverse response either in an ESA-listed species or their designated critical habitat. During consultation, we deconstructed the proposed action to identify stressors that are reasonably certain to result from the proposed activities. These can be categorized as pollution (e.g., exhaust, fuel, oil, trash), vessel strikes, acoustic and visual disturbance (research vessel, multi-beam echosounder, sub-bottom profiler, acoustic Doppler current profiler, ocean bottom seismometers, and seismic airgun array), and entanglement in towed seismic equipment (hydrophone streamers). Below we provide information on these potential stressors. Furthermore, the proposed action includes several conservation measures described in Section 3.1.5 that are designed to minimize effects that may result from these potential stressors. While we consider all of these measures important and expect them to be effective in minimizing the effects of potential stressors, they do not completely eliminate the identified stressors. Nevertheless, we treat them as part of the proposed action and fully consider them when evaluating the effects of the proposed action (Section 3).

4.1 Pollution

The operation of the R/V *Marcus G. Langseth* as a result of the proposed action may result in pollution from exhaust, fuel, oil, trash, and other debris. Air and water quality are the basis of a healthy environment for all species. Emissions pollute the air, which could be harmful to air-breathing organisms and lead to ocean pollution (Duce et al. 1991; Chance et al. 2015). The release of marine debris such as paper, plastic, wood, glass, and metal associated with vessel operations can also have adverse effects on marine species most commonly through entanglement or ingestion (Gall and Thompson 2015), while the discharge of gray water and wastewater (containing pollutants) from the vessels can degrade habitat for marine life. Conversely, depending on whether the surrounding area is nutrient-poor or not, discharging wastewater can potentially increase productivity in the short-term, if the wastewater has nutrients in it. While lethal and non-lethal effects to air-breathing marine animals such sea turtles, birds, and marine mammals from marine debris are well documented, marine debris also adversely affects marine fish (Gall and Thompson 2015). In addition, the ocean bottom seismometers have anchors that will remain after the recording devices (i.e., seismometers) are retrieved, constituting marine debris.

4.2 Vessel Strikes

Seismic surveys necessarily involve vessel traffic within the marine environment, and the transit of any research vessel in waters inhabited by ESA-listed species carries the risk of a vessel strike. Vessel strikes are known to 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 vessel collision depends on the number, size, and speed of vessels, as well as the distribution, abundance, and behavior of the species (Laist et al. 2001; Jensen and

Silber 2004; Hazel et al. 2007; Vanderlaan and Taggart 2007; Conn and Silber 2013b). If an animal is struck by a research vessel, it may experience minor, non-lethal injuries, serious injuries, or death.

4.3 Operational Noise and Visual Disturbance from Vessels and Equipment

The proposed action will produce a variety of different sounds associated with the operation of the vessels and the equipment, including multi-beam echosounders, sub-bottom profilers, acoustic Doppler current profilers, ocean bottom seismometers, and airgun arrays that may produce an acoustic disturbance or otherwise affect ESA-listed species. Operational noise from vessels and equipment may also make the area in and around the sound source undesirable for marine life (prey species like fishes and invertebrates, as well as ESA-listed species), causing them to vacate a particular area. This presence of vessels (and associated equipment) produces a visual disturbance that may affect ESA-listed marine mammals, sea turtles, and fishes.

4.4 Gear Interaction

The towed seismic equipment (e.g., airgun array and hydrophones) that will be used in the proposed seismic survey activities may pose a risk of entanglement to ESA-listed species. The gear used in the proposed action may also strike ESA-listed species while in use, or during deployment or retrieval, resulting in injury. This is a possibility for the oceans bottom seismometers in particular, as they will be lowered into the water from the vessel by a boom, and then, weighted down with an 80-kilogram steel anchor, would drop to the ocean floor. 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). Marine mammal, sea turtle, and fish entanglement, or bycatch, is a global problem that every year results in the death of hundreds of thousands of animals worldwide. Entangled marine mammals and sea turtles may drown or starve due to being restricted by gear, suffer physical trauma and systemic infections, and/or be hit by vessels due to an inability to avoid them. For smaller animals like sea turtles, death is usually quick, due to drowning. However, large whales can typically pull gear, or parts of it, off the ocean floor, and are generally not in immediate risk of drowning. Nonetheless, depending on the entanglement, towing gear for long periods may prevent a whale from being able to feed, migrate, or reproduce (Van der Hoop et al. 2017; Lysiak et al. 2018).

5 ACTION AREA

Action area means all areas affected directly, or indirectly, by the Federal action, and not just the immediate area involved in the action (50 C.F.R. §402.02). 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 upon the high seas (50 CFR 402.02). Types of actions are issuing an IHA or performing actions that directly or indirectly cause modifications to the land, water, or air.

The proposed action will take place in the Eastern Tropical Pacific Ocean between approximately 14° to 18.5° North, and 99° to 105° West. Portions of the proposed survey tracklines in Mexico will take place in the territorial seas of Mexico, as well as in the Mexican EEZ and in the high seas beyond the EEZ. The EEZ in Mexico is 200 nautical miles (370.4 kilometers), with territorial seas defined as 12 nautical miles (22 kilometers) from the mean low-water line along the coast.

Representative tracklines for the proposed action are shown in Figure 1. The representative tracklines shown in Figure 1 have a total length of approximately 3,600 km of transect lines would be surveyed (about 2,230 kilometers of two-dimensional multi-channel seismic reflection data and 1,370 kilometers of ocean bottom seismometer refraction data). Some minor deviation of the tracklines, including the order of operations, may occur for reasons such as poor data quality, inclement weather, or mechanical issues with the equipment and/or research vessel. The tracklines can occur anywhere within the coordinates noted in Figure 1. The turns are the path the R/V *Marcus G. Langseth* will take as it finishes one survey trackline and transits to another; the airgun array will be active during turns.

The action area includes the survey tracklines, the transit for turns, and the area ensonified above ambient background level by the airgun array during the seismic survey. The ambient background levels for the area off the Mexican coast are somewhat variable, as they depend upon local conditions, and several factors, both from natural and anthropogenic sources (e.g., rain, wind, and vessel traffic that typically occur in the region). Seismic operations (like that in the proposed action) are regarded as low frequency (10 to 500 Hertz [Hz]), and experience little attenuation in water, allowing for long-range propagation (Hildebrand 2009a). We are not able to calculate the precise distance to which the sound from the airguns will be above ambient background levels, because we cannot define what those levels are.

The total area ensonified above the acoustic threshold for harassment (160 dB re: 1 µPa rms) for the proposed seismic survey is approximately 67,586 square kilometers. Most of the action will take place in non-territorial waters (63,316.4 square kilometers), with the remainder (4,269.4 square kilometers) occurring in the territorial waters of Mexico.

Approximately 90 percent of the area ensonified above 160 dB re: 1 µPa rms will occur in waters greater than 1,000 meters deep (61,079 square kilometers), 5,313 square kilometers (8 percent) would occur in waters 1,000 to 100 meters deep, and 1,194 square kilometers in waters less than 100 meters deep. None of the tracklines for the survey would take place in waters less than 100 meters deep. However, owing to the size of the area ensonified to the harassment threshold in deep and intermediate depth waters, and how close the tracklines come to shore (closest approach would be 7.5 kilometers), the area ensonified to the harassment threshold will include waters with shallow depths.

The action area will also include the area covered by the R/V *Marcus G. Langseth* while transiting from its port to the seismic survey area, and its return at the conclusion of the seismic survey. The R/V *Marcus G. Langseth* is expected to leave and return to the port of Manzanillo, Mexico.

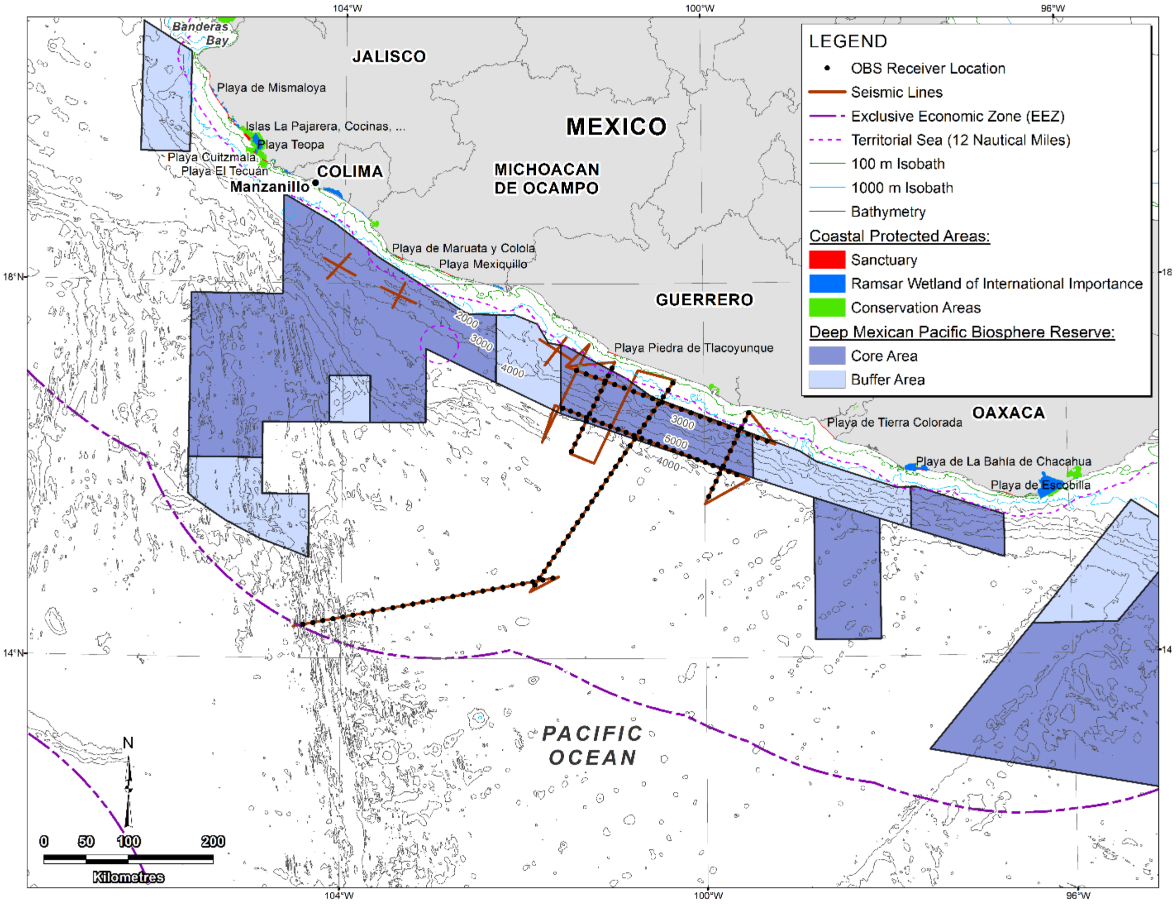

Figure 1. Map of the National Science Foundation and Lamont-Doherty Earth Observatory's high-energy marine seismic survey in the Eastern Tropical Pacific Ocean, Guerrero Gap.

5.1 Mexican Territorial Waters and the Action Area

Mexico considers its territorial seas to extend out 12 nautical miles. A nation's territorial seas are the sovereign territory of that country. According to the draft Environmental Analysis that NSF prepared for this action, most of the survey lines will take place outside the 12 nautical mile line.

NMFS' jurisdiction under the ESA, with respect to exempting incidental take and prescribing minimization measures, only applies to the portions of the seismic survey that occur outside the 12 nautical mile boundary on the high seas. The ESA's authority to prohibit and exempt take is limited by territorial seas of a foreign country. However, under the ESA, we are obligated to evaluate effects and determine jeopardy throughout the action area regardless of where effects occur, and the jeopardy prohibition applies to the entire action.

The fact that portions of the proposed action fall both inside and outside of the 12 nautical mile boundary (the high seas under the ESA) presents us with a complexity with respect to exempting incidental take and prescribing minimization measures. For ESA section 7 consultations, we are required to examine the effects of the action throughout the entire action area in making our jeopardy determination. However, we do not have authority under the ESA to exempt incidental take within the sovereign territory of Mexico (i.e., within 12 nautical mile).

Although portions of the tracklines do occur in the high seas (where the ESA has explicit jurisdiction), we are obligated to consider the effects of the action throughout the entire action area. Therefore, we must consider the 12 nautical mile boundary in relation to:

- The location of the tracklines, and
- The extent of the ensonified area.

By using GIS software, the L-DEO calculated the amount of survey tracklines and ensonified areas that were inside Mexican territorial waters, so that we could quantify the amount of ensonified area in the entire action area (67,585.8 square kilometers), and in Mexican territorial waters (4,269.4 square kilometers). The action area thus extends into the territorial waters of Mexico and this opinion considers effects to species that may occur within those waters including the effects of adverse effects rising to the level of take.

6 ENDANGERED SPECIES ACT-LISTED SPECIES AND DESIGNATED CRITICAL HABITAT PRESENT IN THE PROPOSED ACTION AREA

This section identifies the ESA-listed species and designated and proposed critical habitat that potentially occur within the action area (Table 5) that may be affected by the proposed action. Marine mammal species are expected to occur in the seismic survey area in both offshore and inshore waters. Migratory baleen whales, sperm whales, and Guadalupe fur seals are likely more common in the offshore region during the spring, but other animals like sea turtles are expected to occur closer to shore.

Table 5. Threatened and endangered species and designated critical habitat that may be affected by the proposed action.

Species	ESA Status	Critical Habitat	Recovery Plan
Marine Mammals – Cetaceans			
Blue Whale (*Balaenoptera musculus)*	E – 35 FR 18319	-- --	07/1998 11/2020 - First Revision
Fin Whale (*Balaenoptera physalus)*	E – 35 FR 18319	-- --	75 FR 47538 07/2010
Humpback Whale (*Megaptera novaeangliae*) – Central America DPS	E – 81 FR 62259	86 FR 21082	11/1991
Humpback Whale (*Megaptera novaeangliae*) – Mexico DPS	T – 81 FR 62259	86 FR 21082	11/1991
Sei Whale (*Balaenoptera borealis*)	E – 35 FR 18319	-- --	12/2011
Sperm Whale (*Physeter macrocephalus*)	E – 35 FR 18319	-- --	75 FR 81584 12/2010
Marine Mammals—Pinnipeds			
Guadalupe Fur Seal (*Artocephalus townsendi*)	T – 50 FR 51252	-- --	-- --
Marine Reptiles			
Green Turtle (*Chelonia mydas*) – East Pacific DPS	T – 81 FR 20057	-- --	63 FR 28359 01/1998
Hawksbill Turtle (*Eretmochelys imbricata)*	E – 35 FR 8491	63 FR 46693	57 FR 38818 63 FR 28359 05/1998 – U.S. Pacific
Olive Ridley Turtle (*Lepidochelys olivacea*) Mexico's Pacific Coast Breeding Colonies	E – 43 FR 32800	-- --	63 FR 28359

Species	ESA Status	Critical Habitat	Recovery Plan
Leatherback Turtle (*Dermochelys coriacea*)	E – 35 FR 8491	44 FR 17710 and 77 FR 4170	63 FR 28359 05/1998 – U.S. Pacific
Loggerhead Turtle (*Caretta caretta*) – North Pacific Ocean DPS	E – 76 FR 58868	-- --	63 FR 28359
Fishes			
Giant Manta Ray (*Manta birostris*)	T – 83 FR 2916	-- --	-- --
Oceanic Whitetip Shark (*Carcharhinus longimanus*)	T – 83 FR 4153	-- --	9/2018- Outline
Scalloped Hammerhead Shark (*Sphyrna lewini*) – Eastern Pacific DPS	E – 79 FR 38213	-- --	-- --

7 SPECIES AND CRITICAL HABITAT NOT LIKELY TO BE ADVERSELY AFFECTED

NMFS uses two criteria to identify the ESA-listed species and critical habitats that are not likely to be adversely affected by the proposed action, as well as the effects of activities that are consequences of the Federal agency's proposed action. The first criterion is exposure, or some reasonable expectation of a co-occurrence, between one or more potential stressors associated with the proposed activities and ESA-listed species or designated critical habitat. If we conclude that an ESA-listed species or designated critical habitat is not likely to be exposed to the proposed activities, we must also conclude that the species or critical habitat is not likely to be adversely affected by those activities.

The second criterion is the probability of a response given exposure. ESA-listed species or designated critical habitat that co-occur with a stressor of the action but are not likely to respond to the stressor are also not likely to be adversely affected by the proposed action. We applied these criteria to the ESA-species and designated critical habitats in Table 5 and we summarize our results below.

The probability of an effect on a species or designated critical habitat is a function of exposure intensity and susceptibility of a species to a stressor's effects (i.e., probability of response). An action warrants a "may affect, not likely to be adversely affected" finding when its effects are *wholly beneficial, insignificant* or *discountable*. *Wholly beneficial* effects have an immediate positive effect without any adverse effects to the species or habitat.

Insignificant effects relate to the size or severity of the impact and include those effects that are undetectable, not measurable, or so minor that they cannot be meaningfully evaluated. Insignificant is the appropriate effect conclusion when plausible effects are going to happen, but will not rise to the level of constituting an adverse effect.

Discountable effects are those that are extremely unlikely to occur. For an effect to be discountable, there must be a plausible adverse effect (i.e., a credible effect that could result from the action and that would be an adverse effect if it did impact a listed species), but it is extremely unlikely to occur.

In Section 7.1, we evaluate the proposed action's stressors (Section 6) that are not likely to adversely affect ESA-listed species and proposed or designated critical habitat. We also identify ESA-listed species that are not likely to be adversely affected by stressors from the proposed action (Section 7.2)

7.1 Stressors Not Likely to Adversely Affect Species

There are a number of stressors that could result from the proposed action as described in Section 6. We consider several of these stressors not likely to adversely affect species, and provide our rationale in the sections below. When we conclude that effects from a stressor are discountable it is based on our determination that the adverse effect is plausible but extremely unlikely to occur. When we conclude that effects from a stressor are insignificant, it is based on our determination that the effect may plausibly occur, but will be minor or undetectable, and not rise to the level of constituting an adverse effect.

7.1.1 Pollution

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

Vessel exhaust (i.e., air pollution) would occur during the entirety of the proposed action, during all vessel transit and operations, and could affect air-breathing ESA-listed species such as marine mammals and sea turtles. It is unlikely that vessel exhaust resulting from the operation of the R/V *Marcus G. Langseth* would have a measurable impact on ESA-listed marine mammals or sea turtles given the relatively short duration of the proposed action (~48 days), the brief amount of time that whales and sea turtles spend at the surface, and the various regulations to minimize air pollution from vessel exhaust, such as the NSF's compliance with the Act to Prevent Pollution from Ships. For these reasons, the effects that may result from vessel exhaust on ESA-listed marine mammals and sea turtles are considered insignificant.

Discharges into the water from the R/V *Marcus G. Langseth* in the form of wastewater or leakages of fuel or oil are possible, though effects of any spills to ESA-listed marine mammals, sea turtles, and fishes considered in this opinion will be minimal, if they occur at all. Wastewater from the vessels would be treated in accordance with U.S. Coast Guard standards. The potential for fuel or oil leakages is extremely unlikely. An oil or fuel leak could pose a significant risk to the vessel and its crew and actions to correct a leak should occur immediately to the extent possible. The research vessels used during the NSF-funded seismic survey have spill-prevention plans, which allow a rapid response to a spill in the event one occurs. In the event that a leak should occur, the response would prevent a widespread, high dose contamination (excluding the remote possibilinty of severe damage to the vessels) that will impact ESA-listed species directly or pose hazards to their food sources that may be part of proposed or designated critical habitat in the action area. Because the potential for oil or fuel leakage is extremely unlikely to occur, we find that the risk from this potential stressor on ESA-listed marine mammals, sea turtles, and fishes is discountable.

Trash or other debris resulting from the proposed action may affect ESA-listed marine mammals, sea turtles, and fishes. Any marine debris (e.g., plastic, paper, wood, metal, glass) that might be released would be accidental. The NSF follows standard, established guidance on the handling and disposal of marine trash and debris during the seismic survey. The gear used in the proposed action may also result in marine debris. The ocean bottom seismometers would be released from the attached anchor and float to the surface for retrieval, leaving the anchor behind as debris on the ocean floor. There would be a total of 33 ocean bottom seismometer anchors left behind. The ocean bottom seismometers anchors would be made of steel. Although these anchors can be considered debris, we do not believe them to pose an entanglement risk or other hazards for ESA-listed marine mammals, sea turtles, or fishes. The small amount of debris created by the anchors as a result of the proposed action compared to the relative size of the available habitat used by ESA-listed species is insignificant. 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. The marine debris created by the ocean bottom seismometers is minor, thus we find that the effects from this potential stressor on ESA-listed marine mammals, sea turtles, and fishes are insignificant.

Therefore, 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 as the effects are either insignificant or discountable, and will not be analyzed further in this opinion.

7.1.2 Vessel Strikes

Vessel traffic associated with the proposed action carries the risk of vessel strikes of ESA-listed marine mammals, sea turtles, and fishes. In general, the probability of a vessel collision and the associated response depends, in part, on size and speed of the vessel. The R/V *Marcus G. Langseth* has a length of 235 feet (72 meters) and the operating speed during seismic data acquisition is typically approximately 9.3 kilometers per hour (5 knots). When not towing seismic survey gear, the R/V *Marcus G. Langseth* typically transits at 18.5 kilometers per hour (10 knots). The majority of vessel strikes of large whales occur when vessels are traveling at speeds greater than approximately 18.5 kilometers per hour (10 knots), with faster travel, especially of large vessels (80 meters [262.5 feet] or greater), being more likely to cause serious injury or death (Laist et al. 2001; Jensen and Silber 2004; Vanderlaan and Taggart 2007; Conn and Silber 2013b).

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

Each of the ESA-listed fish species considered in this opinion are thought to spend at least some time in the upper portions of the water column where they may be susceptible to vessel strike. Despite these species' use of the upper portion of the water column for at least some of their life history, in most cases, we would anticipate the ESA-listed fishes considered in this opinion would be able to detect vessels or other in-water devices and avoid them. Fish are able to use a combination of sensory cues to detect approaching vessels, such as sight, hearing, and their lateral line (for nearby changes in water motion). A study on fish behavioral responses to vessels showed that most adults exhibit avoidance responses to engine noise, sonar, depth finders, and fish finders (Jørgensen et al. 2004), reducing the potential for vessel strikes. Misund (1997) found that fish ahead of a ship showed avoidance reactions at ranges of 50 to 350 meters (160 to 490 feet). When the vessel passed over them, some fish responded with sudden escape responses that included movement away from the vessel laterally or through downward compression of the school. In an early study conducted by Chapman and Hawkins (1973), the authors observed avoidance responses of herring from the low-frequency sounds of large vessels or accelerating small vessels. Avoidance responses quickly ended within ten seconds after the vessel departed. Conversely, Rostad (2006) observed that some fish (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 we are not aware of studies specifically focusing on ESA-listed fishes' reactions to vessels, we cannot rule out either occurrence during the proposed action.

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.

While vessel strikes of marine mammals, sea turtles, and fishes during seismic survey activities are possible, we are not aware of any definitive case of a marine mammal, sea turtle, or fish being struck by a vessel associated with NSF seismic surveys. The R/V *Marcus G. Langseth* will be traveling at generally low speeds, reducing the probability of a vessel strike for marine mammals (Kite-Powell et al. 2007; Vanderlaan and Taggart 2007). Personnel on the vessel will maintain watch while in transit. Our expectation of vessel strike being extremely unlikely to occur is due to the hundreds of thousands of kilometers the R/V *Marcus G. Langseth* has traveled without a reported vessel strike, general expected movement of marine mammals and sea turtles away from or parallel to the R/V *Marcus G. Langseth*, as well as the generally slow movement of the R/V *Marcus G. Langseth* during most of its travels (Holst and Smultea 2008b;

Hauser and Holst 2009; Holst 2010). In addition, adherence to observation and avoidance procedures is also expected to avoid vessel strikes of marine mammals and sea turtles. All factors considered, we have concluded vessel strike of ESA-listed species by the research vessels is extremely unlikely to occur. Therefore, 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.

7.1.3 Operational Noise and Visual Disturbance of Vessel and Equipment

The research vessels associated with the proposed action may cause visual or auditory disturbances to ESA-listed species that spend time near the surface or in the upper parts of the water column, such as marine mammals, sea turtles, and fishes, which may generally 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. Although it is known that sound is important for marine mammal communication, navigation, and foraging (NRC 2003b; 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, but given that much less is known about how they use sound, the impacts of anthropogenic sound are difficult to assess (Popper et al. 2014b; Nelms et al. 2016). Nonetheless, depending on the circumstances, exposure to anthropogenic sounds may result in auditory injury, changes in hearing ability, masking of important sounds, behavioral responses, as well as other physical and physiological responses (see Section 10.3.2).

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. 2008a; 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 responses to the visual presences of vessels from those to the sounds associated with those vessels. We consider the effects to marine mammals, sea turtles, and fishes from the visual presence of vessels associated with the proposed action to be insignificant.

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

Very little research exists on sea turtle responses to vessel noise disturbance. Currently, there is nothing in the available literature specifically aimed at studying and quantifying sea turtle response to vessel noise. However, a study examining vessel strike risk to green sea turtles suggests that sea turtles may habituate to vessel sound and may be more likely to respond to the sight of a vessel rather than the sound of a vessel, although both may play a role in prompting reactions (Hazel et al. 2007). Regardless of the specific stressor associated with vessels to which turtles are responding, they only appear to show responses (i.e., avoidance behavior) at approximately 10 meters (32.8 feet) or closer (Hazel et al. 2007). Therefore, the noise from vessels is not likely to affect sea turtles from further distances, and disturbance may only occur if a sea turtle hears a vessel nearby or sees it as it approaches.

All fish species can detect vessel noise due to its low-frequency content and their hearing capabilities. Data for elasmobranch fishes suggest they are capable of detecting sounds from approximately 20 Hz to 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 water motion as well as visually locate an oncoming vessel. In these cases, most fishes located in close proximity that detect the vessel either visually, via sound and motion in the water would be capable of avoiding the vessel or move away from the area affected by vessel sound. Thus, fish are more likely to react to vessel noise at close range than to vessel noise emanating from a greater distance away.

The contribution of vessel noise by the R/V *Marcus G. 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). Also, as stated, sea turtles are most likely to habituate and are shown to be less effected by vessel noise at distances greater than 10 meters (32.8 feet) (Hazel et al. 2007). In addition, during research operations, the R/V *Marcus G. 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). The distance between the research vessel and observed marine mammals and sea turtles, per avoidance protocols, will also minimize the potential for acoustic disturbance from engine noise. Because the potential acoustic interference from engine noise will be undetectable or so minor that it cannot be meaningfully evaluated, we find that the risk from this potential stressor is insignificant. Therefore, we conclude that acoustic interference from engine noise may affect, but is not likely to adversely affect ESA-listed marine mammals, sea turtles, or fishes, and will not be analyzed further.

Unlike vessels, which produce sound as a byproduct of their operations, multi-beam echosounders, sub-bottom profilers, acoustic Doppler current profilers, acoustic release transponders, ocean bottom seismometers, and airgun arrays are designed to actively produce sound, and as such, the characteristics of these sound sources are deliberate and under control. The ocean bottom seismometers have an acoustic release transponder that transmits a signal to the instrument at a frequency of 8 to 11 kHz and a response is received at a frequency of 11.5 to 13 kHz (operator selectable), to activate and release the instrument. The transmitting beam pattern is 55 degrees. The sound source level is approximately 93 dB.

The functional hearing ranges of ESA-listed sea turtles are not well understood and vary by species. In general, the available information on sea turtle hearing indicates that their hearing thresholds are less than 1 kHz (Moein et al. 1994). Loggerhead sea turtles are thought to have a functional hearing range of 250 to 750 Hz (Bartol et al. 1999), Kemp’s ridley sea turtles a range of 100 to 500 Hz, and green sea turtles from 100 to 800 Hz (Ketten and Bartol 2005).

The multibeam echosounder and the sub-bottom profiler will not be operated while the vessel is in transit. These devices will be used during the seismic survey, and we expect that, because the sound from the airguns is greater than that produced by the multibeam echosounder or the sub-bottom profiler, ESA-listed marine mammals, sea turtles, and fish will be affected by the airgun array to an extent that does not allow us to distinguish the effects from the operation of these devices. However, the sounds from operation of this equipment is discussed further in this opinion.

7.1.4 Gear Interaction

There is a variety of gear proposed for use during the proposed action that might entangle, strike, or otherwise interact with ESA-listed species in the action area.

Towed gear from the seismic survey activities pose a risk of entanglement to ESA-listed marine mammals and sea turtles. The towed hydrophone streamer could come in direct contact with ESA-listed species and sea turtle entanglements have occurred in towed gear from seismic survey vessels. We are not aware of any cases of leatherback sea turtles entanglement. However, a NSF-funded seismic survey off the coast of Costa Rica during 2011 recovered a dead olive ridley turtle (*Lepidochelys olivacea*) in the foil of towed seismic equipment; it is unclear whether the sea turtle became lodged in the foil pre- or post mortem (Spring 2011). However, entanglement is highly unlikely due to the towed hydrophone streamer design, as well as observations of sea turtles investigating the towed hydrophone streamer and not becoming entangled or operating 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 marine mammals considered during this consultation. We expect the taut cables will prevent entanglement. Furthermore, marine mammals are expected to avoid areas where the airgun array is actively being used, meaning they will also avoid towed gear. We are not aware of any entanglement events with ESA-listed marine mammals or sea turtles with the towed gear proposed for use in this action.

We do not expect ESA-listed marine mammals or sea turtles to be at the ocean bottom, so the concerns about equipment strike would primarily be as they are being deployed, and dropping to the ocean floor. We expect an ESA-listed marine mammal or sea turtle to perceive the disturbance and be able to detect the ocean bottom seismometers, exhibit avoidance behavior, and move out of the way.

ESA-listed fish species in the action area (giant manta rays, scalloped hammerheads and oceanic whitetip sharks) could be entangled or struck by equipment used during the seismic survey. ESA-listed giant manta rays can occur near the surface when feeding (ten meters), but can also dive to depths of between 200 and 450 meters, and even up to 1,000 meters. ESA-listed scalloped hammerheads occur over continental and insular shelves, as well as adjacent deep waters. The ocean bottom seismometers will operate at or near the ocean floor. The towed hydrophone array, the PAM hydrophone (both towed near the surface), and the towed airgun array (towed at 12 meters below the surface) pose similar risks to ESA-listed fishes species. However, we consider the possibility of equipment entanglement or strike to be remote because of fishes' ability to detect the equipment moving through the water and move out of the way.

Although the towed hydrophone streamer or PAM array could come in direct contact with an ESA-listed species, entanglements are extremely unlikely and considered discountable. Based upon extensive deployment of this type of equipment with no reported entanglement and the nature of the gear that is likely to prevent it from occurring, we find the probability of adverse impacts to ESA-listed species to be discountable; therefore, gear interactions may affect, but are not likely to adversely affect any ESA-listed species, and will not be analyzed further in this opinion.

7.1.5 Stressors Considered Further

The only potential stressor that is likely to adversely affect some ESA-listed species within the action area is sound fields produced by the seismic airgun array, multi-beam echosounder, sub-bottom profiler, acoustic Doppler current profiler, acoustic release transponder, and ocean bottom seismometers. This stressor and these sound sources associated with seismic survey activities may adversely affect the ESA-listed species and are further analyzed and evaluated in detail in Section 10.

7.2 Species Not Likely to be Adversely Affected

There are a number of ESA-listed species, as well as designated and proposed critical habitat, that could potentially be in the action area and possibly be exposed to the stressors associated with the proposed action. As discussed previously, most of the stressors associated with the proposed action are not likely to adversely affect any of the listed species in the action area but acoustic sources (i.e., sound fields by the seismic airguns and the other equipment used in the survey) may result in adverse effects for some ESA-listed species.

7.2.1 Humpback Whales—Mexico Distinct Population Segment

Potentially two distinct population segments of humpback whales could be present in the action area—Mexico and Central America DPSs. The Mexico DPS of humpback whale breeds along the Pacific Coast of mainland Mexico, the Baja California Peninsula Mexico and the Revillagigedo Islands. These areas are north and west of the action area. There is evidence of an individual from the Hawaii breeding grounds traveling to the Revillagigedo Archipelago and a second individual from Guerro, Mexico, to traveling to Hawaii (both movements occurring from February to April) (Darling et al. 2022), suggesting that there is some overlapping of DPSs. The seasonal frequency of humpback sightings varied by location, but were concentrated in winter months (December through February) in the Revillagigedo Islands and the Pacific coast off mainland Mexico (Jorge Urbán and Anelio Aguayo 1987). Sightings which took place in March and April (around the time of the proposed action) occurred further north, off the southern coast of Baja California and the northern Gulf of California, areas outside the action area. Based on the time of year the proposed action will occur, and the location of breeding/concentration areas of humpbacks off Mexico relative to the action area, it is extremely unlikely that the proposed action would cause exposure of Mexico DPS humpbacks to the acoustic stressors discussed in section 7.1.5.

We therefore conclude that the proposed seismic survey activities in the action area are not likely to adversely affect Mexico DPS humpback whales, and this species will not be considered further in this opinion.

7.2.2 ESA-Listed Elasmobranchs

ESA-listed elasmobranchs (giant manta rays, oceanic whitetip sharks, and Eastern Pacific DPS scalloped hammerhead shark) may occur in the action area and be affected by sound fields generated by airguns and echosounders.

Elasmobranchs, like all fish, 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 suggest they are capable of detecting sounds from approximately 20 Hz to 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). However, unlike most teleost fish, elasmobranchs do not have swim bladders (or any other air-filled cavity), and thus are unable to detect sound pressure (Casper et al. 2012). Particle motion is presumably the only sound stimulus that can be detected by elasmobranchs (Casper et al. 2012). Given their assumed hearing range, elasmobranchs are anticipated to be able to detect the low frequency (10 to 500 Hz; (Hildebrand 2009a)) sound from an airgun array if exposed. However, the limited duration of the proposed action's low-frequency acoustic stressors 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 to 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 to 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 to 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 to 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 to 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 or proposed 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. If these behavioral reactions were to occur, we would not expect them to result in fitness impacts such as reduced foraging or reproduction ability.

Therefore, the potential effect of seismic survey activities on the elasmobranch species (giant manta ray, oceanic whitetip shark, and Eastern Pacific DPS scalloped hammerhead shark) listed under the ESA is insignificant. We conclude that the proposed seismic survey activities in the action area are not likely to adversely affect these elasmobranch species because any effects would be insignificant, and these species will not be considered further in this opinion.

8 SPECIES LIKELY TO BE ADVERSELY AFFECTED

This opinion examines the status of ESA-listed species and designated critical habitat that may be adversely affected by the proposed action. There is no designated or proposed critical habitat in the action area. The following species are likely to be adversely affected by acoustic sources employed by the the proposed marine seismic survey: blue whale, fin whale, humpback whale (Central America DPS), sei whale, sperm whale, Guadalupe fur seal, leatherback sea turtle, green sea turtle (East Pacific DPS), hawksbill sea turtle, olive ridley sea turtle (Mexico's Pacific Coast Breeding Colonies), and loggerhead sea turtle (North Pacific Ocean DPS).The evaluation of adverse effects begins by summarizing the biology and ecology of those species that are likely to be adversely affected and what is known about their life histories in the action area. The status is determined by the level of risk that the ESA-listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This helps to inform the description of the species' current "reproduction, numbers, or distribution," which is part of the process of determining whether an action is likely to jeopardize the continued existence of listed species (50 C.F.R. §402.02). More detailed information on the status and trends of these ESA-listed species, and their biology and ecology can be found in the listing regulations and critical habitat designations published in the Federal Register, status reviews, recovery plans, and on this NMFS Web site: https://www.fisheries.noaa.gov/find-species.

One factor affecting the range wide status of marine mammals, sea turtles, and aquatic habitat at large is climate change. Climate change will be discussed in the *Environmental Baseline* section (Section 9).

8.1 Blue Whale

The blue whale is a widely distributed baleen whale found in all major oceans. The blue whale consists of five currently recognized subspecies (NMFS 2020a): *B. m. musculus* is the northern blue whale (North Atlantic and North Pacific Oceans); *B. m. intermedia* is the Antarctic blue whale, sometimes referred to as the "true" blue whale; *B. m. brevicauda* is the pygmy blue whale, generally occurring in the sub-Antarctic southern Indian Ocean and the southwestern Pacific Ocean; *B. m. indica* is the northern Indian Ocean blue whale; and there is a recently recognized, unnamed subspecies that generally occurs off Chile and annually migrates to waters off Peru, Ecuador, and up to the Galapagos Islands in the southeastern Pacific Ocean.The blue whale was originally listed as endangered on December 2, 1970.

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.

8.1.1 Life History

The average life span of blue whales is 80 to 90 years. They have a gestation period of ten to 12 months, and calves nurse for six to seven months. Blue whales reach sexual maturity between 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 to 120 meters (295.3 to 393.7 feet).

8.1.2 Population Dynamics

The global, pre-exploitation estimate for blue whales is approximately 181,200 (IWC 2007b). Current estimates indicate approximately 5,000 to 12,000 blue whales globally (IWC 2007b). Blue whales are separated into populations by ocean basin in the North Atlantic Ocean, North Pacific Ocean, and Southern Hemisphere. There are three stocks of blue whales designated in United States waters: the Eastern North Pacific Ocean, Central North Pacific Ocean, and Western North Atlantic Ocean. Due to the location of the action, the Eastern North Pacific stock of blue whales is most likely to be in the action area. 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 to 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 to 2,500 individuals or greater provide for maintenance of genetic diversity resulting in long-term persistence and protection from substantial environmental variance and catastrophes. Stocks that have a total population of 500 individuals or less may be at a greater risk of extinction due to genetic risks resulting from inbreeding. Stock population at low densities (less than 100) are more likely to suffer from the ‘Allee’ effect, where inbreeding and the heightened difficulty of finding mates reduces the population growth rate in proportion with reducing density.

In general, distribution is driven largely by food requirements; blue whales are more likely to occur in waters with dense concentrations of their primary food source, krill. While they can be found in coastal waters, they are thought to prefer waters further offshore. 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).

8.1.3 Vocalization and Hearing

Blue whale vocalizations tend to be long (greater than 20 seconds), low frequency (less than 100 Hz) signals (Thomson and Richardson 1995b), with a range of 12 to 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 to 80 Hz), with seasonally variable occurrence. Blue whale calls have high acoustic energy, with reports of source levels ranging from 180 to 195 dB re: 1 μPa at 1 meter (Cummings and Thompson 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 meters [98.4 feet] whales), while deeper diving whales (greater than 50 meters [154 feet]) were likely feeding and calling less.

Although general characteristics of blue whale calls are shared in distinct regions (Thompson et al. 1996; Mcdonald et al. 2001; Mellinger and Clark 2003; Rankin et al. 2005), some variability appears to exist among different geographic areas (Rivers 1997). Sounds in the North Atlantic Ocean have been confirmed to have different characteristics (i.e., frequency, duration, and repetition) than those recorded in other parts of the world (Mellinger and Clark 2003; Berchok et al. 2006; Samaran et al. 2010). Clear differences in call structure suggestive of separate populations for the western and eastern regions of the North Pacific Ocean have also been reported (Stafford et al. 2001); however, some overlap in calls from the geographically distinct regions have been observed, indicating that the whales may have the ability to mimic calls (Stafford and Moore 2005). In Southern California, blue whales produce three known call types: Type A, B, and D. B calls are stereotypic of blue whale population found in the eastern North Pacific (McDonald et al. 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 to 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 percent shift in call frequency over four decades (McDonald et al. 2006). McDonald et al. (2009) observed a 31 percent downward frequency shift in blue whale calls off the coast of California, and also noted lower frequencies in seven of the world's ten known blue whale songs originating in the Atlantic, Pacific, Southern, and Indian Oceans. Many possible explanations for the shifts exist but none 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 to 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. 1995c; 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).

8.1.4 Status

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 still at risk of extinction.

8.1.5 Critical Habitat

No critical habitat has been designated for the blue whale.

8.1.6 Recovery Goals

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.

8.2 Fin Whale

The fin whale is a large, widely distributed baleen whale found in all major oceans and comprised of three subspecies: *B. p. physalus* in the Northern Hemisphere, and *B. p. quoyi* and *B. p. patachaonica* (a pygmy form) in the Southern Hemisphere. 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 2010b), recent stock assessment reports (Carretta 2020), and status review (NMFS 2011a) were used to summarize the life history, population dynamics and status of the species as follows.

8.2.1 Life History

Fin whales can live, on average, 80 to 90 years. They have a gestation period of less than one year, and calves nurse for six to seven months. Sexual maturity is reached between six and ten years of age with an average calving interval of two to three years. They mostly inhabit deep, offshore waters of all major oceans. They winter at low latitudes, where they calve and nurse, and summer at high latitudes, where they feed, although some fin whales appear to be residential to certain areas. Fin whales eat pelagic crustaceans (mainly euphausiids or krill) and schooling fish such as capelin, herring, and sand lice.

8.2.2 Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the fin whale.

The pre-exploitation estimate for the fin whale population in the North Pacific Ocean was 42,000 to 45,000. The North Pacific population of fin whales was reduced to 13,620 to 18,680 by 1973 (Ohsumi and Wada 1974). There are three stocks in United States Pacific Ocean waters: Northeast Pacific [minimum 1,368 individuals], Hawaii (approximately 58 individuals [N_{min}=27]) and California/Oregon/Washington (approximately 9,029 [N_{min}=8,127] individuals) (Nadeem et al. 2016). 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.

The best current abundance estimate for fin whales in California, Oregon, and Washington waters out to 300 nautical miles is 9,029 (CV=0.12) (Nadeem et al. 2016); the minimum population estimate is 8,127 individuals (Carretta 2019). More specific estimates for fin whales in the Eastern Tropical Pacific range from 3,388 (Forney et al. 2012), to 2,842 (Barlow 2003), to 574 (NMFS 2015b). 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. From 1991 to 2014, the estimated average rate of increase for California, Oregon, and Washington waters was 7.5 percent, with the caveat that is unknown how much of that rate could be attributed to immigration rather than birth and death processes (Carretta 2019). The species' overall large population size may provide some resilience to current threats, but trends are largely unknown.

Archer et al. (2013) examined the genetic structure and diversity of fin whales globally. Full sequencing of the mitochondrial DNA genome for 154 fin whales sampled in the North Atlantic Ocean, North Pacific Ocean, and Southern Hemisphere, resulted in 136 haplotypes, none of which were shared among ocean basins suggesting differentiation at least at this geographic scale. However, North Atlantic Ocean fin whales appear to be more closely related to the Southern Hemisphere population, as compared to fin whales in the North Pacific Ocean, which may indicate a revision of the subspecies delineations is warranted. Results of a later single-nucleotide polymorphism analysis indicate that distinct mitogenome matrilines in the North Pacific are interbreeding (Archer et al. 2019). 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 Sea of Cortez year-round (Bérubé et al. 2002). This is further supported by satellite telemetry data of fin whales in the Gulf of California (Jiménez López et al. 2019).

The availability of prey, sand lice in particular, 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).

8.2.3 Vocalization and Hearing

Fin whales produce a variety of low frequency sounds in the 10 to 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 to 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 at 1 meter (Watkins 1981; Watkins et al. 1987; Edds 1988; Richardson et al. 1995c; Charif et al.

2002; Clark et al. 2002; Sirovic et al. 2007). These pulses frequently occur in long sequenced patterns, are down swept (e.g., 23 to 18 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. (1995c) reported this call occurring in short series during spring, summer, and fall, and in repeated stereotyped patterns in winter. The seasonality and stereotype nature of these vocal sequences suggest that they are male reproductive displays (Watkins 1981; Watkins et al. 1987); a notion further supported by data linking these vocalizations to male fin whales only (Croll et al. 2002). In Southern California, the 20 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 fin whale pulses. Seasonality of the 40 Hz calls differed from the 20 Hz calls, 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 calls has been reported as 189 ± 5.8 dB re: 1 μPa at 1 meter (Weirathmueller et al. 2013). Some researchers have also recorded moans of 14 to 118 Hz, with a dominant frequency of 20 Hz, tonal vocalizations of 34 to 150 Hz, and songs of 17 to 25 Hz (Watkins 1981; Edds 1988; Cummings and Thompson 1994). In general, source levels for fin whale vocalizations are 140 to 200 dB re: 1 μPa at 1 meter (as compiled by Erbe 2002c; see also Clark and Gagnon 2004). The source depth of calling fin whales has been reported to be about 50 meters (164 feet) (Watkins et al. 1987). Although acoustic recordings of fin whales from many diverse regions show close adherence to the typical 20-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. 1995c; Ketten 1997). This suggests fin whales, like other baleen whales, are more likely to have their best hearing capacities at low frequencies, including frequencies lower than those of normal human hearing, rather than mid- to high-frequencies (Ketten 1997). In a study using computer tomography scans of a calf fin whale skull, Cranford and Krysl (2015) found sensitivity to a broad range of frequencies between 10 Hz and 12 kHz and a maximum sensitivity to sounds in the 1 to 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 to 35 kHz (NOAA 2018).

8.2.4 Status

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

8.2.5 Critical Habitat

No critical habitat has been designated for the fin whale.

8.2.6 Recovery Goals

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.

8.3 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 FR 18319). Since then, NMFS has designated 14 DPSs with four identified as endangered (Cape Verde Islands/Northwest Africa, Western North Pacific, Central America, and Arabian Sea) and one as threatened (Mexico).

Information available from the recovery plan (NMFS 1991), the recent stock assessment report (Carretta 2019), the status review (Bettridge et al. 2015), and the final listing were used to summarize the life history, population dynamics and status of the species as follows.

8.3.1 Life History

Humpback whales can live, on average, 50 years. They have a gestation period of 11 to 12 months, and calves nurse for one year. Sexual maturity is reached between five to 11 years of age. Every one to five years, females give birth to a single calf, with an average calving interval of two to three years. Humpback whales mostly inhabit coastal and continental shelf waters. They winter at lower latitudes, where they calve and nurse, and summer at high latitudes, where they feed. Central America DPS humpback whales breed of 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. 2015).

8.3.2 Population Dynamics

The global, pre-exploitation estimate for humpback whales is 1,000,000 (Roman and Palumbi 2003). Prior to 1905, whaling records indicate that the humpback whale population in the North Pacific was 15,000 whales. By 1966, whaling had reduced the North Pacific population to about 1,200. In the 2015 status review for humpback whales, the abundance of the Central America DPS was 431 (CV=0.3) and 783 (CV=0.17) individuals (Bettridge et al. 2015); however, this estimate is based on data from 2004 through 2006, and is not considered a reliable estimate of current abundance (Carretta 2020). A population growth rate is currently unavailable for the Central America DPS of humpback whales.

For humpback whales, DPSs that have a total population size of 2,000 to 2,500 individuals or greater provide for maintenance of genetic diversity resulting in long-term persistence and protection from substantial environmental variance and catastrophes. Distinct population segments 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 (Bettridge et al. 2015). Populations at low densities (less than one hundred) are more likely to suffer from the ‘Allee” effect, where inbreeding and the heightened difficulty of finding mates reduces the population growth rate in proportion with reducing density. The Central America DPS has just below 500 individuals and so may be subject to genetic risks due to inbreeding and moderate environmental variance (Bettridge et al. 2015).

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 meters deep over winter and through March; with some sightings extending into April and early May. Distance of humpback sightings from shore ranged from 50 meters to 10.3 kilometers, with a maximum of 33.4 kilometers from shore (Audley 2022).

8.3.3 Vocalization and Hearing

Humpback whale vocalization is much better understood than is hearing. Different sounds are produced that correspond to different functions: feeding, breeding, and other social calls (Dunlop et al. 2008). Males sing complex sounds while in low-latitude breeding areas in a frequency range of 20 Hz to 4 kHz with estimated source levels from 144 to 174 dB (Winn et al. 1970b; Richardson et al. 1995f; 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 to 10 kHz with most energy below 3 kHz (Tyack 1983b; Silber 1986b). Such sounds can be heard up to 9 kilometers (4.9 nautical miles) away (Tyack 1983b). Other social sounds from 50 Hz to 10 kHz (most energy below 3 kHz) are also produced in breeding areas (Tyack 1983b; Richardson et al. 1995f). While in northern feeding areas, both sexes vocalize in grunts (25 Hz to 1.9 kHz), pulses (25 to 89 Hz) and songs (ranging from 30 Hz to 8 kHz but dominant frequencies of 120 Hz to 4 kHz), which can be very loud (175 to 192 dB re: 1 µPa at 1 meter) (Payne 1985; Thompson et al. 1986b; Richardson et al. 1995f; Au et al. 2000; Erbe 2002b). However, humpback whales tend to be less vocal in northern feeding areas than in southern breeding areas (Richardson et al. 1995f). NMFS classified humpback whales in the low-frequency cetacean (i.e., baleen whale) functional hearing group. As a group, it is estimated that baleen whales can hear frequencies between 0.007 and 30 Hz (NOAA 2013). Houser et al. (2001) produced a mathematical model of humpback whale hearing sensitivity based on the anatomy of the humpback whale ear. Based on the model, they concluded that humpback whales would be sensitive to sound in frequencies ranging from 0.7 to 10 kHz, with a maximum sensitivity between 2 to 6 kHz.

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 1995c). 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 and 189 dB re: 1 µPa-m and high frequency harmonics extending beyond 24 kHz (Winn et al. 1970b; Au et al. 2006a). Social calls range from 20 Hz to 10 kHz, with dominant frequencies below 3 kHz (D'Vincent et al. 1985; Silber 1986b; 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 to 2 kHz, less than one second in duration, and have source levels of 162 to 192 dB re: 1 µPa-m (D'Vincent et al. 1985; Thompson et al. 1986b). The fundamental frequency of feeding calls is approximately 500 Hz (D'Vincent et al. 1985;

Thompson et al. 1986b). 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 boats of broadband click trains that were acoustically different from toothed whale echolocation: (Stimpert et al. 2007) termed these sounds "mega-clicks" which showed relatively low received levels at the DTAGs (143 to 154 dB re: 1 μPa), with the majority of acoustic energy below 2 kHz.

In terms of functional hearing capability, humpback whales belong to low frequency cetaceans which have a hearing range of 7 Hz to 22 kHz (Southall et al. 2007a). Humpback whale audiograms using a mathematical model based on the internal structure of the ear estimate sensitivity is from 700 Hz to 10 kHz, with maximum relative sensitivity between 2 kHz and 6 kHz (Ketten and Mountain 2014). Research by Au et al. (2001) and Au et al. (2006a) off Hawaii indicated the presence of high frequency harmonics in vocalizations up to and beyond 24 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 to 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.

8.3.4 Status

Humpback whales were originally listed as endangered because of past commercial whaling, and the five DPSs that remain listed (Cape Verde Islands/Northwest Africa, Western North Pacific, Central America, Arabian Sea, and Mexico) have likely not yet recovered from this. According to historical whaling records from five whaling stations in British Columbia, 5,638 humpback whales were killed between 1908 and 1967 (Gregr et al. 2000). We have no way of knowing the degree to which 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 population segment). 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 the 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 climate change. Due to on-going threats, and the purported low population size, the Central America DPS still faces a risk of extinction.

8.3.5 Critical Habitat

Critical habitat has been designated for Central America DPS humpback whales (86 FR 21082). There is no critical habitat in the action area, and it will not be discussed.

8.3.6 Recovery Goals

See the 1991 Final Recovery Plan for the humpback whale for the complete downlisting/delisting criteria for each of the four following recovery goals:

1. Maintain and enhance habitats used by humpback whales currently or historically.
2. Identify and reduce direct human-related injury and mortality.
3. Measure and monitor key population parameters.

Improve administration and coordination of recovery program for humpback whales.

8.4 Sei Whale

Sei whales are distributed worldwide, occurring in the North Atlantic Ocean, North Pacific Ocean, and Southern Hemisphere. Throughout the Eastern Tropical Pacific, sei whales are uncommon, though 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 2011b), recent stock assessment report (Carretta 2019), and status review (NMFS 2012) were used to summarize the life history, population dynamics, and status of the species as follows.

8.4.1 Life History

Sei whales can live, on average, between 50 and 70 years. They have a gestation period of ten to 12 months, and calves nurse for six to nine months. Sexual maturity is reached between 6 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.

8.4.2 Population Dynamics

Models indicate that total abundance declined from 42,000 to 8,600 individuals between 1963 and 1974 in the North Pacific Ocean. More recently, the North Pacific Ocean population was estimated to be 29,632 (95 percent confidence intervals 18,576 to 47,267) between 2010 and

2012 (IWC 2016; Thomas et al. 2016). The best abundance estimate for sei whales in the Eastern North Pacific is 519 (CV=0.40) (Carretta 2019). Abundance estimates for sei whales in the Eastern Tropical Pacific are not available.

Population growth rates for sei whales are not available at this time as there are little to no systematic survey efforts to study sei whales.

Based on genetic analyses, there appears to be some differentiation between sei whale populations in different ocean basins. An early study of allozyme variation at 45 loci found some genetic differences between Southern Ocean and the North Pacific sei whales (Wada and Numachi 1991). However, more recent analyses of mtDNA control region variation show no significant differentiation between Southern Ocean and the North Pacific sei whales, though both appear to be genetically distinct from sei whales in the North Atlantic (Baker and Clapham 2004; Huijser et al. 2018). Within ocean basin, there appears to be intermediate to high genetic diversity and little genetic differentiation despite there being different managed stocks (Danielsdottir et al. 1991; Kanda et al. 2006; Kanda et al. 2011; Kanda et al. 2013; Kanda et al. 2015; Huijser et al. 2018).

8.4.3 Vocalization and Hearing

Data on sei whale vocal behavior is limited, but includes records off the Antarctic Peninsula of broadband sounds in the 100 to 600 Hz range with 1.5 second duration and tonal and upsweep calls in the 200 to 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 to 0.8 seconds, separated by 0.4 to 1.0 seconds) of 10 to 20 short (4 milliseconds) frequency modulated sweeps between 1.5 to 3.5 kHz (Thomson and Richardson 1995a). Source levels of 189 ±5.8 dB re: 1 µPa at 1 meter have been established for sei whales in the northeastern Pacific Ocean (Weirathmueller 2013).

Direct studies of sei whale hearing have not been conducted, but it is assumed that they can hear the same frequencies that they produce (low) and are likely most sensitive to this frequency range (Richardson et al. 1995c; Ketten 1997). This suggests sei whales, like other baleen whales, are more likely to have their best hearing capacities at low frequencies, including frequencies lower than those of normal human hearing, rather than mid- to high-frequencies (Ketten 1997). In terms of functional hearing capability, sei whales belong to the low-frequency group, which have a hearing range of 7 Hz to 35 kHz (NOAA 2018).

8.4.4 Status

The sei whale is endangered as a result of past commercial whaling, reduced to about 20 percent of their pre-whaling abundance in the North Pacific Ocean (Carretta 2019). Current threats include ship strikes, fisheries interactions (including entanglement), climate change (habitat loss and reduced prey availability), and anthropogenic sound.

8.4.5 Critical Habitat

No critical habitat has been designated for the sei whale.

8.4.6 Recovery Goals

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.

8.5 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 kilometers, 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 2010a), recent stock assessment reports (Carretta 2019), and status review (NMFS 2015a) were used to summarize the life history, population dynamics, and status of the species as follows.

8.5.1 Life History

The average lifespan of sperm whales is estimated to be at least 50 years (Whitehead 2009). They have a gestation period of one to one and a half years, and calves nurse for approximately two years. Sexual maturity for sperm whales in the North Pacific is reached between 7 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 meters (1,968 feet) or more, and are uncommon in waters less than 300 meters (984 feet) deep. However, if there are shelf breaks or submarine canyons close to land, sperm whales can occur there. They winter at low latitudes, where they calve and nurse, and summer at high latitudes, where they feed primarily on squid; other prey includes octopus and demersal fish (including teleosts and elasmobranchs).

8.5.2 Population Dynamics

The sperm whale is the most abundant of the large whale species, with a global population of between 300,000 and 450,000 individuals (Whitehead 2009). The higher estimates may be approaching population sizes prior to commercial whaling. In the northeast Pacific Ocean, the abundance of sperm whales was estimated to be between 26,300 and 32,100 in 1997 (NMFS 2015a). (Gerrodette and Forcada 2002) calculated an abundance estimate of sperm whales in the Eastern Tropical Pacific of 4,145. There is insufficient data to evaluate trends in abundance and growth rates of sperm whales at this time. 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 constitute a distinct stock.

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.

8.5.3 Vocalization and Hearing

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

Long, repeated clicks are associated with feeding and echolocation (Whitehead and Weilgart 1991; Weilgart and Whitehead 1993; Goold and Jones 1995; Weilgart and Whitehead 1997b; 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 1997b; 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 1997b; 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 1997b). Three coda types used by male sperm whales have recently been described from data collected over multiple years: these codas are associated with dive cycles, socializing, and alarm (Frantzis and Alexiadou 2008).

Our understanding of sperm whale hearing stems largely from the sounds they produce. The only direct measurement of hearing was from a young stranded individual from which auditory evoked potentials were recorded (Carder and Ridgway 1990). From this whale, responses support a hearing range of 2.5 to 60 kHz and highest sensitivity to frequencies between 5 to 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 1975a; Watkins et al. 1985). In the Caribbean Sea, Watkins et al. (1985) observed that sperm whales exposed to 3.25 to 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. Thode et al. (2007) observed that the acoustic signal from the cavitation of a fishing vessel's propeller (110 dB re: 1 μPa^2-s between 250 Hz and 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 mid-frequency marine mammal hearing group, with a hearing range between 150 Hz and 160 kHz (NOAA 2018).

8.5.4 Status

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 climate change, and noise.

8.5.5 Critical Habitat

No critical habitat has been designated for the sperm whale.

8.5.6 Recovery Goals

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.

8.6 Guadalupe Fur Seal

Guadalupe fur seals were once found throughout Baja California, Mexico and along the California coast. Currently, the species breeds mainly on Guadalupe Island, Mexico, off the coast of Baja California. A smaller breeding colony, discovered in 1997, appears to have been established at Isla Benito del Este in the San Benito Archipelago, Baja California, Mexico (Belcher and T.E. Lee 2002). Guadalupe fur seals were listed as threatened under the ESA on December 16, 1985 (50 FR 51252).

8.6.1 Life History

Guadalupe fur seals prefer rocky habitats and can be found in natural recesses and caves (Fleischer 1978), using sheltered beaches and rocky platforms for breeding (Arias-del-Razo et al. 2016). Breeding occurs in June through August. Adult males return to the colonies in early June. Female Guadalupe fur seals arrive on beaches in June, with births occurring between mid-June to July (Pierson 1978); the pupping season is generally over by late July (Fleischer 1978). Breeding adult males are polygamous, and may mate with up to 12 females during a single breeding season. Females stay with pups for seven to eight days after birthing, and then alternate between foraging trips at sea and lactation on shore; nursing lasts about eight months (Figureroa-Carranza 1994). Guadalupe fur seals feed mainly on squid species (Esperon-Rodriguez and Gallo-Reynoso 2013); the Gulf of Ulloa on the Pacific side of the Baja California peninsula is an important feeding area (Aurioles-Gamboa and Szteren 2019). Based on a stable isotope analysis of male Guadalupe fur seal carcasses, there appears to be some niche segregation between coastal and oceanic males, possibly based on individual age and size (Aurioles-Gamboa and Szteren 2019). Foraging trips can last between four to twenty-four days (average of fourteen days). Tracking data show that adult females spend seventy-five percent of their time at sea, and twenty-five percent at rest (Gallo-Reynoso et al. 1995).

8.6.2 Population Dynamics

It is difficult to obtain an accurate abundance estimate of Guadalupe fur seals due in part to their tendency to stay in caves and remain at sea for extended lengths of time, making them unavailable for counting. At the time of listing in 1985, the population was estimated at 1,600 individuals, compared to approximately 30,000 before hunting occurred in the 18th and 19th centuries. A population was "rediscovered" in 1928 with the capture of two males on Guadalupe Island; from 1949 on, researchers reported sighting Guadalupe fur seals at Isla Cedros (near the San Benito Archipelago), and Guadalupe Island (Bartholomew Jr. 1950; Peterson et al. 1968). In 1994, the population at Guadalupe Island was estimated at 7,408 individuals (Gallo-Reynoso 1994). There have been other, more recent population abundance estimates for Guadalupe Island, with a considerable amount of variation between them: 20,000 in 2010 (García-Capitanachi et al. 2017), and between 34,000 and 44,000 in 2013 (García-Aguilar et al. 2018). Guadalupe fur seals are also found on San Benito Island, likely immigrants from Guadalupe Island, as there are relatively few pups born on San Benito Island (Aurioles-Gamboa et al. 2010). There were an estimated 2,504 seals on San Benito Island in 2010 (García-Capitanachi et al. 2017). Based on information presented by (García-Aguilar et al. 2018), and using a population size:pup count ratio of 3.5, the minimum population estimate is 31,019 (Carretta 2020).

All Guadalupe fur seals represent a single population, with two known breeding colonies in Mexico, and a purported breeding colony in the United States. Gallo-Reynoso (1994) calculated that the population of Guadalupe fur seals in Mexico from thirty years of population and counts and concluded the population was increasing; with an average annual growth rate of 13.3 percent on Guadalupe Island. The 2000 NMFS stock assessment report for Guadalupe fur seals also indicated the breeding colonies in Mexico were increasing; and more recent evidence indicates that this trend is continuing (Aurioles-Gamboa et al. 2010; Esperon-Rodriguez and Gallo-Reynoso 2012). From 1984 to 2013 at Guadalupe Island, the Guadalupe fur seal population increased at an average annual growth rate of 5.9 percent (range 4.1 to 7.7 percent) (García-Aguilar et al. 2018). Other estimates of the Guadalupe fur seal population of the San Benito Archipelago (from 1997-2007) indicate that it is increasing as well at an annual rate of 21.6 percent (Esperon-Rodriguez and Gallo-Reynoso 2012), and that this population is at a phase of exponential increase (Aurioles-Gamboa et al. 2010). However, these estimates are considered too high, and likely result from immigration at Guadalupe Island (Carretta 2017; Carretta 2020). Based on direct counts of animals from 1955 and 1993, the estimated annual population growth rate is 13.7 percent (Carretta 2020).

The Guadalupe fur seal clearly experienced a precipitous decline due to commercial exploitation, and may have undergone a population bottleneck. Bernardi et al. (1998) compared the genetic divergence in the nuclear fingerprint of samples taken from 29 Guadalupe fur seals, and found an average similarity of 0.59 of the DNA profiles. This average is typical of outbreeding populations. When comparing the amount of unique character fragments found in Guadalupe fur seals to that of other pinnipeds that have experienced bottlenecks (e.g., Hawaiian monk seals), that amount is much higher (0.14 vs. 0.05) in Guadalupe fur seals than Hawaiian monk seals. By using mitochondrial DNA sequence analysis in comparing the genetic diversity of Guadalupe fur seals to northern elephant seals (which did experience a severe bottleneck), Guadalupe fur seals had more haplotypes and a higher number of variable sites. The authors hypothesized that the numbers of Guadalupe fur seals left after harvest may have been underestimated, and the population may not have actually experienced a bottleneck, or the bottleneck may have been of short duration and not severe enough to suppress genetic diversity. Although the relatively high levels of genetic variability are encouraging, it is important to note that commercial harvest still influenced the population. Later studies comparing mitochondrial DNA found in the bones of pre-exploitation Guadalupe fur seals against the extant population showed a loss of genotypes, with twenty-five genotypes in pre-harvest fur seals, and seven present today (Weber et al. 2004).

Recent tagging and stranding information (2010 to 2016) indicates that Guadalupe fur seals are present in and near the action area (Ortega-Ortiz et al. 2019; Elorriaga-Verplancken et al. 2021). Juveniles (presumed males) can be found at haul outs on islands near the southern tip of the Baja California peninsula, while Guadalupe fur seals were observed (or reported dead) in surveys off Jalisco and Colima (Ortega-Ortiz et al. 2019; Elorriaga-Verplancken et al. 2021).

8.6.3 Vocalization and Hearing

Pinnipeds produce sounds both in air and water that range in frequency from approximately 100 Hz to several tens of kHz and it is believed that these sounds serve social functions such as mother-pup recognition and reproduction. Source levels for pinniped vocalizations range from approximately 95 to 190 dB re 1 μPa (See Richardson et al. 1995f).

Underwater hearing in otariid seals is adapted to low frequency sound and less auditory bandwidth than phocid seals. Hearing in otariid seals has been tested in two species present in the Study Area: California sea lion (Kastak and Schusterman 1998) and northern fur seal (Moore and Schusterman 1987; Babushina et al. 1991). Based on these studies, Guadalupe fur seals would be expected to hear sounds within the ranges of 50 Hz–75 kHz in air and 50 Hz–50 kHz in water.

8.6.4 Status

Commercial sealers in the 19th century decimated the Guadalupe fur seal population, taking as many 8,300 fur seals from San Benito Island (Townsend 1924). Numbers on the total number of fur seals harvested are difficult to ascertain because of the difficulty the hunters had in distinguishing species while hunting (Seagars 1984). These harvests were devastating for the Guadalupe fur seal population, so much so that in 1892, only seven individuals were observed on Guadalupe Island, the location of one of the larger known breeding colonies (Bartholomew Jr. 1950); two years later, a commercial sealer took all 15 remaining individuals that could be found (Townsend 1899).

The species was presumed extinct, until 1926, when a small herd was found on Guadalupe Island by commercial fishermen, who later returned and killed all the seals they could find. In 1928, the

Mexican government declared Guadalupe Island as a pinniped sanctuary. In 1954, during a survey of the island, Hubbs (1956) discovered at least 14 individuals. The government of Mexico banned the hunting of Guadalupe fur seals in 1967. Although population surveys occurred on an irregular basis in subsequent years, evidence shows that the Guadalupe fur seal population has been increasing ever since (see Section 8.6.2).

How the Guadalupe fur seal population was able to persist despite intensive and repeated episodes of hunting is not precisely known, although several factors likely played a role. Hubbs (1956) postulated that since Guadalupe fur seals bred in caves, it made them difficult to find, and they were able to evade hunters. Furthermore, since the adult females spend up to 75 percent of their time at sea for two weeks or more at a time, enough females were away during hunting to survive these episodes.

Although a number of human activities may have contributed to the current status of this species, historic commercial hunting was likely the most devastating. Even with population surveys occurring on an irregular basis in subsequent years, these surveys provide evidence that the Guadalupe fur seal has been increasing after suffering such a significant decline. Although commercial hunting occurred in the past, and has since ceased, the effects of these types of exploitations persist today. Other human activities, such as entanglements from commercial fishing gear, are ongoing and continue to affect these species. While some incidental breeding takes place on the San Benito Islands and the Channel Islands, the Guadalupe Island breeding colony supports the population (García-Aguilar et al. 2018). The current abundance of the Guadalupe fur seal represents about one-fifth of the estimated historical population size, and although the population has continued to increase, the species has not expanded its breeding range, potentially affecting its recovery (García-Aguilar et al. 2018). Because over the last fifty years, the population has been increasing since being severely depleted, we believe that the Guadalupe fur seal population is resilient to future perturbations.

8.6.5 Critical Habitat

No critical habitat has been designated for Guadalupe fur seals.

8.6.6 Recovery Goals

NMFS has not prepared a Recovery Plan for Guadalupe fur seals.

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

The olive ridley sea turtle is a small, mainly pelagic, sea turtle with a circumtropical distribution. The species was listed under the ESA on July 28, 1978 (43 FR 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). Pacific coast of Mexico beaches where large-scale synchronized nesting occurs (arribadas) are in the Mexican States of Jalisco, Colima, Michoacán, Guerrero and Oaxaca (Figure 2).

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

8.7.1 Life History

Olive ridley females mature at ten to eighteen years of age. They lay an average of two clutches per season (three to six months in duration). The annual average clutch size is one hundred to 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 fifty and sixty 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.

8.7.2 Population Dynamics

Olive ridley sea turtles are thought to be the most abundant species of sea turtle. Shipboard transects along the Mexico and Central American coasts between 1992 and 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 2014a).

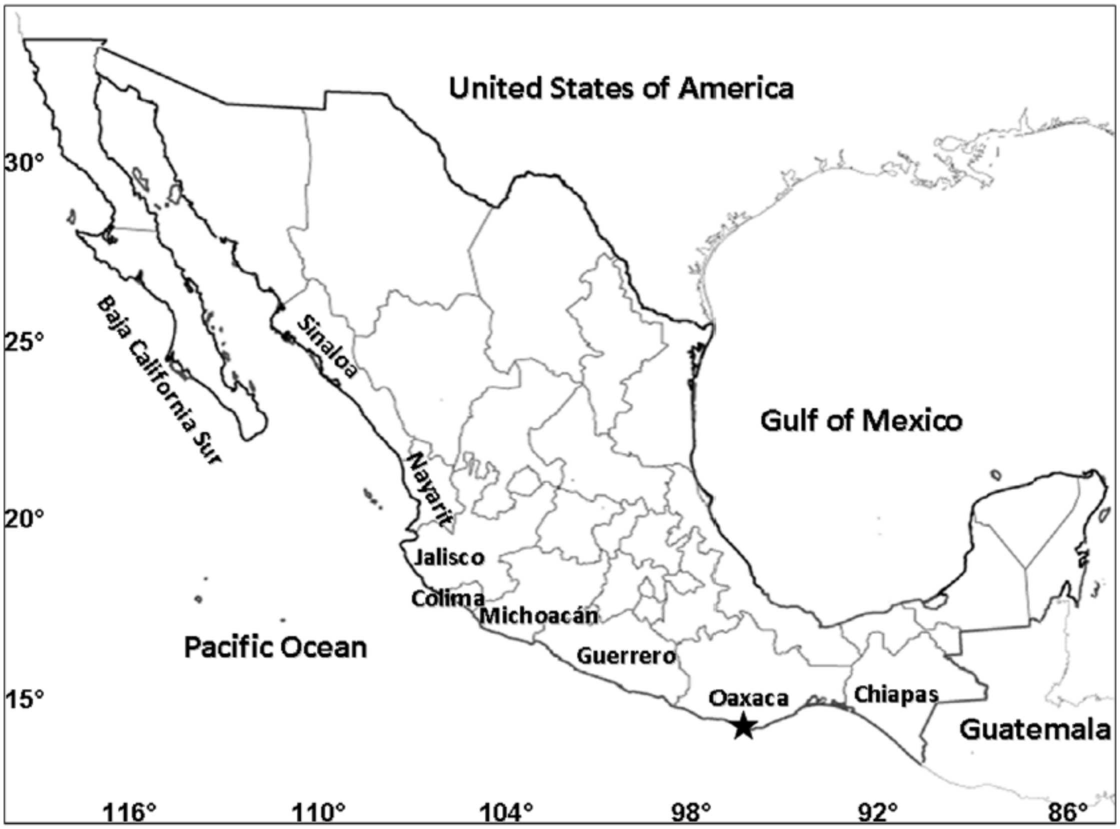

Figure 2. Map of Mexican states where Olive Ridley sea turtle nesting occurs; arribada-nesting beach at La Escobilla, Oaxaca is starred. From Hernández-Echeagaray et al. (2012).

Based on the number of olive ridleys nesting in Mexico, populations appear to be increasing in one location (La Escobilla, Oaxaca: from 50,000 nests in 1988 to more than one million in 2000), decreasing at Chacahua, Oaxaca, and stable at all others. 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.

The range of the endangered Pacific coast breeding population extends as far south as Peru and up to California.

8.7.3 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 low frequency hearing specialists, typically hearing frequencies from 30 Hz to 2 kHz, with a range of maximum sensitivity between

100 to 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 to 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 or 4 kHz (Patterson 1966).

8.7.4 Status

After olive ridleys became targeted in a fishery in Mexico and Ecuador, which the population was severely depleted from an estiamted ten million olive ridleys nesting 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 climate change.

8.7.5 Critical Habitat

No critical habitat has been designated for the olive ridley sea turtles of the breeding population of the Pacific coast of Mexico.

8.7.6 Recovery Goals

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.

8.8 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. Recent 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 biological 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 FR 58868) to summarize the life history, population dynamics and status of the species.

8.8.1 Life History

Mean age at first reproduction for female loggerhead sea turtles is 30 years (standard deviation = 5). Females lay an average of three clutches per season. The annual average clutch size is 112 eggs per nest. The average remigration (i.e., return to natal beaches) interval is 2.7 years. 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. 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). Coastal waters provide important foraging habitat, inter-nesting habitat, and migratory habitat for adult loggerheads.

8.8.2 Population Dynamics

The North Pacific Ocean DPS has a nesting population of about 2,300 nesting females (Matsuzawa 2011). 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).

Overall, Gilman (2009) estimated that the number of loggerheads nesting in the Pacific has declined by eighty percent in the past twenty years. There was a steep (fifty to ninety percent) decline in the annual nesting population in Japan during the last half of the twentieth century (Kamezaki et al. 2003). Since then, nesting has gradually increased, but is still considered to be depressed compared to historical numbers, and the population growth rate is negative (-0.032) (Conant et al. 2009).

There are nine loggerhead DPSs, which are geographically separated and genetically isolated, as indicated by genetic, tagging, and telemetry data. Our understanding of the genetic diversity and population structure of the different loggerhead DPSs is being refined as more studies examine samples from a broader range of specimens using longer mitochondrial DNA sequences.

Recent mitochondrial DNA 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). Genetic analysis of loggerheads captured on the feeding grounds of Sanriku, Japan, found only haplotypes present in Japanese rookeries (Nishizawa et al. 2014).

Loggerheads are circumglobal, occurring throughout the temperate and tropical regions of the Atlantic, Pacific, and Indian oceans, returning to their natal region for mating and nesting. Adults and sub-adults occupy nearshore habitat. While in their oceanic phase, loggerheads undergo long migrations using ocean currents. Individuals from multiple nesting colonies can be found on a single feeding ground.

All nesting for the North Pacific DPS occurs at sites in Japan (NMFS 2020b). There is no loggerhead nesting on the Pacific coast of Mexico (Chapman and Seminoff 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). 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).

8.8.3 Hearing

Sea turtles are low frequency hearing specialists, typically hearing frequencies from 30 Hz to 2 kHz, with a range of maximum sensitivity between 100 and 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 to 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 and 800 Hz and auditory evoked potential responses between 100 and 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 to 800 Hz while juveniles responded to sounds in the range of 50 Hz to 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 and 700 Hz, with slow declines below 100 ha 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 or 4 kHz (Patterson 1966).

8.8.4 Status

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 climate change) and numerous (habitat loss and modification, overutilization, and predation) threats acting on a small, subdivided population (NMFS 2020b).

8.8.5 Critical Habitat

No critical habitat has been designated for loggerhead sea turtle North Pacific Ocean DPS.

8.8.6 Recovery Goals

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.

8.9 Hawksbill Sea Turtle

The hawksbill turtle has a circumglobal distribution throughout tropical and, to a lesser extent, subtropical oceans. The species was first listed under the Endangered Species Conservation Act and listed as endangered under the ESA since 1973. We used information available in the 2007 and 2013 five-year reviews (NMFS and USFWS 2007b; NMFS and USFWS 2013a) to summarize the life history, population dynamics and status of the species.

8.9.1 Life History

Hawksbill sea turtles reach sexual maturity at twenty to forty years of age. Females return to their natal beaches every two to five years to nest and nest an average of three to five times per season. The majority of nesting for the species in the eastern Pacific (80 percent) occurs in El Salvador and Nicaragua (Liles et al. 2015). Clutch sizes are large (up to 250 eggs). In the eastern Pacific, timing of nesting varies. In Costa Rica, peak nesting occurred in late November (Gaos et al. 2010); in Guatemala, nesting was reported in July (Muccio and Izquierdo 2019). Hatchlings emerge from nests after 60 days. Sex determination is temperature dependent, with warmer incubation producing more females. Hatchlings migrate to and remain in pelagic habitats until they reach approximately twenty two to twenty five centimeters in straight carapace length. As juveniles, they take up residency in coastal waters to forage and grow. As adults, hawksbills use their sharp beak-like mouths to feed on sponges and corals. Hawksbill sea turtles are highly migratory and use a wide range of habitats during their lifetimes (Musick and Limpus 1997; Plotkin 2003). Satellite tagged turtles have shown significant variation in movement and migration patterns. Gaos et al. (2017) tagged adult females on nesting beaches in the Pacific coasts of El Salvador, Nicaragua, and Ecuador and found that tagged individuals used inshore estuarine bays and mangrove saltwater forests as foraging habitat. Similarly, tagged hawksbills in the Gulf of California, Mexico, also used mangrove estuaries as foraging habitat (Martínez-Estévez et al. 2021). Distance traveled between nesting and foraging locations ranges from a few hundred to a few thousand kilometers (Miller et al. 1998; Horrocks et al. 2001). However, hawksbill sea turtles in the eastern Pacific generally stay relatively close (about seven kilometers) to their natal beaches and foraging areas in mangrove estuaries (Gaos et al. 2012).

8.9.2 Population Dynamics

Surveys at eighty eight nesting sites worldwide indicate that 22,004 to 29,035 females nest annually (NMFS and USFWS 2013a). In general, hawksbills are doing better in the Atlantic and Indian Ocean than in the Pacific Ocean, where despite greater overall abundance, a greater proportion of the nesting sites are declining. In the eastern Pacific, it is estimated that there are fewer than 600 nesting females (Gaos et al. 2017). Nesting records in the region from 2007 to 2009 indicate that El Salvador hosts almost 80 percent of nesting for the eastern Pacific (between 100 and 215 nests), with only minor nesting areas (< 20 nests each) reported in Nicaragua, Costa Rica, Ecuador, and Guatemala (Gaos et al. 2010). There are less than ten nests reported in Mexico (Baja California), and no known hawksbill nests adjacent to the action area (NMFS and USFWS 2013a).

The current population trends are not known for hawksbill sea turtles in the eastern Pacific, but it is generally believed that the number of nests have declined from historical numbers (NMFS and USFWS 2013a).

Populations are distinguished generally by ocean basin and more specifically by nesting location. Our understanding of population structure is relatively poor. Genetic analysis of hawksbill sea turtles foraging off the Cape Verde Islands identified three closely-related haplotypes in a large majority of individuals sampled that did not match those of any known nesting population in the western Atlantic, where the vast majority of nesting has been documented (McClellan et al. 2010; Monzón-Argüello et al. 2010). Hawksbills in the Caribbean seem to have dispersed into separate populations (rookeries) after a bottleneck roughly 100,000 to 300,000 years ago (Leroux et al. 2012).

The hawksbill has a circumglobal distribution throughout tropical and, to a lesser extent, subtropical waters of the Atlantic, Indian, and Pacific Oceans. In their oceanic phase, juvenile hawksbills can be found in mats of floating vegetation; post-oceanic hawksbills may occupy a range of habitats that include coral reefs or other hard-bottom habitats, sea grass, algal beds, mangrove bays and creeks (Musick and Limpus 1997; Bjorndal and Bolten 2010).

8.9.3 Hearing

Sea turtles are low frequency hearing specialists, typically hearing frequencies from 30 Hz to 2 kHz, with a range of maximum sensitivity between 100 to 800 Hz (Ridgway et al. 1969b; Lenhardt 1994; Bartol et al. 1999; Lenhardt 2002; Bartol and Ketten 2006). Piniak et al. (2012) found hawksbill turtle hatchlings capable of hearing underwater sounds at frequencies of between 50 Hz to 1.6 kHz (maximum sensitivity at 200 to 400 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 to 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 or 4 kHz (Patterson 1966).

8.9.4 Status

Long-term data on the hawksbill sea turtle indicate that sixty-three sites have declined over the past twenty to one hundred years (historic trends are unknown for the remaining twenty-five sites). Recently, twenty-eight sites (sixty-eight percent) have experienced nesting declines, ten have experienced increases, three have remained stable, and forty-seven have unknown trends. Hawksbill sea turtles were once common in the eastern Pacific from Mexico to Ecuador, but due largely to commercial exploitation, now is rare (Gaos et al. 2010). The greatest threats to hawksbill sea turtles are overharvesting of turtles and eggs, degradation of nesting habitat, and fisheries interactions. Adult hawksbills are harvested for their meat and carapace, which is sold as tortoiseshell. Eggs are taken at high levels; the poaching of eggs is such a concern that in El Salvador, where over 80 percent of the hawksbill nesting occurs on two beaches, most (90 percent) of the nests are relocated to hatcheries to prevent the eggs from being harvested (Liles et al. 2015). In addition, lights on or adjacent to nesting beaches are often fatal to emerging hatchlings and alters the behavior of nesting adults. The species' resilience to additional perturbation is low.

8.9.5 Critical Habitat

There is no designated critical habitat within the action area for this species.

8.9.6 Recovery Goals

See the 1992 Recovery Plan for the U.S. Caribbean, Atlantic and Gulf of Mexico (NMFS and USFWS 1993) and the 1998 Recovery Plan for the U.S. Pacific populations (NMFS and USFWS 1998b) of hawksbill sea turtles, for complete down listing/delisting criteria for each of their respective recovery goals. The following items were the top recovery actions identified to support in the recovery plans:

1. Identify important nesting beaches.
2. Ensure long-term protection and management of important nesting beaches.
3. Protect and manage nesting habitat; prevent the degradation of nesting habitat caused by seawalls, revetments, sand bags, other erosion-control measures, jetties and breakwaters.
4. Identify important marine habitats; protect and manage populations in marine habitat.
5. Protect and manage marine habitat; prevent the degradation or destruction of important [marine] habitats caused by upland and coastal erosion.
6. Prevent the degradation of reef habitat caused by sewage and other pollutants.
7. Monitor nesting activity on important nesting beaches with standardized index surveys.
8. Evaluate nest success and implement appropriate nest-protection on important nesting beaches.
9. Ensure that law-enforcement activities prevent the illegal exploitation and harassment of sea turtles and increase law-enforcement efforts to reduce illegal exploitation.
10. Determine nesting beach origins for juvenile and sub adult populations.

8.10 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 meters (6.5 feet) 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 FR 8491) and listed as endangered under the ESA since 1973. In the 2020 Five-Year Status 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 3).

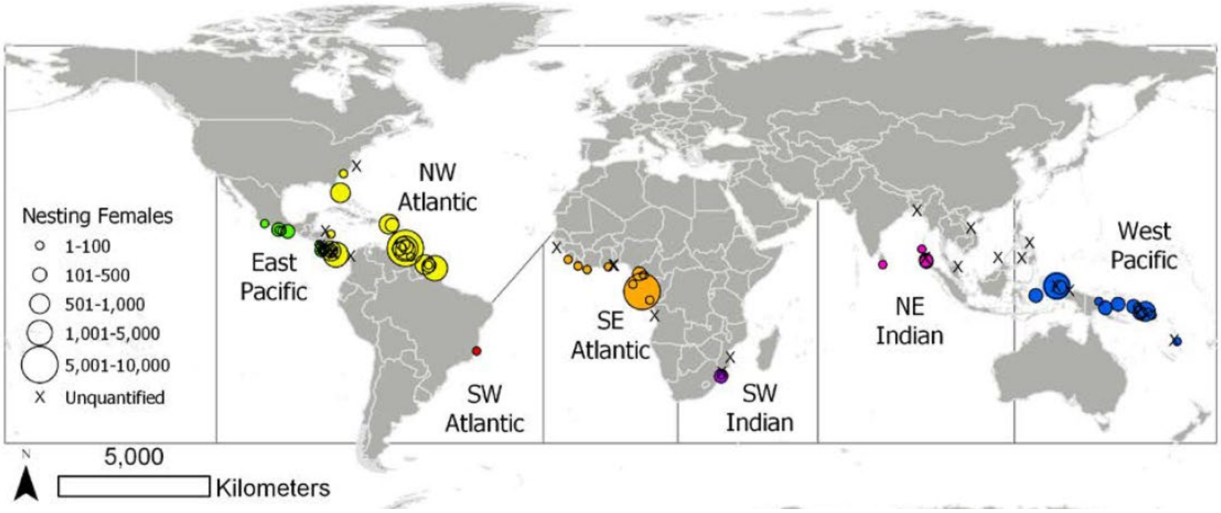

Figure 3. Map of Leatherback DPS boundaries and nesting beaches. From NMFS and USFWS 2020.

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. This DPS forages primarily in the East Pacific Ocean, off the coasts of Central and South America and nest primarily on beaches in Mexico, Costa Rica, and Nicaragua. We used information available in the five year review (NMFS and USFWS 2013b) and (NMFS 2020c) and the critical habitat designation (77 FR 61573) to summarize the life history, population dynamics and status of the species.

8.10.1 Life History

Age at maturity has been difficult to ascertain, with estimates ranging from five to 29 years (Spotila et al. 1996; Avens et al. 2009). Females lay up to seven clutches per season, with more than sixty-five eggs per clutch and eggs weighing greater than 80 grams (0.17 pounds) (Reina et al. 2002; Wallace et al. 2007). The number of leatherback turtle hatchlings that make it out of the nest on to the beach (i.e., emergent success) is approximately 50 percent worldwide (Eckert et al. 2012). Females 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. 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 of the East Pacific DPS include coastal and pelagic waters of the southeastern Pacific Ocean, with some tagged individuals foraging in coastal areas off Peru and Chile (NMFS 2020c). Jellyfish and tunicates are relatively nutrient-poor, such that leatherback turtles must consume large quantities to support their body weight. Leatherback turtles weigh about 33 percent more on their foraging grounds than at nesting, indicating that they probably catabolize fat reserves to fuel migration and subsequent reproduction (James et al. 2005; Wallace et al. 2006). Sea turtles must meet an energy threshold before returning to nesting beaches. Therefore, their remigration intervals 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).

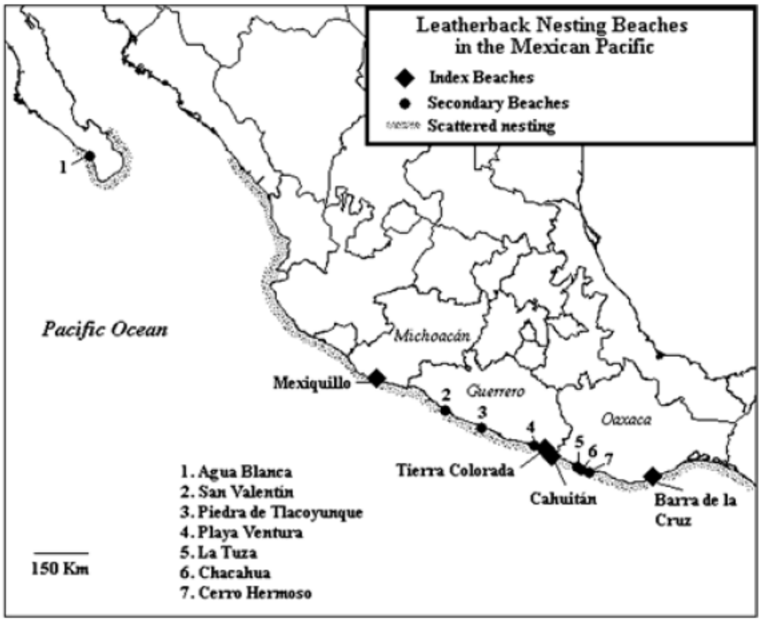

Figure 4. Leatherback nesting beaches in Mexico. From Martínez et al. (2007).

8.10.2 Population Dynamics

Leatherback turtles are globally distributed, with nesting beaches in the Atlantic, Indian, and Pacific Oceans. Detailed population structure is unknown, but is likely dependent upon nesting beach location. 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). Mexico historically hosted the world’s largest aggregation of leatherback nesting, with 75,000 nesting females observed in 1980 during an aerial survey. Mexico hosts seven leatherback nesting beaches (Figure 4). 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 four kilometers of this nesting beach. By 1993, less than 100 nests were counted along the entire 18-kilometer beach (Sarti-Martínez

2002). According to Sarti et al. (1996), nesting declined at this location at an annual rate of over 22 percent from 1984 to 1995.

Overall, there has been a steep decline (97.4 percent) in nesting productivity for leatherbacks in the eastern Pacific over the last thirty to forty years. In Mexico, annual median nest counts vary from beach to beach, with some (Playa Barra de la Cruz /Playa Grande) increased by 9.5 percent annually, while others (Cahuitán) decreased from 1997/1998 through 2016/2017, with a median trend of −4.3 percent annually (NMFS 2020c).

Analyses of mitochondrial DNA from leatherback turtles indicates a low level of genetic diversity, pointing to possible difficulties in the future if current population declines continue (Dutton et al. 1999). Previously, Wallace et al. (2013) 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.

There are 16 nesting sites for leatherbacks in the eastern Pacific, with seven sites in Mexico (Figure 4). Of the estimated 755 nesting females in the eastern Pacific, 572 nest in Mexico. Tierra Colorada, Guerrero, hosts 120 nesting females annually, making it the second largest nesting beach in Mexico. Playón Mexiquillo, Michoacán has 78 nesting females. Playa Barra de la Cruz, Playa Grande, to the south in Oaxaca, has 209 nesting females (NMFS 2020c).

8.10.3 Hearing

Sea turtles are low frequency hearing specialists, typically hearing frequencies from 30 Hz to 2 kHz, with a range of maximum sensitivity between 100 and 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 and 1.6 kHz in air between 50 Hz and 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 and 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 to 4 kHz (Patterson 1966).

8.10.4 Status

The leatherback turtle is an endangered species whose once large nesting populations have experienced steep declines in recent decades. The primary threats to leatherback turtles include fisheries bycatch, harvest of nesting females, and egg harvesting (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 is common in leatherback turtles and can block gastrointestinal tracts leading to death. Climate change may alter sex ratios (as temperature determines hatchling sex), range (through expansion of foraging habitat), and habitat (through the loss of nesting beaches, because of sea-level rise). The species' resilience to additional perturbation is low.

8.10.5 Critical Habitat

There is no designated critical habitat in the action area.

8.10.6 Recovery Goals

See the 1998 and 1991 Recovery Plans for the U.S. Pacific and U.S Caribbean, Gulf of Mexico and Atlantic leatherback turtles for complete down listing/delisting criteria for each of their respective recovery goals. 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

8.11 Green Sea Turtle—East Pacific Distinct Population Segment

On April 6, 2016, NMFS listed eleven 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. The DPSs considered in this biological opinion that occur within the action area are the threatened Central North Pacific and East Pacific DPSs.

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

8.11.1 Life History

Age at first reproduction for females is twenty to forty 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 sixty 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.

8.11.2 Population Dynamics

There are thirty-nine 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 fifty-eight percent of the nesting females (11,588) 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). There are no estimates of population growth. Only one nesting site in the East Pacific DPS at Colola, Mexico, has sufficient long-term data to determine population trends. Data analysis indicates that the population there is increasing and is likely to continue to do so.

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).

8.11.3 Hearing

Sea turtles are low frequency hearing specialists, typically hearing frequencies from 30 Hz to 2 kHz, with a range of maximum sensitivity between 100 to 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 to 1,600 Hz (maximum sensitivity at 200 to 400 Hz). Hearing below 80 Hz is less sensitive but still possible (Lenhardt 1994). Other studies have similarly found greatest sensitivities between 200 to 400 Hz for the green turtle with a range of 100 to 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 to 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 to 4 kHz (Patterson 1966).

8.11.4 Status

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). 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.

8.11.5 Critical Habitat

No critical habitat has been designated for green sea turtle East Pacific DPS.

8.11.6 Recovery Goals

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 1998a). 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.

9 ENVIRONMENTAL BASELINE

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

The environmental baseline for this opinion includes the effects of several human activities that affect the survival and recovery of populations of ESA-listed marine mammals, sea turtles, and fish in the action area. Some human activities are ongoing and appear to continue to affect marine mammal, sea turtle, and fish populations in the action area for this consultation. Some of these activities, most notably commercial whaling, occurred extensively in the past and continue at low levels that no longer appear to significantly affect marine mammal populations, although the effects of past reductions in numbers persist today. The following discussion summarizes the impacts, which include climate change, oceanic temperature regimes, unusual mortality events, vessel activity, whale watching, fisheries (fisheries interactions, hatcheries, and aquaculture), pollution (marine debris, pesticides and contaminants, and hydrocarbons), aquatic nuisance species, anthropogenic sound (vessel sound and commercial shipping, seismic surveys, and marine construction), military activities, and scientific research activities.

9.1 Climate Change

There is a large and growing body of literature on past, present, and future impacts of global climate change, exacerbated and accelerated by human activities. Effects of climate change include sea level rise, increased frequency and magnitude of severe weather events, changes in air and water temperatures, and changes in precipitation patterns, all of which affect ESA resources. NOAA's climate information portal provides basic background information on these and other measured or anticipated climate change effects (see https://www.climate.gov).

This section provides some examples of impacts to ESA-listed species and their habitats that have occurred or may occur as the result of climate change. We address climate change as it has affected and continues to affect ESA-listed species and their habitat, and we look to the foreseeable future to consider effects that we anticipate will occur as a result of ongoing activities. While the consideration of future impacts may also be suited to our cumulative effects analysis, it is discussed here to provide a comprehensive analysis of the effects of climate change in one location in the document. Although it is difficult to accurately predict the consequences of climate change to a particular species or habitat, a range of consequences are expected that are likely to change the status of the species and the condition of their habitats both within and outside of the action area.

Changes in the marine ecosystem caused by global climate change (e.g., ocean acidification, salinity, oceanic currents, dissolved oxygen levels, nutrient distribution) could influence the distribution and abundance of lower trophic levels (e.g., phytoplankton, zooplankton, submerged aquatic vegetation, crustaceans, mollusks, forage fish), ultimately affecting primary foraging areas of ESA-listed species including cetaceans, sea turtles, and fish. 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). We expect the same changes to occur with ESA-listed species within the action area.

Though predicting the precise consequences of climate change on highly mobile marine species is difficult (Simmonds and Eliott 2009), recent research has indicated a range of consequences already occurring. For example, in sea turtles, sex is determined by the ambient sand temperature (during the middle third of incubation) with female offspring produced at higher temperatures and males at lower temperatures within a thermal tolerance range of 25 to 35°C (Ackerman 1997). These impacts will be exacerbated by sea level rise. The loss of habitat because of climate change could be accelerated due to a combination of other environmental and oceanographic changes such as an increase in the frequency of storms and/or changes in prevailing currents, both of which could lead to increased beach loss via erosion (Antonelis et al. 2006; Baker et al. 2006).

Hazen et al. (2012) examined top predator distribution and diversity in the Pacific Ocean in light of rising sea surface temperatures using a database of electronic tags and output from a global climate model. They predicted up to a 35 percent change in core habitat area for some key marine predators in the Pacific Ocean, with some species predicted to experience gains in available core habitat and some predicted to experience losses. Notably, leatherback turtles were predicted to gain core habitat area, whereas blue whales were predicted to experience losses in available core habitat. (McMahon and Hays 2006) predicted increased ocean temperatures would expand the distribution of leatherback turtles into more northern latitudes. The authors noted this is already occurring in the Atlantic Ocean. (Macleod 2009) estimated, based upon expected shifts in water temperature, 88 percent of cetaceans will be affected by climate change; with 47 percent predicted to experience unfavorable conditions (e.g., range contraction). (Willis-Norton et al. 2015) acknowledged there would be both habitat loss and gain, but overall climate change could result in a 15 percent loss of core pelagic habitat for leatherback turtles in the eastern South Pacific Ocean.

For ESA-listed sea turtles, Guadalupe fur seals, and ESA-listed whales which undergo long migrations, if either prey availability or habitat suitability is disrupted by changing ocean temperatures, regimes, the timing of migration can change or negatively impact population sustainability (Simmonds and Eliott 2009).

Climate-related changes in important prey species populations are likely to affect predator populations. Climate-mediated changes in the distribution and abundance of keystone prey species like krill and in cephalopod populations worldwide will likely affect marine mammal populations as they re-distribute throughout the world's oceans in search of prey. Blue whales, as predators that specialize in eating krill, seem likely to change their distribution in response to changes in the distribution of krill (Payne et al. 1990). If they did not change their distribution or could not find the biomass of krill necessary to sustain their population numbers, their populations seem likely to experience declines, 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. Pecl and Jackson (2008) predicted climate change will likely result in squid that hatch out smaller and earlier, undergo faster growth over shorter life-spans, and mature younger at a smaller size. This could have negative consequences for species such as sperm whales and Guadalupe fur seals, whose diet is primarily squid and cephalopods, that would have to re-distribute following changes in the distribution and abundance of their prey. This statement assumes that projected changes in global climate would only affect the distribution of cephalopod populations, but would not reduce the number or density of cephalopod populations. If, however, cephalopod populations collapse or decline dramatically, sperm whale populations are likely to collapse or decline dramatically as well.

Climate change can impact coral reefs and other calcium carbonate habitats generally, which in turn can affect species that rely on these habitats. For example, adult hawksbill sea turtles rely on corals for foraging. The magnitude and the rapid pace of change in greenhouse gas concentrations (e.g., carbon dioxide and methane) and atmospheric warming since the Industrial Revolution in the mid-19th century is causing concerns due to the impacts to coral reefs. These changes are increasing the warming of the global climate system and altering the carbonate chemistry of the ocean (ocean acidification; (IPCC 2014a). As carbon dioxide concentrations increase in the atmosphere, more carbon dioxide is absorbed by the oceans, causing lower pH and reduced availability of calcium carbonate. Because of the increase in carbon dioxide and other greenhouse gases (GHG) in the atmosphere since the Industrial Revolution, ocean acidification has already occurred throughout the world's oceans and is predicted to increase considerably through the 21st century (IPCC 2022).

In order to evaluate the implications of different climate outcomes and associated impacts throughout the 21st century, many factors have to be considered with GHG emissions and the potential variability in emissions serving as a key variable. Developments in technology, changes in energy generation and land use, global and regional economic circumstances, and population growth must also be considered.

9.2 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).

The Pacific decadal oscillation is the leading mode of variability in the North Pacific Ocean and operates over longer periods than either El Niño or La Niña/Southern Oscillation events and is capable of altering sea surface temperature, surface winds, and sea level pressure (Mantua and Hare 2002; Stabeno et al. 2004). During positive Pacific decadal oscillations, the northeastern Pacific experiences above average sea surface temperatures while the central and western Pacific Ocean undergoes below-normal sea surface temperatures (Royer 2005). Warm Pacific decadal oscillation regimes, as occurs in El Niño events, tends to decrease productivity along the U.S. west coast, as upwelling typically diminishes (Hare et al. 1999; Childers et al. 2005). Recent sampling of oceanographic conditions just south of Seward, Alaska has revealed anomalously cold conditions in the Gulf of Alaska from 2006 through 2009, suggesting a shift to a colder Pacific decadal oscillation phase. More research needs to be done to determine if the region is indeed shifting to a colder Pacific decadal oscillation phase in addition to what effects these phase shifts have on the dynamics of prey populations important to ESA-listed cetaceans throughout the Pacific action area. A shift to a colder decadal oscillation phase would be expected to impact prey populations, although the magnitude of this effect is uncertain.

In addition to period variation in weather and climate patterns that affect oceanographic conditions in the action area, longer-term trends in climate change and/or variability also have the potential to alter habitat conditions suitable for ESA-listed species in the action area on a much longer time scale. The average global surface temperature rose by 0.85ºC from 1880 to 2012, and it continues to rise at an accelerating pace (IPCC 2014b); the 15 warmest years on record since 1880 have occurred in the 21st century (NCEI 2016). 2016 is the warmest year on record, followed by 2020 as the second warmest, and 2021 as the sixth warmest.[1] The warmest year on record for global sea surface temperature was also 2016, and 2021 as the seventh warmest[2].

Possible effects of this trend in climate change and/or variability 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. 2005; Robinson et al. 2005; Kintisch 2006; Learmonth et al. 2006; McMahon and Hays 2006). Climate change can influence reproductive success by altering prey availability, as evidenced by the low success of Northern elephant seals (*Mirounga angustirostris*) during El Niño periods (McMahon and Burton 2005), as well as data suggesting that sperm whale females have lower rates of conception following periods of unusually warm sea surface temperature (Whitehead et al. 1997). However, gaps in information and the complexity of climatic interactions complicate the ability to predict the effects that climate change and/or variability may have to these species from year to year in the action area (Kintisch 2006; Simmonds and Isaac 2007).

9.3 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 meters from the vessel, and stayed underwater for three minutes beyond its projected surfacing time (Szesciorka et al. 2019). There are thirteen seaports on the Pacific coast of Mexico, with the largest—Lázaro Cárdenas in Michoacán, and the second largest—Manzanillo in Colima, both in the action area. Lázaro Cárdenas has a capacity of about 25 million tons of cargo and about 1,500 cargo ships annually[3], while

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[1] https://www.noaa.gov/news/2021-was-worlds-6th-warmest-year-on-record (Accessed 1/24/2022).

[2] https://www.ncei.noaa.gov/news/global-climate-202112 (Accessed 2/24/2022)

[3] https://en.wikipedia.org/wiki/Port_of_L%C3%A1zaro_C%C3%A1rdenas. (Accessed 1/24/2022).

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.

9.3.1 Vessel Strike

Vessel strikes are considered a serious and widespread threat to 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 meters (262.5 feet) 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 kilometers per hour (14 knots) (Laist et al. 2001). 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 percent 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).

The region in and around the action area is regarded as suffering from a lack of reporting of large whale vessel strikes, with 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 percent) or sustained life-threatening injuries (5 percent), while in a smaller percentage (7.5 percent) of the cases the whale was expected to survive. In the remaining 40 percent 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 meters)

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[4] https://shipnext.com/port/manzanillo-mxzlo-mex. (Accessed 1/24/2022).

making up 27.5 percent 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) in the action area and 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 kilometers per hour (2.6 knots); 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 percent (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 possible to occur, data on vessel strikes of sea turtles in the action area is lacking.

9.4 Fisheries

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

9.4.1 Marine Mammals

Entrapment and entanglement in fishing gear is a frequently documented source of human-caused mortality in cetaceans (see Dietrich et al. 2007). Materials entangled tightly around a body part may cut into tissues, enable infection, and severely compromise an individual's health (Derraik 2002). Entanglements also make animals more vulnerable to additional threats (e.g., predation and vessel strikes) by restricting agility and swimming speed. The majority of marine mammals that die from entanglement in fishing gear likely sink at sea rather than strand ashore, making it difficult to accurately determine the extent of such mortalities.

There is a lack of information regarding large whale entanglement specific to the action area (and the Pacific coast of Mexico at large), although 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 gill-nets 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 gill nets 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 gill nets 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 the nearshore, artisanal fisheries.

There have been reports of Guadalupe fur seals stranding with evidence of entanglement in fishing gear or other marine debris (Hanni et al. 1997). For Guadalupe fur seals outside the action area, from the period of 2009 to 2013, there were 20 Guadalupe fur seals reported as injured or killed as a result of human-related injury; 13 dead, three seriously injured, and four non-seriously injured (Carretta et al. 2015). Several of these individuals were entangled in pieces of gillnet, trawl nets, or gear from an unidentified net fishery. While there is little information available regarding Guadalupe fur seal entanglement in the action area, based on information elsewhere, and the presence of regional fisheries, we can assume that entanglement poses a risk for Guadalupe fur seals in the action area.

In addition to direct impacts like entanglement, marine mammals may also be subject to indirect impacts from fisheries. In a study of retrospective data, Jackson et al. (2001) concluded that ecological extinction caused by overfishing precedes all other pervasive human disturbance of coastal ecosystems, including pollution and anthropogenic climate change.

Fisheries can have a profound influence on fish populations. 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.

9.4.2 Sea Turtles

Fishery interaction remains a major factor in sea turtle recovery and, frequently, the lack thereof. Wallace et al. (2010) estimated that worldwide, 447,000 sea turtles are killed each year from bycatch in commercial fisheries. Although sea turtle bycatch reduction efforts have been undertaken in Mexico, mortality still occurs (Wang et al. 2010; Trejo and Diaz 2012; Bojórquez-Tapia et al. 2017).

As with marine mammals, there is a lack of information about sea turtle bycatch in the action area. However, since we are aware of artisanal fisheries in the action area (Gomez-Vanega et al. 2021), and we are aware of the risk posed by the fisheries to sea turtles, we can assume that incidental bycatch is occurring, although undocumented or under-reported. In areas elsewhere in the region where small-scale gill net fisheries overlap with nearshore green turtle foraging areas, mortality from incidental bycatch can be significant. Green turtles incidentally bycaught in artisanal fisheries in Baja California Sur originated from nesting beaches in Michoacán, within the action area (Mancini et al. 2012). For hawksbill sea turtles captured in small-scale lobster gill net fisheries in El Salvador and Nicaragua, estimated mortality is 74 percent (Liles et al. 2017). For loggerheads captured in high-use areas of artisanal gill net fisheries in Baja California Sur, researchers estimated over 1,000 loggerhead mortalities annually from only two fisheries (Peckham et al. 2007). Although we were not able to find information on olive ridley bycatch rates in fisheries in the action area, based on the information available for other species, the amount of fishing effort in the action area, and that olive ridley sea turtles are the most abundant sea turtle species in the region, it is reasonable to assume that olive ridley sea turtles are subjected to the same capture and mortality risk as other species. 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. Roe (2014) found the greatest areas of bycatch risk were in the jurisdictional waters of several Indo-Pacific nations, largely affecting the western nesting individuals.

9.5 Poaching

Poaching and illegal harvest of sea turtles and eggs for human consumption is a widespread problem for sea turtles throughout the region, including in the action area. For some species, poaching either was the cause for the population decline historically, or is currently a barrier to recovery. Hawksbill sea turtles were once common in the eastern Pacific from Mexico to Ecuador, but due largely to commercial exploitation, now are rare (Gaos et al. 2010). Illegal harvest of hawksbill eggs is such a prevalent problem that in some areas of El Salvador and

Nicaragua, there are intensive efforts to relocate over 90 percent of clutches to safe, monitored locations (e.g., hatcheries) to increase hatchling survival (Liles et al. 2015). During beach surveys from 2000 to 2003 in Bahia Magdalena, Mexico, researchers recovered nearly 2,000 carcasses of olive ridley, loggerhead, hawksbill, and green sea turtles, most (>95 percent) of which were evidently slaughtered for human consumption (Koch et al. 2006).

Despite efforts to curb illegal harvest, sea turtle poaching still continues. Conservation and monitoring programs in Oaxaca are criticized as being inadequate, and the illegal sale of sea turtle eggs continues (Navarro 2015). By interviewing local residents, researchers found that individuals overall supported sea turtle conservation broadly, but economic and community pressure were cited as obstacles to curbing illegal harvest (Senko et al. 2011).

9.6 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.

9.6.1 Marine Debris

Data on marine debris in some locations of 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 Pacific Ocean, but we assume similar effects from marine debris documented within other ocean basins could also occur to species from marine debris.

Cetaceans are impacted by marine debris, which includes plastics, glass, metal, polystyrene foam, rubber, and derelict fishing gear (Baulch and Perry 2014b; Li et al. 2016). 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 percent of individuals in some populations containing marine debris in their guts and being the cause of death for up to 22 percent of individuals found stranded on shorelines (Baulch and Perry 2014a).

Plastic waste in the ocean can leach chemical additives into the water or these additives, such as brominated flame retardants, stabilizers, phthalate esters, biphenyl A, and nonylphenols (Panti et al. 2019). Additionally, plastic waste chemically attracts hydrocarbon pollutants such as polychlorinated biphenyl and dichlorodiphenyltrichloroethane. Individuals can mistakenly consume these wastes containing elevated levels of toxins instead of their prey. Once consumed, plastics can act as nutritional diluents in the gut, making the animal feel satiated before it has acquired the necessary amount of nutrients required for general fitness (reviewed in (Machovsky-Capuska et al. 2019)). Plastics may therefore influence the nutritional niches of animals in higher trophic levels, such as Guadalupe fur seals and other pinnipeds (Machovsky-Capuska et al. 2019).

Given the limited knowledge about the impacts of marine debris on marine mammals, it is difficult to determine the extent of the threats that marine debris poses to marine mammals. However, marine debris is consistently present and has been found in marine mammals in and near the action area. In 2008, two sperm whales stranded along the California coast, with an assortment of fishing related debris (e.g., net scraps, rope) and other plastics inside their stomachs (Jacobsen et al. 2010). One whale was emaciated, and the other had a ruptured stomach. It was suspected that gastric impactions was the cause of both deaths. Jacobsen et al. (2010) speculated the debris likely accumulated over many years, possibly in the North Pacific gyre that will carry derelict Asian fishing gear into eastern Pacific Ocean waters.

Ingestion of marine debris can be a serious threat to sea turtles. When feeding, sea turtles (e.g., leatherback turtles) can mistake debris (e.g., tar and plastic) for natural food items, especially jellyfish, which are a primary prey. Some types of marine debris may be directly or indirectly toxic, such as oil. One study found plastic in 37 percent of dead leatherback turtles and determined that nine percent 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). Other types of marine debris, such as discarded or derelict fishing gear and cargo nets, may entangle and drown sea turtles of all life stages.

Plastic debris is a major concern because it degrades slowly and many plastics float. The floating debris is transported by currents throughout the oceans and has been discovered accumulating in oceanic gyres (Law et al. 2010). Additionally, plastic waste in the ocean chemically attracts hydrocarbon pollutants. Marine mammals, sea turtles, and fish can mistakenly consume these wastes containing elevated levels of toxins instead of their prey. It is expected that marine mammals, sea turtles, and fish may be exposed to marine debris over the course of the action although the risk of ingestion or entanglement and the resulting impacts are uncertain at the time of this consultation.

9.6.2 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 (POPs), including polychlorinated-biphenyls, dibenzo-p-dioxins, dibenzofurans and related compounds, through trophic transfer may cause mortality and sub-lethal effects in long-lived higher trophic level animals (Waring et al. 2016), including immune system abnormalities, endocrine disruption, and reproductive effects (Krahn et al. 2007). POPs 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 juveniles 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).

Pollutants and contaminants cause adverse health effects in pinnipeds. Acute toxicity events may result in mass mortalities; repeated exposure to lower levels of contaminants may also result in immune suppression and/or endocrine disruption (Atkinson et al. 2008). In addition to hydrocarbons and other persistent chemicals, pinnipeds may become exposed to infectious diseases (e.g., Chlamydia and leptospirosis) through polluted waterways (Aguirre et al. 2007).

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 sub-lethal effects on hatchlings (Stewart 2011). Further study has shown that polybrominated diphenyl ethers (PBDEs; i.e., the brominated flame retardants described above) in leatherback eggs show a negative correlation to hatching success (De Andrés et al. 2016).

Because POPs are both ubiquitous and persistent in the environment, marine mammals, sea turtles, and other forms of marine life will continue to be exposed to POPs for all of their lives. The effects of POPs to ESA-listed species are unknown and not directly studied, but it is possible that the effects could be sub-lethal 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. At present, however, the effects of POPs in ESA-listed species are not currently well known.

9.7 Aquatic Nuisance Species

Aquatic nuisance species are aquatic and terrestrial organisms, introduced into new habitats throughout the U.S. and other areas of the world that produce harmful impacts on aquatic ecosystems and native species (http://www.anstaskforce.gov). They are also referred to as invasive, alien, or non-indigenous species. Invasive species have been referred to as one of the top four threats to the world's oceans (Raaymakers and Hilliard 2002; Raaymakers 2003; Terdalkar et al. 2005; Pughiuc 2010). Introduction of these species is cited as a major threat to biodiversity, second only to habitat loss (Wilcove et al. 1998). A variety of vectors are thought to have introduced non-native species including, but not limited to aquarium and pet trades, recreation, 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). 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 marine mammals, fish, and sea turtles in the action area through the duration of the project. Therefore, the level of risk and degree of impact to ESA-listed marine mammals, sea turtles, and fish is unknown.

9.8 Anthropogenic Sound

The ESA-listed species that occur in the action area are regularly exposed to several sources of natural and anthropogenic sounds. A wide variety of anthropogenic and natural sources contribute to ocean noise throughout the world's oceans. Anthropogenic sources of noise that are most likely to contribute to increases in ocean noise are vessel noise from commercial shipping and general vessel traffic, oceanographic research, oil, gas and mineral exploration, underwater construction, geophysical (seismic) surveys, Naval and other sources of sonar, and underwater explosions (Richardson et al. 1995f; Hatch and Wright 2007b).

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.

There is a large and 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). However, 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. 1995f; NRC 2000; NRC 2003a; 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 2003a). Commercial fishing vessels, cruise ships, transport boats, airplanes, helicopters and recreational boats all contribute sound into the ocean (NRC 2003a). The military uses sound to test the systems of Navy vessels as well as for naval operations. In some areas where oil and gas production takes place, noise originates from the drilling and production platforms, tankers, vessel and aircraft support, seismic surveys, and the explosive removal of platforms (NRC 2003a).

Andrew et al. (2002) compared ocean ambient sound from the 1960s to the 1990s from a receiver off the California coast. The data showed an increase in ambient noise of approximately 10 dB in the frequency ranges of 20 to 80 Hz and 200 to 300 Hz, and about 3 dB at 100 Hz over a 33-year period. Each 3 dB increase is noticeable to the human ear as a doubling in sound level. A possible explanation for the rise in ambient noise is the increase in shipping noise. There are approximately 11,000 supertankers worldwide, each operating approximately 300 days per year, each producing constant broadband noise at typical source levels of 198 dB (Hildebrand 2004b). Generally the most energetic regularly operated sound sources are seismic airgun arrays from approximately 90 vessels with typically 12 to 48 individual guns per array, firing about every 10 seconds (Hildebrand 2004b).

9.8.1 Seismic Surveys

Similar to the proposed action, offshore seismic surveys involve the use of high-energy sound sources operated in the water column to probe below the seafloor. Numerous seismic surveys have been conducted off the west coast over the past several decades. Unlike other regions (e.g., Gulf of Mexico) where the large majority of seismic activity is associated with oil and gas development, seismic surveys conducted in the action area are primarily for scientific research, to identify possible seafloor or shallow-depth geologic hazards, and to better understand phenomena surrounding earthquake risk.

For past scientific research seismic surveys in the action area, NMFS issued authorizations for seismic activity conducted near marine mammals and ESA-listed sea turtles. MMPA incidental take authorizations and ESA incidental take statements specify the conditions under which researchers can operate seismic sound sources, such as airguns, including mitigation measure to minimize adverse effects to protected species. In the action area, other past seismic surveys include one in 2004 (off the Pacific coast of Costa Rica and Panama), which resulted in a no jeopardy or adverse modification determination.

9.8.2 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. 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 one kHz and less, mid frequency for one to 10 kHz; high frequency for 10 to 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). The effective source level of an low-frequency active array, when viewed in the horizontal direction, can be 235 dB re 1µPa-m or higher (Hildebrand 2004a). Signal transmissions are emitted in patterned sequences that may last for days or weeks. An example of a low-frequency active sonar system is the U.S. Navy Surveillance Underwater Towed Array Sensor System (SURTASS), discussed in more detail below. Mid-frequency military sonars include tactical anti-submarine warfare sonars, designed to detect submarines over several tens of kilometers, depth sounders and communication sonars. High-frequency military sonars includes those incorporated into weapons (torpedoes and mines) or weapon countermeasures (mine countermeasures or anti-torpedo devices), as well as side-scan sonar for seafloor mapping. Commercial sonars are designed for fish finding, depth sounding, and sub-bottom profiling. They typically generate sound at frequencies of 3 to 200 kHz, with source levels ranging from 150 to 235 dB re 1µPa-m (Hildebrand 2004a). Depth sounders and sub-bottom profilers are operated primarily in nearshore and shallow environments, however, fish finders are operated in both deep and shallow areas.

9.8.3 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 ten to 50 Hz and range from 195 dB re: μPa^2-s at 1 m for fast-moving (greater than 20 knots) supertankers to 140 dB re: μPa^2-s at 1 m for smaller vessels (NRC 2003a). Although large vessels emit predominantly low frequency sound, studies report broadband sound from large cargo vessels above two kHz, which may interfere with important biological functions of cetaceans (Holt 2008). At frequencies below 300 Hz, ambient sound levels are elevated by 15 to 20 dB when exposed to sounds from vessels at a distance (McKenna et al. 2013a).

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 2003a; Hildebrand 2009b; McKenna et al. 2012). Shipping traffic constitutes a major source of low-frequency (five to 500 Hz) sound in the ocean (Hildebrand 2004a), particularly in the Northern Hemisphere where the majority of vessel traffic occurs. 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 14 to 962 feet at speeds of 10 knots and at a distance of 500 yards 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 (AIS). On average, container ships and bulk carriers had the highest estimated broadband source levels (186 dB re 1 lPa2 20 to 1000 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.

Sound emitted from large vessels, such as shipping and cruise ships, is the principal source of low frequency noise in the ocean today, and marine mammals are known to react to or 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). Several studies have demonstrated short-term effects of disturbance on humpback whale behavior (Hall 1982; Baker et al. 1983; Krieger and Wing 1984; Bauer and Herman 1986), but the long-term effects, if any, are unclear or not detectable. Carretta et al. (2001) and Jasny et al. (2005) identified the increasing levels of anthropogenic noise as a habitat concern for whales and other cetaceans because of its potential effect on their ability to communicate. Significant changes in odontocete behavior attributed to vessel noise have been documented up to at least 5.2 kilometers away from the vessel (Pirotta et al. 2012).

Commercial shipping traffic is a major source of low frequency (5 to 500 Hz) human generated sound in the world's oceans (Simmonds and Hutchinson 1996; NRC 2003a). The radiated noise spectrum of merchant ships ranges from 20 to 500 Hz and peaks at approximately 60 Hz. Ross (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 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.

9.9 Military Activities

Many researchers have described behavioral responses of marine mammals to the sounds produced by helicopters and fixed-wing aircraft, boats and ships, as well as dredging, construction, geological explorations, etc. (Richardson et al. 1995f). Most observations have been limited to short-term behavioral responses, which included cessation of feeding, resting, or social interactions. Smultea et al. (2008b) documented a recognized "stress behavioral reaction" by a group of sperm whales in response to small aircraft fly-bys. The group ceased forward movement, moved closer together in a parallel flank-to-flank formation, and formed a fan-shaped semi-circle with the lone calf remaining near the middle of the group. In-air noise levels from aircraft can be problematic for marine life, and that sound can also extend into water. Kuehne et al. (2020) found that sounds from military aircraft at Whidbey Island, Washington, were detectable 30 meters below the water surface at levels of 134 dB re 1 μPa rms.

9.10 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, PAM, biological sampling (i.e., biopsy, breath, fecal, sloughed skin), and tagging. Research activities involve non-lethal "takes" of these marine mammals.

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

9.11 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, pollution, illegal harvest), whereas others result in more indirect (e.g., fishing that impacts prey availability) or non-lethal (e.g., vessel activity) impacts.

We consider the best indicator of the environmental baseline on ESA-listed resources to be the status and trends of those species. As noted in Section 8, some of the species considered in this consultation are experiencing increases in population abundance, some are declining, and for others, their status remains unknown. Taken together, this indicates that the environmental baseline is impacting species in different ways. The species experiencing increasing population abundances are doing so despite the potential negative impacts of the activities described of the environmental baseline. Therefore, while the environmental baseline may slow their recovery, recovery is not being prevented. For the species that may be declining in abundance, it is possible that the suite of conditions described in this *Environmental Baseline* section is limiting their recovery. However, it is also possible that their populations are at such low levels (e.g., due to historical commercial whaling) that even when the species' primary threats are removed, the species may not be able to achieve recovery. At small population sizes, species may experience phenomena such as demographic stochasticity, inbreeding depression, and Allee effects, among others, that cause their limited population size to become a threat in and of itself. A thorough review of the status and trends of each species for which NMFS has found the action is likely to cause adverse effects is discussed in Section 8 of this opinion.

10 EFFECTS OF THE ACTION

Endangered Species Act section 7 regulations define "effects of the action" as all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (see 50 C.F.R. §402.17; 50 C.F.R. §402.02).

This effects analysis section is organized following the stressor, exposure, response, risk assessment framework (Section 2).

In this section, we further describe the potential stressors associated with the proposed action, the probability of individuals of ESA-listed species being exposed to these stressors based on the best scientific and commercial evidence available, and the probable responses of those individuals (give probable exposures) based on the available evidence. As described in Section 10.3.2, for any responses that would be expected to reduce an individual's fitness (i.e., growth, survival, annual reproductive success, or lifetime reproductive success), the assessment will consider the risk posed to the viability of the population(s) those individuals comprise and to the ESA-listed species those populations represent. For this consultation, we are particularly concerned about behavioral and stress-related physiological disruptions and potential unintentional mortality that may result in animals that fail to feed, reproduce, or survive because these responses are likely to have population-level consequences. The purpose of this effects assessment and, ultimately, of this consultation is to determine if the proposed action's effects on ESA-listed species could appreciably reduce their likelihood of surviving and recovering in the wild.

10.1 Stressors Associated with the Proposed Action

Stressors are any physical, chemical, or biological entity that may induce an adverse response either in an ESA-listed species or their proposed or designated critical habitat. The seismic survey activities and issuance of an incidental harassment authorization will authorize activities that may expose ESA-listed cetaceans, pinnipeds, and sea turtles within the action area to a variety of stressors.

The potential stressors we expect to result from the proposed actions are:

1. Pollution by exhaust, fuel, oil, trash, and other debris;
2. Vessel strike;
3. Vessel noise and visual disturbance;
4. Entanglement in the airgun array and towed hydrophone streamer;
5. Sound fields produced by the sub-bottom profiler, multi-beam echosounder, acoustic Doppler current profiler, and acoustic release transponder; and
6. Sound fields produced by the airgun array.

Based on a review of available information, during consultation we determined which of these possible stressors will be reasonably certain to occur and which will be insignificant or extremely unlikely to occur for the species and habitats affected by these activities. These species and habitats were discussed in Section 7, and will not be further addressed. Stressors (i.e., sound fields produced by the airgun array) that are likely to adversely affect ESA-listed species are discussed in the *Exposure and Response Analysis* sections.

10.2 Mitigation to Minimize or Avoid Exposure

As described in the *Description of the Proposed Actions* section (Section 3), the NSF's proposed action and NMFS Permits Division's proposed incidental harassment authorization requires monitoring and mitigation measures that include the use of proposed exclusion and buffer zones, shut-down procedures, pre-clearance and ramp-up procedures, vessel-based visual monitoring with NMFS-approved protected species observers, vessel strike avoidance measures, and additional mitigation measures considered in the presence of ESA-listed species to minimize or avoid exposure. The NMFS Permits Division's proposed IHA and possible renewal will contain additional mitigation measures to minimize or avoid exposure that are described in Appendix A (see Section 17). We anticipate that the mitigation measures included in the proposed IHA will be substantially similar to those included in the final IHA, if issued. If there is a substantial deviation we would evaluate whether they would implicate our effects analysis in this opinion and require reinitiation.

10.3 Exposure and Response Analysis

Exposure analyses identify the ESA-listed species that are likely to co-occur with the action's effects on the environment in space and time, and identify the nature of that co-occurrence. The *Exposure Analysis* section identifies, as possible, the number, age or life stage, and gender of the individuals likely to be exposed to the action's effects and the population(s) or sub-population(s) those individuals represent. The *Response Analysis* section evaluates the available evidence to determine how individuals of those ESA-listed species are likely to respond given their probable exposure and the potential effects on their prey in the action area. The *Response Analysis* section also considers information on the potential stranding of ESA-listed marine mammals.

For our ESA section 7 consultation, we evaluated both the National Science Foundation and the NMFS Permits Division's exposure estimates of the number of ESA-listed marine mammals that will be "taken" relative to the definition of MMPA Level B harassment, which we have adopted to evaluate harassment of ESA-listed marine mammals in this consultation. Generally, the NMFS Permits Division estimates "take" by considering:

1. Acoustic thresholds above which NMFS believes the best available science indicates marine mammals will be behaviorally harassed or incur some degree of permanent hearing impairment;
2. The area or volume of water that will be ensonified above these levels in a day;
3. The density or occurrence of marine mammals within these ensonified areas; and
4. The number of days of seismic survey activities.

They note that while these basic factors can contribute to a basic calculation to provide an initial prediction of "takes," additional information that can qualitatively inform "take" estimates is also sometimes available (e.g., previous monitoring results or average group size). We adopted the NMFS Permits Division's analysis because, after our independent review, we determined it utilized the best available scientific information and methods to evaluate exposure to ESA-listed marine mammals. Below we describe the exposure analysis for ESA-listed marine mammals.

10.3.1 Exposure Analysis

Although there are multiple acoustic and non-acoustic stressors associated with the proposed actions, the stressor of primary concern is the acoustic impacts of the airgun arrays. Airguns contribute a massive amount of anthropogenic energy to the world's oceans ($3.9x10^{13}$ Joules cumulatively) (Hildebrand 2005a). Although most airgun energy is in the low-frequency range (10 to 500 Hz) (Hildebrand 2009a), airguns emit a substantial amount of energy up to 150 kHz (Goold and Coates 2006). Seismic airgun noise can propagate substantial distances at low frequencies (e.g., Nieukirk et al. 2004).

In this section, we quantify the likely exposure of ESA-listed species to sound from the airgun array. For this consultation, the National Science Foundation and NMFS Permits Division estimated 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 C.F.R. §216.3) as “to harass, hunt, capture, collect, or kill, or attempt to harass, hunt, capture, collect, or kill any marine mammal.” This includes, without limitation, any of the following:

- The collection of dead animals, or parts thereof
- The restraint or detention of a marine mammal, no matter how temporary
- Tagging a marine mammal
- The negligent or intentional operation of an aircraft or vessel
- The doing of any other negligent or intentional act which results in disturbing or molesting a marine mammal
- Feeding or attempting to feed a marine mammal in the wild.”

For purposes of the proposed actions, the two levels of harassment are further 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 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 C.F.R. §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 December 21, 2016, NMFS issued interim guidance on the term “harass,” defining it as to “create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to breeding, feeding, or sheltering.”

NMFS’ interim 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 proposed incidental take authorization will authorize take under both the ESA and MMPA, our ESA analysis, which relies on NMFS’ interim guidance on the ESA term harass, may result in different conclusions than those reached by the NMFS Permits and Conservation Division in their MMPA analysis. Given the differences between the MMPA and ESA standards for harassment, there may be circumstances in which an act is considered harassment, and thus take, under the MMPA but not the ESA.

For ESA-listed marine mammal species, consultations that involve the NMFS Permits and Conservation 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.

We use the numbers of individuals expected to be taken from the MMPA's definition of Level A and Level B harassments to estimate the number of ESA-listed marine mammals that are likely to be harmed or harassed as a result of the proposed actions. This is a conservative approach since we assume all forms of Level B harassment under the MMPA constitute harassment under the ESA and all forms of Level A harassment under the MMPA constitute harm under the ESA (e.g., NMFS 2017).

Therefore, under the ESA, harassment 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" related to harm or harass under the ESA for ESA-listed species.

Our exposure analysis relies on two basic components: (1) information on species distribution (i.e., density or occurrence within the action area), and (2) information on the level of exposure to sound (i.e., acoustic thresholds) at which species are reasonably certain to be affected (i.e., exhibit some response). Using this information, and information on the proposed high-energy seismic survey (e.g., active acoustic sound source specifications, area or volume of water that will be ensonified at certain sound levels, trackline locations, days of operation, etc.), we then estimate the number of instances in which an ESA-listed species may be exposed to sound fields from the airgun array that are likely to result in adverse effects such as harm or harassment. In many cases, estimating the potential exposure of animals to anthropogenic stressors is difficult due to limited information on animal density estimates in the action area and overall abundance, the temporal and spatial location of animals; and proximity to and duration of exposure to the sound source. For these reasons, we evaluate the best available data and information in order to reduce the level of uncertainty in making our final exposure estimates.

10.3.1.1 Ensonified Area

In 2003, empirical data concerning 190, 180, and 160 dB re: 1 μPa (rms) distances were acquired during the acoustic calibration study of the R/V *Maurice Ewing*'s airgun array in a variety of configurations in the northern Gulf of Mexico (Tolstoy 2004). At the time, these sound levels represented the harm (injury) threshold for pinnipeds and cetaceans, and harassment threshold for marine mammals. In addition, propagation measurements of pulses from the R/V *Marcus G. Langseth*'s 36 airgun array at a tow depth of 6 meters (19.7 feet) have been reported in deep water (approximately 1,600 meters [5,249.3 feet]), intermediate water depth on the slope (approximately 600 to 1,100 meters [1,968.5 to 3,608.9 feet]), and shallow water (approximately 50 meters [164 feet]) in the Gulf of Mexico in 2007 through 2008 (Tolstoy et al. 2009; Diebold et al. 2010). Results of the propagation measurements (Tolstoy et al. 2009) showed that radii around the airguns for various received levels varied with water depth. However, the depth of the airgun array was different in the Gulf of Mexico calibration study, which operated at 6 meters [19.7 feet]), whereas in the proposed seismic survey activities the depths are 10 to 12 meters (32.8 to 39.4 feet). Because propagation varies with airgun array depth, correction factors have been applied to the distances reported by Tolstoy et al. (2009).

For deep and intermediate water depth cases, the field measurements in the Gulf of Mexico cannot be used readily to derive the harm and harassment isopleths, as at those sites the calibration hydrophone was located at a roughly constant depth of 350 to 500 meters (1,148.3 to 1,640.4 feet), which may not intersect all the sound pressure level isopleths at their widest point from the sea surface down to the maximum relevant water depth for marine mammals of approximately 2,000 meters (6,561.7 feet). At short ranges, where the direct arrivals dominate and the effects of seafloor interactions are minimal, the data recorded at the deep and slope sites are suitable for comparison with modeled levels at the depth of the calibration hydrophone. At longer ranges, the comparison with the model, constructed from the maximum sound pressure level through the entire water column at varying distances from the airgun array, is the most relevant.

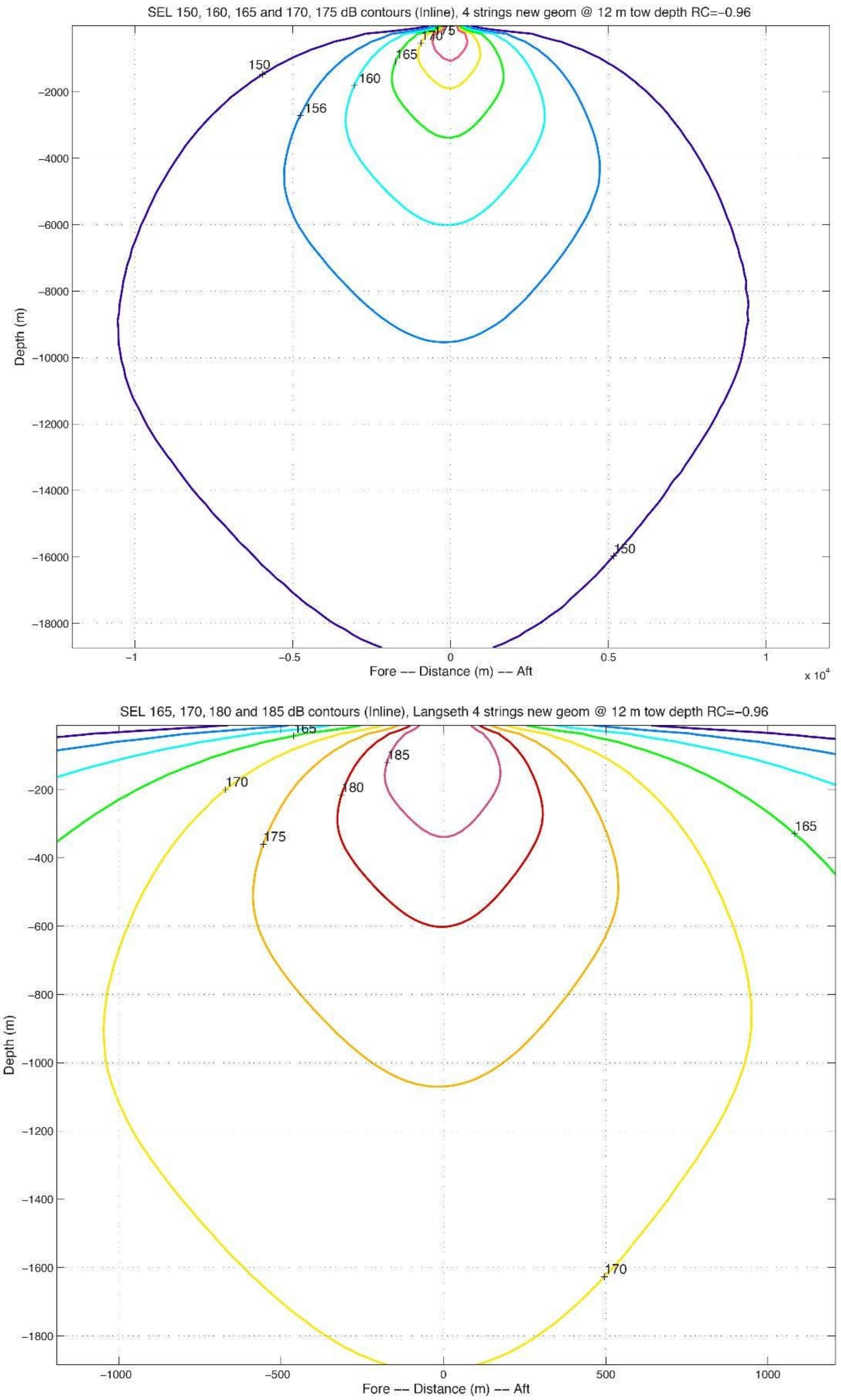

Figure 5. Modeled deep-water received sound exposure levels (SELs) from the 36-airgun array at a 12-m tow depth planned for use during the proposed survey off the Pacific coast of Mexico. Received rms levels (SPLs) are expected to be ~10 dB

higher. For example, the radius to the 150-dB SEL isopleth is a proxy for the 160-dB rms isopleth. The lower plot is a zoomed-in version of the upper plot.

In deep and intermediate water depths, comparisons at short ranges between sound levels for direct arrivals recorded by the calibration hydrophone and model results from the same airgun array tow depth are in good agreement. Consequently, isopleths falling within this domain can be 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. Aside from local topography effects, the region around the critical distance is where the observed levels rise closest to the model curve (Figure 5). However, the observed sound levels are found to fall almost entirely below the model curve. Thus, analysis of the Gulf of Mexico calibration measurements demonstrates that although simple, the L-DEO model is a robust tool for conservatively estimating isopleths. For deep water depths (greater than 1,000 meters [3,280.8 feet]), L-DEO used the deep water radii obtained from model results down to a maximum water depth of 2,000 meters (6,561.7 feet).

10.3.1.2 Exposure Estimates of Endangered Species Act-Listed Marine Mammals

As discussed in the *Species Likely to be Adversely Affected* section, there are six ESA-listed marine mammal species that are likely to be adversely affected by the proposed action: blue whale, fin whale, Central America DPS of humpback whale, sei whale, sperm whale, and Guadalupe fur seals.

During the proposed action, ESA-listed marine mammals may be exposed to sound from five sound sources: the airgun array, multi-beam echosounder, sub-bottom profiler, acoustic Doppler current profiler, and acoustic release transponder.

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 sound sources associated with the proposed action. The exposure estimates stem from the best available information on marine mammal densities (Table 6) and a predicted radius (rms; Table 2) along seismic survey tracklines. ESA-listed marine mammals exposed to these sound sources could be harmed, exhibit changes in behavior, suffer stress, or even strand.

To determine marine mammal exposures to acoustic sources, the NSF, L-DEO, and Permits Division used the radial distances from the airgun array to the predicted isopleths. The area estimated to be ensonified in a single day (187 kilometers [101 nautical miles] for the two-dimensional seismic survey is then calculated, based on the areas predicted to be ensonified around the airgun array and representative trackline distances traveled per day. The ensonified areas were then multiplied by the number of survey days. The product is then multiplied by 1.25 to account for the additional 25 percent contingency. This results in an estimate of the total area expected to be ensonified. The total area ensonified at 160 dB re: 1 μPa (rms) is 67,585.8 square kilometers (19,704.6 square nautical miles), which was calculated in the geographic information system mapping program by multiplying the 160 dB harassment buffer zone widths for the different airgun array configurations by the trackline distance. The number of marine mammals that can be exposed to the sounds from the airgun array on one or more occasions is estimated for the calculated marine area along with the expected density of animals in the area. Summing exposures along all of the tracklines yields the total exposures for each species for the proposed action for the 36-airgun array configuration for the seismic survey activities. The method also yields exposures for each seismic survey trackline individually, allowing examination of those exemplary tracklines that will yield the largest or smallest exposures. The approach assumes that no marine mammals will move away or toward the trackline in response to increasing sound levels before the levels reach the specific thresholds as the R/V *Marcus G. Langseth* approaches. This calculation assumes 100 percent 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. Because of the size of the ensonified area, and the ability of an individual exposed marine mammal to leave that area (i.e., swim away), an individual could be affected by more than a single pulse.

Based on information provided by the NSF and L-DEO, we have determined that marine mammals are likely to be exposed to sound levels at or above the threshold at which TTS and behavioral responses will occur. From modeling by the L-DEO, the NSF and L-DEO provided sound source levels of the airgun array (Table 2) and estimated distances for the 160 dB re: 1 μPa (rms) sound levels, as well as PTS thresholds generated by the airgun array configurations (single airgun and the full 36 airgun array) and water depth. To briefly summarize, for the 36-airgun array, the predicted distances to the 160 dB re: 1 μPa (rms) sound level threshold for TTS and behavioral harassment in shallow, intermediate and deep water are 25,494 meters, 10,100 meters, and 6,733 meters, respectively. The modeled radial distances for permanent threshold shift thresholds (harm) for various marine mammal hearing groups were presented in Table 4.

In developing the NSF's draft environmental analysis and L-DEO's incidental harassment authorization application, they used estimates of marine mammal densities in the action area to calculate the number of animals exposed (Table 6). We agree those marine mammal densities are the best available estimates for the action area and we utilize them in this consultation (Barlow et al. 2009; NMFS 2015b; Navy 2017).

In their *Federal Register* notice of the proposed incidental harassment authorization, the Permits Division stated that they did not expect the sound emanating from the other equipment to exceed the levels produced by the airgun array. Therefore, the Permits Division did not expect additional responses from sound sources other than the airgun array. We agree with this assessment and similarly focus our analysis on responses to sound from the airgun array. The multi-beam echosounder, sub-bottom profiler, acoustic Doppler current profiler, and acoustic release transponder are also expected to affect a smaller ensonified area within the larger sound field produced by the airgun array and are not expected to be of sufficient duration that will lead to the onset of TTS or PTS for an animal.

In this section, we describe the analytical methods to estimate the number of ESA-listed marine mammal species that might be exposed to the sound field and experience an adverse response. We also rely on acoustic thresholds to determine sound levels at which marine mammals are expected to exhibit a response, utilize these thresholds to calculate ensonified areas, and, finally, either multiply these areas by data on marine mammal density or use the sound field in the water column as a surrogate to estimate the number of marine mammals exposed to sounds levels generated by the airgun array that are likely to result in adverse effects to the animals.

The total ensonified area for marine mammals to the 160 dB threshold in all waters, inside and outside Mexican territorial waters is 67,585.8 km^2 (the amount of ensonified waters in non-territorial waters is 63,316.4 km^2 and 4,269.4 km^2 in the territorial waters of Mexico). The total area ensonified above the 160 dB threshold is used to calculate exposures based on density estimates of ESA-listed marine mammals for the action area.

Overall, there are limited density estimates available for marine mammals in the action area, due mostly to a lack of recent, systematic surveys in the region. Density estimates for the exposure calculations came from NMFS (2015b), Barlow et al. (2009) and Navy (2017); see Table 6. In 2015, a letter of authorization was issued for the Southwest Fisheries Science Center's research activities in the Eastern Tropical Pacific, overlapping with the action area (NMFS 2015b) The density data used in the exposure estimates for that authorization relied upon survey data in the region from the mid-80s into the mid-2000s. Barlow et al. (2009) also relied on survey data from a similar time period). In the absence of more recent data, we used the density estimates from NMFS (2015b). For species with a quantitative density range within or around the action area, the maximum presented density was conservatively used. The approach used here is based on the best available data.

Table 6. Densities used for calculating exposure of ESA-listed marine mammals.

Species	Density (#/km^2) in Shallow Water (< 100 meters)**	Density (#/km^2) in Intermediate Water (100 to 1,000 meters)**	Density (#/km^2) in Deep Water (> 1,000 meters)**	Source
Humpback Whale	0.00013	0.00013	0.00013	NMFS (2015b)
Blue Whale	0.00010	0.00009	0.00008	Barlow et al. (2009)
Fin Whale	0.00003	0.00003	0.00003	(NMFS (2015b)
Sei Whale	0.00005	0.00005	0.00005	Navy (2017)

Sperm Whale	0.00019	0.00019	0.00019	NMFS (2015b)
Guadalupe Fur Seals	0	0	0.00741*	NMFS (2015b)

*Density for Guadalupe fur seals applied to waters greater than 2,000 meters deep; see explanation in text.

**In cases where there was not depth-specific density information available, the same (and only available) density was applied to each depth category.

In the action area, Guadalupe fur seals are extremely unlikely to occur in waters over the continental shelf, less than 2,000 meters deep (T. Norris, pers. comm.). To calculate Guadalupe fur seal exposure estimates, we partitioned the ensonified area into waters greater and less than 2,000 meters deep. We assumed the density of Guadalupe fur seals in waters less than 2,000 meters deep to be zero, and applied the density 0.00741 #/km^2 (NMFS 2015b) in waters greater than 2,000 meters deep.

Blue Whales

Blue whales potentially exposed in the action area would likely be migrating from their calving and breeding areas to feeding areas. The Costa Rican Dome is a highly productive upwelling feature south of the action area that is thought to be one of the overwintering locations for blue whales (Mate et al. 1999). Blue whales migrate south to the region in the fall from California, spend the winter, and then travel north again in the spring. When the proposed action occurs in late spring, blue whales would likely transit through the action area from the feeding and breeding area on their way north. We expect that blue whales of both sexes and all age classes could be exposed. According to tagging data in the region, blue whales migrate over deep waters (e.g., 900 meters; 2,500 to 3,200 meter depth contour) (Mate et al. 1999). When the action occurs in these areas, blue whales could potentially exposed.

Fin and Sei Whales

Fin and sei whale habitat in the Pacific waters of the action area typically includes the continental shelf break, continental slope, and oceanic waters beyond the shelf break. There are no known fin or sei whale breeding or feeding areas in the action area. Overall, fin and sei whales are scarce in the action area (Wade and Gerrodette 1993). There is an apparently resident population of fin whales in the Gulf of California (Jiménez López et al. 2019), north of the action area, so fin whales exposed during the action would come from other locations in the region, migrating through the action area (Falcone and Schorr 2013). Sei whales have been sighted in the Gulf of California, so individuals originating from here may enter the action area (Gendron and Rosales 1996). We expect that fin and sei whales of any age class or sex could be exposed to the proposed action.

Central America DPS Humpback Whales

Individual humpback whales from the Central America DPS could be present in the action area during the seismic survey. Humpback whales are more coastal than other large whale species, and are more likely to be exposed when the action takes place in more nearshore areas. Mother-calf pairs in particular show a preference for coastal waters (Ransome et al. 2021). The over-wintering area for the DPS is south of the action area, off the coasts of Costa Rica, Panama, Guatemala, El Salvador, Honduras, and Nicaragua during the months of January, February, and March (Rasmussen et al. 2012), as well as within the action area, off the coast of southern Mexico (Martien et al. 2021). Based on the timing and location of the proposed action, humpback whales from the Central America DPS would be traveling from the over-wintering areas to their summer feeding grounds off the U.S. West Coast. Adults and juveniles of both sexes could be exposed to the proposed seismic activities, notably mother-calf pairs.

Sperm Whales

Sperm whales occur most commonly in deep waters (600 meters or more), also inhabiting shelf breaks or submarine canyons (NMFS 2010a). When the proposed action occurs in these environments, we expect that sperm whales will be more likely to be exposed. Sperm whales overwinter at low latitudes (e.g., near the action area), and there are no known breeding or calving areas in the action area. Sperm whales exposed to the proposed action would likely be transiting through on their migration back north to higher-latitude feeding areas. We expect that adults and juveniles of both sexes could be exposed to the proposed action.

Guadalupe Fur Seals

In June, adult males and females arrive at their colonies to breed and pup; breeding colonies for the species are on Guadalupe Island and San Benito Island, Mexico, with a purported breeding colony on San Miguel Island, of the Channel Islands, California, all far outside the action area.

With the population increasing, the broad range of the species at sea, and strandings in the area, we do expect Guadalupe fur seals to be in the action area and be exposed to the proposed action. Because the seismic activities take place in May through July, during breeding and pupping season, we do think adult Guadalupe fur seals would be exposed to the proposed action, because they would be potentially at their breeding locations. There are likely foraging grounds near Jalisco and Colima, just north of and within the action area, respectively (Ortega-Ortiz et al. 2019). Based on strandings in the area, we expect that adults and sub-adults of both sexes would be exposed to the proposed action (Ortega-Ortiz et al. 2019). Stranded animals often show signs of malnutrition with secondary bacterial and parasitic infections, so it is possible that exposed Guadalupe fur seals would already be compromised when exposed to the seismic activities.

Marine Mammal Exposure Summary

The density estimates of ESA-listed marine mammals (Table 6) and the total ensonified area at or above the 160 dB threshold inside and outside Mexican territorial waters (67,585.8 km^2) were used to calculate exposures to the proposed seismic survey sound (Table 7).

Table 7. Total number of exposures of ESA-listed marine mammals in the entire action area to underwater sound above the 160 dB harassment threshold from acoustic sources used for the National Science Foundation's seismic survey in the Eastern Tropical Pacific Ocean.

Species	Total Number of Exposures
Blue Whale	5
Fin Whale	2
Humpback Whale – Central America DPS	9
Sei Whale	3
Sperm Whale	13
Guadalupe Fur Seal	448

As discussed in Section 5.1, parts of the action area take place in the territorial waters of Mexico, and we are not able to authorize take in those waters. However, we must estimate the amount of ESA-listed species that could be exposed throughout the entire action area in making our jeopardy determination; in this case, that means the entire ensonified area for the proposed action.

The NSF and the L-DEO provided exposure estimates both inside and outside Mexican territorial waters, representing all potential exposures no matter where they might occur in the action area. Those estimates are presented in Table 7.

10.3.1.3 Exposure of Endangered Species Act-Listed Sea Turtles

As discussed in the *Species Likely to be Adversely Affected* section, there are five ESA-listed sea turtle species that are likely to be affected by the proposed action: leatherback sea turtles, olive ridley sea turtles, green sea turtles, loggerhead sea turtles, and hawksbill sea turtles.

During the proposed action, ESA-listed sea turtles may be exposed to sound from five sound sources: the airgun array, multi-beam echosounder, sub-bottom profiler, acoustic Doppler current profiler, and acoustic release transponder.

Density Estimates and Modeled Exposure

The L-DEO used a similar method to calculate exposure for sea turtles as that for marine mammals. For sea turtles, the L-DEO used the 175 dB threshold to create a buffer in GIS representing the ensonified area within each of the three water depth categories (< 100 meters, 100 to 1000 meters, and >1000 meters). The total ensonified area for sea turtles to the 175 dB threshold in all waters, inside and outside Mexican territorial waters is 18,149.3 km^2 (the amount of ensonified waters in non-territorial waters is 17,252.8 km^2 and 896.5 km^2 in the territorial waters of Mexico)[5].

Overall, there is a lack of density and abundance information for sea turtles in the action area. The L-DEO used density estimates from Eguchi et al. (2007) (0.4 $\#/km^2$) to estimate the number of olive ridley sea turtles exposed (7,315) in the entire action area, inside and outside the territorial waters of Mexico. The Eguchi et al. (2007) density estimates were generated based on ship-based line transect surveys conducted off the western coasts of Mexico and Central America, in off-shore and coastal areas, in 1992, 1998, 1999, 2000, 2003, and 2006. Density estimates varied by year (0.1 to 0.4 $\#/km^2$). The L-DEO chose the highest density estimate to calculate exposures of olive ridley sea turtles. Although the information is many years old, we are not aware of more current density information for olive ridley sea turtles in the action area, and consider Eguchi et al. (2007) to be the most current available information.

The Eguchi et al. (2007) olive ridley density estimates were calculated for offshore areas directly overlapping the proposed action area. The estimates were also adjusted to account for unobservable individuals (i.e., time underwater). The surveys used a variety of equipment to count and identify sea turtles, including the naked eye, hand-held binoculars (7 x 50 millimeters), and more powerful deck-mounted binoculars (25 x 150 millimeters), and during optimal sighting conditions of Beaufort sea state 3 or less, sea turtles could be sighted greater than 5 kilometers away. However, generally, we consider that larger, older individuals are more likely to be observed, and that hatchlings are less likely to be seen or counted during a vessel-based survey due to their smaller size. Therefore, the at-sea density estimates developed by Eguchi et al. (2007) more closely reflect the density of large juveniles or adult olive ridley sea turtles and we have no estimates of hatchling density in the action area. Similar to the vessel-based survey, it will be difficult to observe hatchlings during the proposed action. Considering the timing and location of the action, it is likely that olive ridley hatchlings would be present.

Olive ridley sea turtle abundance is increasing in the region (NMFS and USFWS 2014a; Ariano-Sánchez et al. 2020). Eguchi et al. (2007) found an increase in density in the study area over a time period that correlated with reported increases in nesting female abundance (Chaloupka et al. 2004).

While the Eguchi et al. (2007) data are 16 to 30 years and lack hatchling representation, it is still the best available information to use for this analysis. Calculated exposures for olive ridley sea turtles to the proposed seismic activities based on the Eguchi et al. (2007) densities, could be over 7,300 individuals; adults, sub adults, and large juveniles of both sexes.

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[5] This figure (18,189.3) excludes the amount of ensonified area representing PTS for the survey (144 square kilometers), which we have concluded is not likely to occur for sea turtles.

The L-DEO used density estimates from Navy (2019) (0.000114 #/km^2) to obtain an estimated three leatherback sea turtles exposed. We were not able to find a more location-specific density estimate for leatherback sea turtles. It should be noted that the density estimate for leatherback sea turtles comes from estimates developed for the California Current Ecosystem, which were then applied to the Eastern Tropical Pacific, due to a lack of a more specific, relevant density estimate for the action area. For leatherback sea turtles, the California Current Ecosystem is different habitat than the Eastern Tropical Pacific, and the leatherback densities generated for that area may not completely reflect the age class composition of leatherbacks that we could expect to find in the action area. Leatherback sea turtles in the California Current Ecosystems are there on foraging grounds, having migrated there from the western Pacific, and would be either adults or large juveniles. Since there are no nesting beaches in the California Current Ecosystem area, we would not expect hatchlings there. There are nesting beaches in the Eastern Tropical Pacific, meaning that relying on a California Current Ecosystem density estimate would neglect to include leatherback hatchlings, and any nesting females that might be present. Furthermore, given the proximity of the action area to leatherback nesting beaches, the number and size of the nesting beaches in the action area, and that the action would occur just after the nesting season, we believe that the density estimate from Navy (2019) would underestimate the number of leatherbacks potentially exposed to the proposed action.

The L-DEO was not able to generate exposure estimates for green, loggerhead, or hawksbill sea turtles because there were no density data available for these species. Upon further examination, we were not able to find density data for these three sea turtle species either. Although we do not have current information on density specific to the action area, we know that these sea turtle species are present in the region, and that there is a likelihood of exposure to the proposed seismic activities. In the absence of better information, we are going to rely on a surrogate to estimate exposure of olive ridley, leatherback, green, loggerhead, and hawksbill sea turtles, that is, the area area within the 175 dB re: 1 µPa (rms) isopleth is where sea turtles are likely to be adversely affected. Based on the available information on sea turtle hearing (see Sections 8.7.3, 8.8.3, 8.9.3, 8.10.3, and 8.11.3), and the similarities in the species' hearing capabilities, we expect that exposed sea turtles will respond similarly to the sound associated with the proposed action.

The sound source (i.e., airgun array) is in motion during the survey. The R/V *Marcus G. Langseth* moves at 8.3 kilometers per hour (4.5 knots) during the three-dimensional seismic survey (slight slower for the two-dimensional survey [7.8 kilometers per hour; 4.2 knots]). The distance to the 175 dB re: 1 µPa (rms) is 2,796 meters in intermediate depth water, and 1,864 meters in deep water. Given the vessel speeds, and distance to the 175 dB re: 1 µPa (rms) in different water depths, it would take the R/V *Marcus G. Langseth* and the 175 dB distance as much as 20 minutes[6] to move past a stationary point. This means that a sea turtle in the ensonified area would be exposed to the sound from the airgun multiple times. Therefore, the extent of take for sea turtles includes the amount of time that the individual is in the 175 dB re: 1 μPa (rms) ensonified area.

For sea turtle species where there was no sufficient density information to calculate exposure numbers, 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 a leatherback, olive ridley, green, loggerhead, or hawksbill 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).

Olive Ridley Sea Turtles: Mexico's Pacific Coast Breeding Colonies

Olive ridley hatchlings could be exposed while at-sea or soon after emerging from their nests. Juveniles, sub-adults, and adult olive ridley sea turtles of both sexes would be more likely to be exposed during the offshore portion of the proposed action.

Leatherback Sea Turtles

Adult leatherback sea turtle females that have left the nesting beaches would likely be migrating to southern foraging areas, along with adult males and juveniles/sub adults of either sex (Bailey et al. 2012). Leatherback hatchlings would emerge from the nest and enter the coastal waters adjacent to their nesting beaches.

Green Sea Turtles East Pacific DPS

East Pacific DPS green sea turtle nesting beaches are in and near the action area. Hatchlings could be exposed in the nearshore environment (while they are leaving the nesting beaches) and during the offshore portion of the survey, while they are dispersing into the ocean. Adult green turtles and post-nesting females tend to stay near the coast while foraging. During the portions of the survey that occur close to shore, adult and large juveniles of both sexes could be exposed. It is less likely that green sea turtles would be exposed when the action is occurring in offshore waters. During the six years of vessel surveys conducted by Eguchi et al. (2007) at sea, only one green sea turtle was observed.

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[6] For example, when the R/V *Marcus G. Langseth* is surveying in intermediate depth waters, the distance to the 175 dB threshold is 2.7 kilometers. During the three-dimensional portion of the seisimic survey, the vessel moves at 7.8 kilometers per hour, meaning it would take approximately 20 minutes for the vessel to travel 2.7 kilometers, or for a stationary sea turtle to be out of the 175 dB ensonified area. For the R/V *Marcus G. Langseth* to travel 1.8 kilometers (i.e, the distance to the 175 dB threshold in deep water) during the two-dimensional portion of the survey (8.3 kilometers per hour), it would take about 13 minutes.

Loggerhead Sea Turtles North Pacific Ocean DPS

Loggerhead sea turtle movement in the region is poorly understood, so it is difficult to entirely rule out the possibility of exposure during the proposed action. Most available information indicates that the majority of reports of loggerhead sea turtles in the region are from north of the action area, or south of it, with few reports of loggerheads in the action area (Chapman and Seminoff 2016). However, during vessel surveys, loggerhead sea turtles were observed at-sea in and near the action area, although in much fewer numbers than olive ridley sea turtles (Eguchi et al. 2007). If exposed, we would expect large adults or juveniles of either sex could be exposed, likely moving between foraging areas. When the action is taking place offshore, we consider it more likely that loggerhead sea turtles could be exposed. Since all nesting for the North Pacific Ocean DPS occurs in Japan (NMFS 2020b), with no known nesting on the Pacific coast of Mexico (Chapman and Seminoff 2016), we do not expect hatchlings, young juveniles, or nesting adult females to be exposed to the proposed action.

Hawksbill Sea Turtles

There are no known hawksbill nesting beaches in the action area, therefore, we do not expect hatchlings or nesting adult females to be exposed to the proposed action. Furthermore, hawksbill sea turtles in the region tend to stay relatively close to their natal beach, foraging in shallow coastal areas and mangrove estuaries (Gaos et al. 2017; Martínez-Estévez et al. 2021), so it is unlikely that other age classes (juveniles and sub adults of either sex) would be exposed to the proposed action. However, hawksbill sea turtles are sighted at-sea off Mexico (Gaos et al. 2010; Liles et al. 2017; Martínez-Estévez et al. 2021), so when the proposed action is occurring further offshore, it is possible that hawksbill sea turtles would be exposed then.

10.3.2 Response Analysis

A pulse of sound from the airgun array displaces water around the airgun array and creates a wave of pressure, resulting in physical effects on the marine environment that can then affect marine organisms, such as ESA-listed marine mammals and sea turtles, considered in this opinion. Possible responses considered in this analysis consist of:

- Hearing threshold shifts;
- Auditory interference (masking);
- Behavioral responses; and
- Non-auditory physical or physiological effects.

The *Response Analysis* also considers information on the potential for stranding and the potential effects on prey of ESA-listed marine mammals and sea turtles in the action area.

As discussed in *The Assessment Framework* (Section 2) of this opinion, response analyses determine how ESA-listed resources are likely to respond after exposure to an action's effects on the environment, on designated critical habitat, or directly on ESA-listed species themselves. For the purposes of consultation, our assessments try to detect potential lethal, sub-lethal (or physiological), or behavioral responses that might result in reduced fitness of ESA-listed individuals. Response analyses will consider and weigh evidence of adverse consequences as well as evidence suggesting the absence of such consequences.

During the proposed actions, ESA-listed marine mammals and sea turtles may be exposed to sound from the airgun array. We evaluated the estimates of the expected number of ESA-listed marine mammals exposed to received levels greater than or equal to 160 dB re: 1 μPa (rms) for the airgun array sound sources. For ESA-listed sea turtles, we examined the amount of individuals exposed to received levels greater than or equal to 175 dB re: 1 μPa (rms).

Table 8. Summary table describing the isopleth distances and received sound levels corresponding to take under the ESA.

ESA Take	Received Sound Level [dB re: 1 μPa (rms)]	Distance (meters) Intermediate Water Depths	Distance (meters) Deep Water Depths
Harassment (Marine Mammals)	160[7]	10,100	6,733
Harassment (Sea Turtles)	175	2,796	1,864

Within these isopleths, we expect exposure to elicit a response from ESA-listed marine mammals and sea turtles (Table 8). Take (harassment) within these isopleths (i.e., distances from the sound source) is reasonably likely to occur.

In consideration of the received sound levels in the nearfield, we expect the potential for ESA harm of low-frequency cetaceans (blue, fin, sei, and Central America humpback whales), mid-frequency cetaceans (sperm whales) and phocid pinnipeds (Guadalupe fur seals) to be de minimis, even before the likely moderating effects of aversion and/or other compensatory behaviors (e.g., Nachtigall et al. 2018) are considered. Based on the small anticipated isopleths for harm and in consideration of the proposed mitigation and monitoring measures, take by harm is not expected to occur. The estimated exposure of ESA-listed marine mammals at the ESA harassment threshold during the National Science Foundation's seismic survey on the R/V *Marcus G. Langseth* in the Pacific Ocean can be found in Table 7. The approach assumes that no marine mammals will move away or toward the trackline in response to increasing sound levels before the levels reach the specific thresholds as the R/V *Marcus G. Langseth* approaches. The

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[7] In the IHA, the Permits Division uses the same threshold for Level B harassment.

extent to which marine mammals will move away from the sound source is difficult to quantify and is, therefore, not accounted for in the take estimates.

Acoustic Thresholds

To determine at what point during exposure to airgun arrays marine mammals are considered "harassed", NMFS applies certain acoustic thresholds. These thresholds are used in the development of radii for buffer and exclusion zones around a sound source and the necessary mitigation requirements necessary to limit marine mammal exposure to harmful levels of sound (NOAA 2018). The references, analysis, and methodology used in the development of these thresholds are described in *NOAA 2018 Revision to Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing* (NOAA 2018), which is available at the following website: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-acoustic-technical-guidance. For Level B harassment under the MMPA, and behavioral responses under the ESA, NMFS has historically relied on an acoustic threshold for 160 dB re: 1 μPa (rms) for impulsive sound sources. These values are based on observations of behavioral responses of mysticetes, but are used for all marine mammals species. For the proposed actions, the NMFS Permits Division continued to rely on this historic NMFS acoustic threshold to estimate the number of takes by MMPA Level B harassment, and accordingly, take of ESA-listed marine mammals that are proposed in the incidental harassment authorization for the airgun array operations during the low-energy and high-energy seismic survey.

For physiological responses to active acoustic sources, such as TTS and PTS, the NMFS Permits Division relied on NMFS' technical guidance for auditory injury of marine mammals (NOAA 2018). Unlike NMFS' 160 dB re: 1 μPa (rms) threshold for MMPA Level B harassment (behavioral) (which does not include TTS or PTS), these TTS and PTS auditory thresholds differ by marine mammal species hearing group (Table 8). Furthermore, 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 criteria incorporate auditory weighting functions based upon a species group's hearing sensitivity, and thus susceptibility to TTS and PTS, over the exposed frequency range and duration of exposure. The metric that results in 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, since it is the more precautionary criteria. In recognition of the fact that the requirement to calculate ESA harm ensonified areas can be more technically challenging to predict due to the duration component and the use of weighting functions in the new SEL_{cum} thresholds, NMFS developed an optional user spreadsheet that includes tools to help predict a simple isopleth that can be used in conjunction with marine mammal density or occurrence to facilitate the estimation of take numbers.

In using these acoustic thresholds to estimate the number of individuals that may experience auditory injury, the NMFS Permits Division classify any exposure equal to or above the acoustic threshold for the onset of PTS (see Table 9) as auditory injury, and thus MMPA Level A harassment, and harm under the ESA. Any exposure below the threshold for the onset of PTS, but equal to or above the 160 dB re: 1 µPa (rms) acoustic threshold is classified as MMPA Level B harassment, which will also be considered ESA harassment. Among ESA harassment exposures, the NMFS Permits Division does not distinguish between those individuals that are expected to experience TTS and those that will only exhibit a behavioral response.

Table 9. Functional hearing groups, generalized hearing ranges, and acoustic thresholds identifying the onset of permanent threshold shift and temporary threshold shift for marine mammals exposed to impulsive sounds (NOAA 2018).

Hearing Group	Generalized Hearing Range*	Permanent Threshold Shift Onset	Temporary Threshold Shift Onset
Low-Frequency Cetaceans (Baleen Whales) (LE,LF,24 hour)	7 Hertz to 35 kHz	$L_{\text{pk,flat}}$: 219 dB $L_{\text{E,LF,24h}}$: 183 dB	213 dB peak SPL 168 dB SEL
Mid-Frequency Cetaceans (Dolphins, Toothed Whales, Beaked Whales, Bottlenose Whales) (LE,MF,24 Hour)	150 Hz to 160 kHz	$L_{\text{pk,flat}}$: 230 dB $L_{\text{E,MF,24h}}$: 185 dB	224 dB peak SPL 170 dB SEL
Otariid Pinnipeds (Guadalupe Fur Seals) (LE,MF,24 Hour) – Underwater	60 Hz to 39 kHz	$L_{\text{pk,flat}}$: 232 dB $L_{\text{E,MF,24h}}$: 203 dB	212 dB peak SPL 170 dB SEL

LE, X, 24 Hour=Frequency Sound Exposure Level (SEL) Cumulated over 24 Hour

LF=Low Frequency

MF=Mid-Frequency

*Represents the generalized hearing range for the entire group as a composite (i.e., all species within the group), where individual species' hearing ranges are typically not as broad. Generalized hearing range chosen based on approximately 65 dB threshold from normalized composite audiogram, with the exception for lower limits for low frequency cetaceans (Southall et al. 2007a) (approximation).

Note: Dual metric acoustic thresholds for impulsive sounds (peak and/or SEL_{cum}): Use whichever results in the largest (most conservative for the ESA-listed species) isopleth for calculating PTS onset. If a non-impulsive sound has the potential of exceeding the peak sound pressure level thresholds associated with impulsive sounds, these thresholds should also be considered.

Note: Peak sound pressure (Lpk) has a reference value of 1 µPa, and cumulative sound exposure level (LE) has a reference value of 1 $\mu\text{Pa}^2\text{s}$. 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.

Using the above acoustic thresholds, the NMFS Permits Division evaluated the exposure and take estimates of ESA-listed marine mammals associated with the sounds from the airgun array.

10.3.2.1 Potential Response of Marine Mammals to Acoustic Sources

Exposure of marine mammals to very strong impulsive sound sources from airgun arrays can result in auditory damage, such as changes to sensory hairs in the inner ear, which may temporarily or permanently impair hearing by decreasing the range of sound an animal can detect within its normal hearing ranges. Hearing threshold shifts depend upon the duration, frequency, sound pressure, and rise time of the sound. TTS results in a temporary change to hearing sensitivity (Finneran 2013), and the impairment can last minutes to days, but full recovery of hearing sensitivity is expected. However, a study looking at the effects of sound on mice hearing, has shown that, although full hearing can be regained from TTS (i.e., the sensory cells actually receiving sound are normal), damage can still occur to the cochlear nerve leading to delayed but permanent hearing damage (Kujawa and Liberman 2009). At higher received levels, particularly in frequency ranges where animals are more sensitive, PTS can occur, meaning lost auditory sensitivity is unrecoverable. Either of 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. A TTS and PTS are generally specific to the frequencies over which exposure occurs but can extend to a half-octave above or below the center frequency of the source in tonal exposures (less evident in broadband noise such as the sound sources associated with the proposed action; (Schlundt 2000; Kastak 2005; Ketten 2012)).

Few data are available to precisely define each ESA-listed species hearing range, let alone its sensitivity and levels necessary to induce TTS or PTS. Baleen whales (e.g., blue, fin, humpback, and sei whales) have an estimated functional hearing frequency range of 7 Hz to 35 kHz and sperm whales have an estimated functional hearing frequency range of 150 Hz to 160 kHz (see Table 8) (Southall 2007). For pinnipeds in water, data are limited to measurements of TTS in harbor seals (*Phoca vitulina*), an elephant seal (*Mirounga angustirostris*), and California sea lions (*Zalophus californianus*) (Kastak et al. 1999; Kastelein et al. 2012). Otariid sea lions and fur seals, like Guadalupe fur seals, have an estimated functional hearing range of 60 Hz to 39 kHz.

Based upon captive studies of odontocetes, our understanding of terrestrial mammal hearing, and extensive modeling, the best available information supports the position that sound levels at a given frequency will need to be approximately 186 dB SEL or approximately 196 to 201 dB re: 1 μPa (rms) in order to produce a low-level TTS from a single pulse (Southall et al. 2007c). PTS is expected at levels approximately 6 dB greater than TTS levels on a peak-pressure basis (i.e., peak sound pressure level), or 15 dB greater on an SEL basis than TTS (Southall et al. 2007c). In terms of exposure to the R/V *Marcus G. Langseth*'s airgun array, an individual mid-frequency cetacean (i.e., a sperm whale) will need to be within a few meters of the largest airgun to experience a single pulse greater than 230 dB re: 1 μPa (peak) (i.e., PTS) (Caldwell and Dragoset 2000; NOAA 2018) (Table 9). If an individual experienced exposure to several airgun pulses of approximately 219 dB for low-frequency cetaceans, 230 dB for mid-frequency cetaceans, or 202 dB for high-frequency cetaceans, PTS could occur (NOAA 2018). Marine mammals (cetaceans and pinnipeds) will have to be within certain modeled radial distances specified in Table 2 and Table 4 from the R/V *Marcus G. Langseth*'s single airgun and 36 airgun array to be within the PTS threshold isopleth and risk a PTS and within the 160 dB harassment threshold isopleth and risk behavioral responses.

Overall, we do not expect TTS to occur to any ESA-listed marine mammals because of exposure to the airgun array. We expect that most individuals will move away from the airgun array as it approaches; however, a few individuals may be exposed to sound levels that may result in TTS or PTS, but we expect the probability to be low. As the seismic survey proceeds along each transect trackline and approaches ESA-listed individuals, the sound intensity increases and individuals will experience conditions (stress, loss of prey, discomfort, etc.—that is, harassment) that prompt them to move away from the research vessel and sound source and thus avoid exposures that will induce TTS or PTS. Ramp-ups will also reduce the probability of TTS-inducing exposure at the start of seismic survey activities for the same reasons, as acoustic intensity increases, animals will move away and therefore are unlikely to accumulate more injurious levels. Furthermore, mitigation measures will be in place to initiate a shut-down if individuals enter or are about to enter the 500 meter (1,640.4 feet) exclusion zone during full airgun array operations, which is beyond the distances believed to have the potential for PTS in any of the ESA-listed marine mammals as described above. Each individual may be exposed to 160 dB re: 1 µPa (rms) levels. We do not expect this to produce a cumulative TTS or other physical injury for several reasons. Specifically, we expect that individuals will recover from TTS between each of these exposures, we expect monitoring to produce some degree of mitigation such that exposures will be reduced, and (as stated above), we expect individuals to generally move away at least a short distance as received sound levels increase, reducing the likelihood of exposure that is biologically meaningful. In summary, we do not expect animals to be present for a sufficient duration to accumulate sound pressure levels that will lead to the onset of TTS or PTS.

Marine Mammals and Auditory Interference (Masking)

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). Low frequency sounds are broad and tend to have relatively constant bandwidth (NMFS 2006c).

There is frequency overlap between airgun array sounds and vocalizations of ESA-listed marine mammals, particularly baleen whales and to some extent sperm whales. 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). Most of the energy of sperm whale clicks is concentrated at 2 to 4 kHz and 10 to 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 (2 to 188 Hz for the R/V *Marcus G. Langseth*'s airgun array). 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 R/V *Marcus G. Langseth* are planned to occur over the course of approximately 48 days, including approximately 20 days of airgun activity, approximately 19 days of equipment deployment and retrieval, and approximately three days of transit, for seismic survey in the Eastern Tropical Pacific Ocean in May through July 2022.

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). Overlap of the dominant low frequencies of airgun pulses with low-frequency baleen whale calls may pose a somewhat greater risk of masking. The R/V *Marcus G. Langseth*'s airguns will emit a 0.1-second pulse when fired approximately every 16 to 17 seconds, with sperm whale calls lasting 0.5 to 1 second. Therefore, pulses will not "cover up" the vocalizations of ESA-listed sperm whales to a significant extent (Madsen et al. 2002b). We address the response of ESA-listed marine mammals stopping vocalizations because of airgun sound in the *Marine Mammals and Behavioral Responses* section below.

Although sound pulses from airguns begin as short, discrete sounds, they interact with the marine environment and lengthen through processes such as reverberation. This means that in some cases such as in shallow water environments, airgun sound can become part of the acoustic background 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 significantly 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 the usual types of masking studies might 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 data demonstrating 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 to 2 kHz in several marine mammals, including killer whales (Richardson et al. 1995c). 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), masking is not expected to be significant for individual marine mammals.

Marine Mammals and 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. 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 of other related whales (such as bowhead and gray whales) are relevant in determining the responses expected by species under consideration. Therefore, studies from non-ESA-listed or species outside the action area are also considered here.

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 (84 FR 26940), as well as one of several reviews (e.g., Southall et al. 2007b; 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 for 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. 2006). However, humpback whale males 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 the area of a seismic survey while airguns were operational, as well as for at least a week thereafter (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 to 129 dB re: 1 µPa (rms), but did not change at received levels of 99 to 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 ten minutes (Blackwell et al. 2015). Once sound levels exceeded approximately 127 dB re: 1 μPa^2-s over ten minutes, call rates began to decline and at approximately 160 dB re: 1 μPa^2-s over ten minutes, bowhead whales appeared to cease calling all together (Blackwell et al. 2015). While we are aware of no data documenting changes in North Atlantic right whale vocalization in association with seismic surveys, as mentioned previously, they do shift calling frequencies and increase call amplitude over both long- and short-term periods due to chronic exposure to vessel sound (Parks and Clark 2007; Parks et al. 2007; Parks et al. 2009; Parks et al. 2011; Parks et al. 2012; Tennessen and

Parks 2016). 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 R/V *Marcus G. Langseth*'s 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 later time or location away from the R/V *Marcus G. Langseth*'s airgun array during the course of the proposed seismic survey once the acoustic stressor has diminished.

There are numerous studies of the responses of some baleen whales to airgun arrays. Although responses to lower-amplitude sounds are known, most studies seem to support a threshold of approximately 160 dB re: 1 µPa (rms) (the level used in this opinion to determine the extent of acoustic effects for marine mammals) as the received sound level to cause behavioral responses other than vocalization changes (Richardson et al. 1995c).

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. 1984a; Malme and Miles 1985; Richardson et al. 1995c; 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 to 50 kilometers 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 to 130 dB re: 1 µPa (rms) at distances of 20 to 30 kilometers (10.8 to 16.2 nautical miles), but only changed dive and respiratory patterns while feeding and showed total avoidance at higher received sound levels (152 to 178 dB re: 1 µPa [rms]) (Richardson et al. 1986b; Ljungblad et al. 1988; Richardson et al. 1995c; 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. 2007b; Barkaszi et al. 2012; Castellote et al. 2012b; NAS 2017; Stone et al. 2017). Despite the above observations and exposure to repeated seismic surveys, bowhead whales continue to return to summer feeding areas and, when displaced, appear to re-occupy within a day (Richardson et al. 1986b). We do not know whether the individuals exposed in these ensonified areas are the same returning or whether, though they tolerate repeat exposures, they may still experience a stress response. However, we expect the presence of the PSOs and the shut-down that will occur if a marine mammal were present in the exclusion zone that are part of the proposed action 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. 1984a; 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 to 160 re: 1 μPa (rms) (Malme et al. 1984b; 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. 1984b). 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).

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 to 12 kilometers (3.8 to 6.5 nautical miles) from the acoustic source (McCauley et al. 1998; McCauley et al. 2000a). A startle response occurred as low as 112 dB re: 1 μPa (rms). Closest approaches were generally limited to 3 to 4 kilometers (1.6 to 2.2 nautical miles), although some individuals (mainly males) approached to within 100 meters (328.1 feet) on occasion where sound levels were 179 dB re: 1 μPa (rms). Changes in course and speed generally occurred at estimated received levels of 157 to 164 dB re: 1 μPa (rms). Similarly, on the east coast of Australia, migrating humpback whales appear to avoid seismic airguns at distances of 3 kilometers (1.6 nautical miles) at levels of 140 dB re: 1 μPa^2-second. A recent study examining the response of migrating humpback whales to a full 51,291.5 cubic centimeters (3,130 cubic inch) 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 to 169 dB re: 1 μPa (rms) and no clear evidence of avoidance was apparent at received levels up to 172 dB re: 1 μPa (rms) (Malme et al. 1984a;

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 are sparse for specific baleen whale life histories (breeding and feeding grounds) in response to airguns. Available data support a general avoidance response. Some fin and sei whale sighting data indicate similar sighting rates during seismic versus non-seismic periods, but sightings tended to be further away and individuals remained underwater longer (Stone 2003; Stone and Tasker 2006; Stone et al. 2017). Other studies have found at least small differences in sighting rates (lower during seismic 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 (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 Mexico suggests some alteration in foraging from less than 130 to 162 dB re: 1 μPa peak-to-peak, although other behavioral reactions were not noted by several authors (Gordon et al. 2004; Gordon et al. 2006; Jochens et al. 2006; Madsen et al. 2006; Winsor and Mate 2006). This has been contradicted by other studies, which found avoidance reactions by sperm whales in the Gulf of Mexico in response to seismic ensonification (Mate et al. 1994; Jochens 2003; Jochens and Biggs 2004). Johnson and Miller (2002) noted possible avoidance at received sound levels of 137 dB re: 1 μPa. Other anthropogenic sounds, such as pingers and sonars, disrupt behavior and vocal patterns (Watkins and Schevill 1975a; Watkins et al. 1985; Goold 1999). Miller et al. (2009) found sperm whales to be generally unresponsive to airgun exposure in the Gulf of Mexico, 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 and Mate (2013) did not find a non-random distribution of satellite-tagged sperm whales at and beyond 5 kilometers (2.7 nautical miles) from airgun arrays, suggesting individuals were not displaced or move away from the airgun array at and beyond these distances in the Gulf of Mexico, but also point to the fact that the study did not have a large enough sample size to assume a random distribution. In addition, no tagged whales were available to assess potential displacement within 5 kilometers (2.7 nautical miles) (Winsor and Mate 2013). In a follow-up study using additional data, Winsor et al. (2017) found no evidence to suggest sperm whales avoid active airguns within distances of 50 kilometers (27 nautical miles). The lack of response by 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. 1995c). 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 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 2010a).

Similar to other marine mammal species, behavioral responses of pinnipeds can range from a mild orienting response, or a shifting attention, to flight and panic. They may react in a number of ways depending on their experience with the sound source that what activity they are engaged in at the time of the exposure. For example, different responses displayed by captive and wild phocid seals to sound judged to be 'unpleasant' have been reported; where captive seals habituated (did not avoid the sound), and wild seals showed avoidance behavior (Götz and Janik 2011). Captive seals received reinforcement during sound playback, while wild seals were exposed opportunistically. These results indicate that motivational state (e.g., reinforcement via food acquisition) can be a factor in whether or not an animal habituates to novel or unpleasant sounds. Captive studies with other pinnipeds have shown a reduction in dive times when presented with qualitatively 'unpleasant' sounds. These studies indicated that the subjective interpretation of the pleasantness of a sound, minus the more commonly studied factors of received sound level and sounds associated with biological significance, can affect diving behavior (Götz and Janik 2011). More recently, a controlled-exposure study was conducted with U.S. Navy California sea lions at the Navy Marine Mammal Program facility specifically to study behavioral reactions (Houser et al. 2013). Animals were trained to swim across a pen, touch a panel, and return to the starting location. During transit, a simulated mid-frequency sonar signal was played. Behavioral reactions included increased respiration rates, prolonged submergence, and refusal to participate, among others. Younger animals were more likely to respond than older animals, while some sea lions did not respond consistently at any level.

Kvadsheim et al. (2010) found that captive hooded seal (*Cystophora cristata*) reacted to 1 to 7 kHz sonar signals by moving to the areas of last sound pressure level, at levels between 160 and 170 dB re: 1 µPa. Finneran et al. (2003b) found that trained captive sea lions showed avoidance behavior in response to impulsive sounds at levels above 165 to 170 dB re: 1 µPa (rms). These studies are in contrast to the results of Costa (1993) which found that free-ranging elephant seals showed no change in diving behavior when exposed to very low frequency sounds (55 to 95 Hz) at levels up to 137 dB re: 1 µPa (though the received level in this study were much lower (Costa et al. 2003). Similar to behavioral responses of mysticetes and odontocetes, potential behavioral responses of pinnipeds to the proposed seismic survey activities are not expected to impact the fitness of any individual animals as the responses are not likely to adversely affect the ability of the animals to forage, detect predators, select a mate, or reproduce successfully. As noted in (Southall et al. 2007a), substantive behavioral reactions to noise exposure (such as disruption of critical life functions, displacement, or avoidance of important habitat) are considered more likely to be significant if they last more than 24 hours, or recur on subsequent days. 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. That we do not expect fitness consequences is further supported by Navy monitoring of Navy-wide activities since 2006, which has documented hundreds of thousands of marine mammals on training and testing range complexes. Only two instances of overt behavioral change have been observed and there have been no demonstrable instances of injury to marine mammals because of non-impulsive acoustic sources such as low frequency active sonar. We do not expect significant fitness consequences to individual animals to result from instances of behavioral response.

Pinnipeds are not likely to show a strong avoidance reaction to the airgun array sources proposed for use. Visual monitoring from seismic survey vessels has shown only slight (if any) avoidance of airgun arrays by pinnipeds and only slight (if any) changes in behavior. Monitoring work in the Alaskan Beaufort Sea during 1996 through 2001 provided considerable information regarding the behavior of Arctic ice seals exposed to seismic pulses (Harris et al. 2001; Moulton and Lawson 2002). These seismic survey projects usually involved airgun arrays of six to 16 airguns with total volumes of 9,176.8 to 24,580.6 cubic centimeters (560 to 1,500 cubic inches). The combined results suggest that some seals avoid the immediate area around seismic survey vessels. In most survey years, ringed seal (*Phoca hispida*) sightings tended to be farther away from the seismic survey vessel when the airgun arrays were operating than when they were not (Moulton and Lawson 2002). However, these avoidance movements were relatively small, approximately 100 meters (328.1 feet) to a few hundreds of meters, and many seals remained within 100 to 200 meters (328.1 to 656.2 feet) of the trackline as the operating airgun array passed by the animals. Seal sighting rates at the water surface were lower during airgun array operations than during no-airgun periods in each survey year except 1997. Similarly, seals are often very tolerant of pulsed sounds from seal-scaring devices (Mate and Harvey 1987; Jefferson and Curry 1994; Richardson et al. 1995a). However, initial telemetry work suggests that avoidance and other behavioral reactions by two other species of seals to small airgun array sources may at times be stronger than evident to date from visual studies of pinniped reactions to airguns (Thompson et al. 1998).

Elephant seals are unlikely to be affected by short-term variations in prey availability (Costa 1993), as cited in New et al. (2014). We expect the Guadalupe fur seals considered in this opinion to be similarly unaffected. We have no information to suggest animals eliciting a behavioral response (e.g., temporary disruption of feeding) from exposure to the proposed seismic survey activities will be unable to compensate for this temporary disruption in feeding activity by either immediately feeding at another location, by feeding shortly after cessation of acoustic exposure, or by feeding later.

If Guadalupe fur seals are exposed to active acoustic sources, they may react in a number of ways depending on their experience with the sound source and what activity they are engaged in at the time of the acoustic exposure. Guadalupe fur seals may not react at all until the sound source is approaching within a few hundred meters and then may alert, approach, ignore the stimulus, change their behaviors, or avoid the immediate area by swimming away or diving (Finneran et al. 2003a; Kvadsheim et al. 2010; Götz and Janik 2011). Significant behavioral reactions would not be expected in most cases, and long-term consequences for individuals are unlikely.

In summary, ESA-listed marine mammals are expected to exhibit a wide range of behavioral responses when exposed to sound fields from the airgun array. Baleen whales are expected to mostly exhibit avoidance behavior, and may also alter their vocalizations. Toothed whales (i.e., sperm whales) are expected to exhibit less overt behavioral changes, but may alter foraging behavior, including echolocation vocalizations. Pinnipeds (i.e., Guadalupe fur seals) are expected to exhibit avoidance and behavioral changes. These responses are expected to be temporary with behavior returning to a baseline state shortly after the sound source becomes inactive or leaves the area.

Marine Mammals and Physical or Physiological Effects

Individual whales exposed to airguns (as well as other sound sources) could experience effects not readily observable such as stress (Romano et al. 2002) that may have adverse effects. Other possible responses to impulsive sound sources like airgun arrays include neurological effects, bubble formation, resonance effects, and other types of organ or tissue damage (Cox et al. 2006; Southall et al. 2007b; Zimmer and Tyack 2007; Tal et al. 2015), but similar to stress, these effects are not readily observable. Importantly, these more severe physical and physiological responses have been associated with explosives and/or mid-frequency tactical sonar, but not seismic airguns. There have been no reported stranding events after NSF surveys. Thus, we do not expect ESA-listed marine mammals to experience any of these more severe physical and physiological responses because of 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 onset of TTS will also experience physiological stress response (NRC 2003b; 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, will experience a stress response, which may also 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 a TTS exposure will result in a longer duration response before returning to a baseline state as compared to exposure to levels below the TTS threshold).

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 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). 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 20 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.

Marine Mammals and Strandings

There is some concern regarding the coincidence of marine mammal strandings and proximal seismic surveys. No conclusive evidence exists to causally link stranding events to seismic surveys. Suggestions that there was a link between seismic surveys and strandings of humpback whales in Brazil (Engel et al. 2004) were not well founded (Iagc 2004; IWC 2007a). In September 2002, two Cuvier's beaked whales (*Ziphius cavirostris*) stranded in the Gulf of California, Mexico. The R/V *Maurice Ewing* had been operating a 20-airgun array (139,126.2 cubic centimeters [8,490 cubic inch]) 22 kilometers (11.9 nautical miles) 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 of airgun arrays from seismic surveys that may contribute to marine mammal strandings are unknown and we have no evidence to lead us to believe that aspects of the airgun array proposed for use will cause marine mammal strandings. The seismic survey will take place in the Eastern Tropical Pacific Ocean, and the closest approach to the Mexican coastline will be approximately 7.5 kilometers (4.6 miles) from land. 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.

Marine Mammal Response to Multi-Beam Echosounder, Sub-Bottom Profiler, Acoustic Doppler Current Profiler, and Acoustic Release Transponder

We expect ESA-listed marine mammals to experience ensonification from not only the airgun array, but also from the multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler. The multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler used during the seismic survey operate at a frequency of 10.5 to 13 (usually 12) kHz, 3.5 kHz, and 75 kHz, respectively. These frequencies are within the functional hearing range of baleen whales (7 Hz to 35 kHz), such as blue, fin, humpback, and sei whales, as well as sperm whales (150 Hz to 160 kHz) (NOAA 2018). We expect that these mapping systems will produce harmonic components in a frequency range above and below the center frequency similar to other commercial sonars (Deng 2014). Although Todd et al. (1992) found that mysticetes reacted to sonar sounds at 3.5 kHz within the 80 to 90 dB re: 1 µPa range, it is difficult to determine the significance of this because the sound source was a signal designed to be alarming and the sound level was well below typical ambient noise. Goldbogen et al. (2013) found blue whales to respond to 3.5 to 4 kHz mid-frequency sonar at received levels below 90 dB re: 1 µPa. Responses included cessation of foraging, increased swimming speed, and directed travel away from the source (Goldbogen 2013). Hearing is poorly understood for ESA-listed baleen whales, but it is assumed that they are most sensitive to frequencies over which they vocalize, which are much lower than frequencies emitted by the multi-beam echosounder, sub-bottom profiler, acoustic Doppler current profiler, and acoustic release transponder (Richardson et al. 1995e; Ketten 1997).

Humpback and sperm whales vocalize between 3.5 to 12.6 kHz and an audiogram of a juvenile sperm whale provides direct support for hearing over this entire range (Payne 1970; Winn et al. 1970a; Levenson 1974; Tyack 1983a; Tyack and Whitehead 1983; Payne and Payne 1985; Silber 1986a; Thompson et al. 1986a; Carder and Ridgway 1990; Weilgart and Whitehead 1993; Goold and Jones 1995; Richardson et al. 1995e; Weilgart and Whitehead 1997a; Au 2000; Frazer and Mercado 2000; Erbe 2002a; Au et al. 2006a; Weir et al. 2007). The response of a blue whale to

3.5 kHz sonar supports this species' ability to hear this signal as well (Goldbogen 2013). Maybaum (1990a; 1993) observed that Hawaiian humpback whales moved away and/or increased swimming speed upon exposure to 3.1 to 3.6 kHz sonar. Kremser et al. (2005) concluded the probability of a cetacean swimming through the area of exposure when such sources emit a pulse is small. The animal would have to pass the transducer at close range and be swimming at speeds similar to the vessel in order to receive the multiple pulses that might result in sufficient exposure to cause TTS Sperm whales have stopped vocalizing in response to six to 13 kHz pingers, but did not respond to 12-kHz echosounders (Backus and Schevill 1966; Watkins and Schevill 1975b; 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).

Investigations stemming from a 2008 stranding event in Madagascar indicated a 12 kHz multi-beam echosounder, similar in operating characteristics as that proposed for use aboard the R/V *Marcus G. Langseth*, suggest that this sonar 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 is lacking and the authors acknowledge that, 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 multi-beam echosounder (Southall 2013). This incident highlights the caution needed when interpreting effects that may or may not stem from anthropogenic sound sources, such as the R/V *Marcus G. Langseth*'s use of the multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler. 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).

Although navigational sonars are operated routinely by thousands of vessels around the world, strandings have not been correlated to use of these sonars. Stranding events 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 R/V *Marcus G. Langseth* differ from sonars used during naval operations, which generally have a longer pulse duration and more horizontal orientation than the more downward-directed multi-beam echosounder. The sound energy received by any individuals exposed to the multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler sound sources during the proposed seismic survey activities is lower relative to naval sonars, as is the duration of exposure. The area of possible influence for the multi-beam echosounder, sub-bottom profiler, acoustic Doppler current profiler, and acoustic release transponder 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 a stranding event on the part of ESA-listed marine mammals exposed to sound from operation of these systems during the proposed action.

We do not expect appreciable masking of blue, fin, humpback, sei, or sperm whales communication to occur due to the multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler's signal directionality, low duty cycle, and brief period when an individual could be within their beam. These factors were considered when Burkhardt et al. (2013) estimated the risk of injury from multi-beam echosounder was less than three percent that of vessel strike. Behavioral responses to the multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler are likely to be similar to the pulsed sources associated with the rest of the equipment operating during the seismic surveys if received at the same levels. We do not expect hearing impairment such as TTS and other physical effects if the animal is in the area while this equipment is operating, as it would have to pass the transducers at close range in order to be subjected to sound levels that could cause injurious effects.

10.3.2.2 Potential Responses of Sea Turtles to Acoustic Sources

As with marine mammals, ESA-listed sea turtles may exhibit a variety of responses to sound fields associated with seismic survey activities. Below we review what is known about the following responses that sea turtles may exhibit (reviewed in Nelms et al. 2016):

- Hearing threshold shifts;
- Behavioral responses; and
- Non-auditory physical or physiological effects.

To our knowledge, strandings of sea turtles in association with anthropogenic sound has not been documented, and so no such stranding response is expected. In addition, masking is not expected to affect sea turtles because they are not known to rely heavily on acoustics for life functions (Popper et al. 2014b; Nelms et al. 2016).

Acoustic Thresholds

In order to estimate exposure of ESA-listed sea turtles to sound fields generated by the airgun arrays that will be expected to result in a response, we relied on the available scientific literature. Currently, the best available data come from studies by O'Hara and Wilcox (1990) and McCauley et al. (2000b), who experimentally examined behavioral responses of sea turtles in response to airgun arrays. O'Hara and Wilcox (1990) found that loggerhead turtles exhibited avoidance behavior at estimated sound levels of 175 to 176 dB re: 1 μPa (rms) (or slightly less) in a shallow canal. McCauley et al. (2000b) reported a noticeable increase in swimming behavior for both green and loggerhead turtles at received levels of 166 dB re: 1 μPa (rms). At 175 dB re: 1 μPa (rms), both green and loggerhead turtles displayed increased swimming speed and increasingly erratic behavior (McCauley et al. 2000b). Based on these data, we assume that sea turtles will exhibit a behavioral response when exposed to received levels of 175 dB re: 1 μPa (rms) and higher, and so use this threshold to estimate the number of instances of exposure that will result in harassment response. The predicted distances to which sound levels of 175 dB re: 1

μPa (rms) will be received from the single (40 cubic inch), and 36 airgun arrays for sea turtles during the seismic activities were presented in Table 3. To summarize, the predicted distances to the 175 dB re: 1 μPa (rms) threshold in shallow, intermediate, and deep waters are 3,924 meters, 2,542 meters, and 1,864 meters, respectively.

We have determined that PTS for sea turtles is highly unlikely to occur. For sea turtles, the thresholds for PTS are 204 dB re 1 $\mu Pa^2 \cdot s$ $SEL_{cum;}$ and 232 dB re: 1 μPa SPL (0-pk). With a source level at the frequency of greatest energy, which is within the sensitive hearing range of sea turtles, the animal will almost have to be directly under the sound source exactly when it fires. Further, PTS may not ever be realized at close distances due to near-field interactions. The airgun array will be shut down if a sea turtle is about to enter the 150 meter exclusion zone; the calculated isopleth distance to the PTS threshold for sea turtles is 15.4 meters. Thus, we believe the only responses of sea turtles will be behavioral and assess the consequences of these responses in our risk analysis.

Sea Turtles and Hearing Thresholds

Like marine mammals, if exposed to loud sounds sea turtles may experience TTS and/or PTS. For the 36-airgun array, the distances to the 175 dB re: 1 μPa [rms] TTS threshold for sea turtles in shallow, intermediate, and deep waters are 4,123 meters, 2,796 meters, and 1,864 meters respectively. The distance to the 195 dB re: 1 μPa [rms] PTS threshold for sea turtles is 15.4 meters. Although all sea turtle species exhibit the ability to detect low frequency sound in studies, the potential effects of exposure to loud sounds on sea turtle biology remain largely unknown (Samuel et al. 2005; Nelms et al. 2016). Few data are available to assess sea turtle hearing, let alone the effects sound sources from seismic surveys may have on their hearing potential. The only study which addressed sea turtle TTS was conducted by Moein et al. (1994), in which a loggerhead turtle experienced TTS upon multiple exposures to an airgun in a shallow water enclosure, but recovered full hearing sensitivity within one day.

As with marine mammals, we assume that sea turtles will not move towards a sound source that causes them stress or discomfort. Some experimental data suggest sea turtles may avoid seismic sound sources (Moein et al. 1994; McCauley et al. 2000a; McCauley et al. 2000c), but monitoring reports from seismic surveys in other regions suggest that some sea turtles do not avoid airguns and were likely exposed to higher levels of pulses from seismic airgun arrays (Smultea and Holst 2003). For this reason, mitigation measures will be implemented to limit sea turtle exposure at 150 meters (492.1 feet) through the use of observers and shutdowns. Based on the reported information, in some cases, we expect sea turtles will move away from sounds produced by the airgun array. For the sea turtles that do not move away from the sound source, implementing shutdowns at 150 meters would limit sea turtle exposure at closer range. Although data on the precise sound levels that can result in TTS or PTS are lacking for sea turtles and the effectiveness of mitigation measures such as those that will be implemented as part of the proposed action is not fully understood, we do not expect the vast majority of sea turtles present in the action area to be exposed to sound levels that will result in TTS or PTS. For those individuals that experience TTS, the available data suggest hearing will return to normal within days of the exposure (Moein et al. 1994).

Sea Turtles and Behavioral Responses

As with ESA-listed marine mammals, it is likely that sea turtles will exhibit behavioral responses in the form of avoidance. We do not have much information on how sea turtles will respond, but we present the available information. Behavioral responses to human activity have been investigated for only a few species of sea turtles: green and loggerhead (O'Hara and Wilcox 1990; McCauley et al. 2000b); and leatherback, loggerhead, olive ridley, and 160 unidentified turtles (hardshell species) (Weir 2007). The work by O’Hara and Wilcox (1990) and McCauley et al. (2000b) reported behavioral changes of sea turtles in response to seismic airgun arrays. These studies formed the basis for our 175 dB re: 1 μPa (rms) threshold for determining when sea turtles could experience behavioral or injurious 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 meters (32.8 feet) 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 20 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 R/V *Marcus G. Langseth* transits through because of behavioral responses to sound sources.

Sea Turtles and Physical or Physiological Effects

Direct evidence of seismic sound causing stress is lacking 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 experience a stress response if exposed to loud sounds from airgun arrays. Individuals may experience a stress response at levels lower than approximately 175 dB re: 1 μPa (rms), but data are lacking to evaluate this possibility. Therefore, we follow the best available evidence identifying a behavioral response as the point at which we also expect a significant stress response.

Sea Turtles Response to Multi-Beam Echosounder, Sub-Bottom Profiler, Acoustic Doppler Current Profiler, and Acoustic Release Transponder

Sea turtles do not possess a hearing range that includes frequencies emitted by the multi-beam echosounder (10.5 to 13 [usually 12] kHz), sub-bottom profiler (3.5 kHz), acoustic Doppler current profiler (75 kHz), and acoustic release transponder (8 to 13 kHz). Therefore, ESA-listed sea turtles are not expected to detect these sounds even if they are exposed and are not expected to respond to them.

Responses of Marine Mammal, and Sea Turtle Prey

Seismic surveys may also have indirect, adverse effects on ESA-listed marine mammals, and sea turtles by affecting their prey (including larval stages) through lethal or sub-lethal damage, stress responses, or alterations in their behavior or distribution. Such prey include fishes (blue, fin, humpback, sei, sperm, and Guadalupe fur seals), zooplankton (blue, fin, humpback, and sei whales), cephalopods (sperm whales and Guadalupe fur seals), and other invertebrates such as crustaceans, mollusks, amphipods, isopods, aquatic insects, insect larvae, and jellyfish (blue whales, leatherback sea turtles). In a recent review, Carroll et al. (2017) summarized the available information on the impact 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.

There has been research suggesting that seismic airgun arrays may lead to a significant reduction in zooplankton, including copepods. McCauley et al. (2017) found that the use of a single airgun (approximately 150 cubic inches) led to a decrease in zooplankton abundance by over 50 percent and a two- to three-fold increase in dead adult and larval zooplankton when compared to control scenarios. In addition, effects were found out to 1.2 kilometers (0.6 nautical miles); 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, three-dimensional 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 20 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 off the western Mexican coast.

However, Fields et al. (2019a) has demonstrated different results through a series of control experiments using seismic blasts from two airguns (260 cubic inches) 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 meters (32.8 feet) of the seismic airguns, but there was no measurable impact at greater distances. The study also found significantly higher immediate mortality at distances of less than 5 meters from the airgun and a higher cumulative mortality (7 days after exposure) at a distance somewhere between 10 and 20 meters from the airgun, and observed no sub lethal effects but did see changes in gene expression (Fields et al. 2019b). Furthermore, Fields et al. (2019a) demonstrated that seismic airgun blasts had no effect on the escape response of *C. finmarchicus*. They conclude that the effects of seismic airgun blasts 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. Furthermore, the energy of the proposed seismic arrays (6,630 cubic inches versus 150 or 260 cubic inches) proposed in this consultation suggests that any copepod or crustacean directly exposed to the seismic airguns (underneath or within five meters [16.4 feet]) would likely suffer mortality to an extent greater than described by McCauley et al. (2017).

Results of McCauley et al. (2017) provide little information on the effects to copepods at the surface because their analyses excluded zooplankton at the surface bubble layer. Given that airguns primarily transmit sound downward, and that those associated with the proposed action will be towed at depths of 12 meters (39 feet), we expect that sounds from airgun array will be relatively low at the surface (i.e., above the airgun array), and greater below the airguns. Krill and copepod prey can be found throughout the water column. Baleen whales will dive to different depths to feed, depending on the locations of dense prey aggregations. The foraging depth dives vary by location, whale species, and, in some cases, by time of day, as whales will follow zooplankton prey vertical diel movements.

Seismic surveys are less likely to have significant effects over a broad area on zooplankton because of their fast growth rate and because of the high turnover rate of zooplankton. In the Mexican Eastern Tropical Pacific, off the coasts of Jalisco and Colima (in the action area), zooplankton biomass values are high between the months of January and May, coinciding with the lowest sea surface temperatures (Franco-Gordo et al. 2001). We expect ocean currents will circulate zooplankton within the action area within a matter of days to weeks (3 to 39 days; (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). Richardson et al. (2017) simulated a “typical” seismic survey (60 survey lines in a lawnmower pattern, acquired over 35 days). The seismic activities in the proposed action will last for 20 days, and involve the vessel surveying a given area briefly over several hours then transiting to another area (i.e., survey lines will not be repeatedly shot in a given area as in the lawnmower pattern described in Richardson et al. 2017). 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, 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, and this is limited to close-range exposure to high amplitudes (Falk and Lawrence 1973; Kostyuchenko 1973; Holliday et al. 1987; La Bella et al. 1996; D'Amelio 1999; McCauley et al. 2000a; 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). 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 also expect they will return to the area and be available as prey for marine mammals and sea turtles.

There are reports showing sub-lethal effects to some fish species from airgun arrays. Several species at various life stages have been exposed to high-intensity sound sources (220 to 242 dB re: 1 μPa) at close distances, with some cases of injury (Booman et al. 1996; McCauley et al. 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 $\mu Pa^2 s$, but pike did show 10 to 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 to 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. Similarly, 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. As with marine mammals and sea turtles, behavioral responses by fishes and invertebrates may also be associated with a stress response.

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 to 60 minutes after firing of the airgun ceased. A downward shift was also noted by

Skalski et al. (1992) at received seismic sounds of 186 to 191 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 kilometer (1.3 nautical miles) away; this response increased in severity as the vessel approached and sound levels increased, but returned to normal after about two hours following cessation of airgun activity.

Whiting (*Merlangius merlangus*) exhibited a downward distributional shift upon exposure to 178 dB re: 1 µPa 0-to-peak sound from airguns, but habituated to the sound after one hour and returned to normal depth (sound environments of 185 to 192 dB re: 1 µPa) despite airgun activity (Chapman and Hawkins 1969). Whiting may also flee from sounds from airguns (Dalen and Knutsen 1986). Hake (*Merluccius* spp.) may re-distribute downward (La Bella et al. 1996). Lesser sand eels (*Ammodytes tobianus*) exhibited initial startle responses and upward vertical movements before fleeing from the seismic survey area upon approach of a vessel with an active source (Hassel et al. 2003; Hassel et al. 2004).

McCauley et al. (2000; 2000a) found small fish show startle responses at lower levels than larger fish in a variety of fish species and generally observed responses at received sound levels of 156 to 161 dB re: 1 µPa (rms), but responses tended to decrease over time suggesting habituation. As with previous studies, caged fish showed increases in swimming speeds and downward vertical shifts. Pollock (*Pollachius* spp.) did not respond to sounds from airguns received at 195 to 218 dB re: 1 µPa 0-to-peak, but did exhibit continual startle responses and fled from the acoustic source when visible (Wardle et al. 2001). Blue whiting (*Micromesistius poutassou*) and mesopelagic fishes were found to re-distribute 20 to 50 meters (65.6 to 164 feet) deeper in response to airgun ensonification and a shift away from the seismic survey area was also found (Slotte et al. 2004). Startle responses were infrequently observed from salmonids receiving 142 to 186 dB re: 1 µPa peak-to-peak sound levels from an airgun (Thomsen 2002). Cod (*Gadus* spp.) and haddock (*Melanogrammus aeglefinus*) likely vacate seismic survey areas in response to airgun activity and estimated catchability decreased starting at received sound levels of 160 to 180 dB re: 1 µPa 0-to-peak (Dalen and Knutsen 1986; Løkkeborg 1991; Engås et al. 1993; Løkkeborg and Soldal 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 to 191 dB re: 1 µPa 0-to-peak (Turnpenny and Nedwell 1994). Similarly, European sea bass apparently did not leave their inshore habitat during a four- to five-month seismic survey (Pickett et al. 1994). La Bella et al. (1996) found no 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.

Squid are important prey for sperm whales. Squid responses to operating airguns have also been studied, although to a lesser extent than fishes. In response to airgun exposure, squid exhibited both startle and avoidance responses at received sound levels of 174 dB re: 1 µPa (rms) by first ejecting ink and then moving rapidly away from the area (McCauley et al. 2000a; McCauley et al. 2000c; Fewtrell 2013b). The authors also noted some movement upward. During ramp-up, squid did not discharge ink but alarm responses occurred when received sound levels reached 156 to 161 dB re: 1 µPa (rms). Tenera Environmental (2011) reported that Norris and Mohl (1983, summarized in Mariyasu et al. 2004) observed lethal effects in squid (*Loligo vulgaris*) at levels of 246 to 252 dB after three to 11 minutes. Andre et al. (2011) exposed four cephalopod species (*Loligo vulgaris*, *Sepia officinalis*, *Octopus vulgaris*, and *Ilex coindetii*) to two hours of continuous sound from 50 to 400 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. 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. Another laboratory study observed abnormalities in larval scallops after exposure to low frequency noise in tanks (de Soto et al. 2013).

Lobsters did not exhibit delayed mortality, or apparent damage to mechanobalancing systems after up to eight months post-exposure to airguns fired at 202 or 227 dB peak-to-peak pressure (Christian 2013). However, feeding did increase in exposed individuals (Christian 2013). Sperm whales regularly feed on squid and some fishes, and we expect individuals to feed while in the action area during the proposed seismic survey activities. Based upon the best available information, fishes and squids located within the sound fields corresponding to the approximate 160 dB re: 1 µPa (rms) isopleths could vacate the area and/or dive to greater depths. ESA-listed whales which feed on these species may follow them out of the ensonified area.

The overall response of fishes and squids is to exhibit startle responses and undergo vertical and horizontal movements away from the sound field. We are not aware of any specific studies regarding sound effects on and the detection ability of other invertebrates such as krill (*Euphausiacea* spp.), the primary prey of most ESA-listed baleen whales. As described above, we do anticipate some krill mortality (Richardson et al. 2017). However, we do not expect krill to experience population-level effects from sounds of airguns, since ocean circulation and the high turnover rate of zooplankton would minimize effects. Although humpback whales consume fish regularly, we expect that any disruption to their prey will be temporary, if at all. Therefore, we do not expect any adverse effects from a potential temporary lack of prey availability in localized areas to baleen whales. We expect indirect effects from airgun array operations through reduced feeding opportunities for ESA-listed marine mammals to be temporary and, if displaced, both marine mammals, sea turtles, and their prey will re-distribute back into the action area once seismic survey activities have passed or concluded.

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 airgun array immediately following the use of active seismic sound sources. This may be due to changes in prey distributions (i.e., due to avoidance) or abundance (i.e., due to mortality) or both. However, we do not expect this to have a meaningful impact on ESA-listed marine mammals or sea turtles. As described above, we believe that, in most cases, ESA-listed marine mammals and sea turtles will avoid closely approaching the airgun array when active, and as such will not be in areas from which prey have been temporarily displaced or otherwise affected.

10.4 Risk Analysis

In this section, we assess the consequences of the responses of the individuals that have been exposed, the populations those individuals represent, and the species those populations comprise.

We measure risks to individuals of threatened or endangered species based upon effects on the individual's fitness, which may be indicated by changes to the individual's growth, survival, annual reproductive fitness, and lifetime reproductive success. We expect the numbers of the following species to be exposed to the airgun array within 160 dB re: 1 µPa (rms) ensonified areas throughout the entirety of the action area during the seismic survey activities:

- 5 blue whales,
- 2 fin whales,
- 9 Central America DPS of humpback whales,
- 3 sei whales,
- 13 sperm whales,
- 448 Guadalupe fur seals.

We expect that any olive ridley, East Pacific DPS green, North Pacific Ocean DPS loggerhead, leatherback, or hawksbill sea turtles within the 175 dB re: 1 µPa (rms) ensonified areas during air gun operations to be exposed to the air guns during the seismic survey.

Our exposure estimates stem from the best available information on species densities and a predicted radial distance (Table 2, Table 3, and Table 4) based on isopleths corresponding to harm and harassment thresholds along tracklines for the seismic survey. Based upon information presented in the *Response Analysis*, ESA-listed marine mammals exposed to these sound sources could be harmed, exhibit changes in behavior, suffer stress, or even strand. ESA-listed sea turtles could be harmed, exhibit changes in behavior, or suffer stress.

When we do not expect individual ESA-listed animals (marine mammals) exposed to an action's effects to experience reductions in fitness, we will not expect the action to have adverse consequences on the viability of the populations those individuals belong or the species those populations comprise. As a result, if we conclude that ESA-listed animals are not likely to experience reductions in their fitness, we will conclude our assessment. If, however, we conclude that individual animals are likely to experience reductions in fitness, we will assess the consequences of those fitness reductions on the population(s) to which those individuals belong.

Because of the required mitigation and monitoring measures that are part of the NSF's action, and those measures in the NMFS Permits Division's proposed incidental harassment authorization, as described above, we do not expect adverse effects to result in any injury or mortality to ESA-listed species from the exposure to the acoustic sources resulting from the proposed actions. As described above, the proposed actions will result in temporary effects, largely behavioral responses (e.g., avoidance, discomfort, loss of foraging opportunities, loss of mating opportunities, masking, alteration of vocalizations, and stress) but with some potential for TTS, to the exposed marine mammals (blue, fine, sei, sperm, and Central America DPS humpback whales, and Guadalupe fur seal seals), and sea turtles (leatherback, East Pacific DPS green, North Pacific Ocean DPS loggerhead, hawksbill, and olive ridley sea turtles). Harassment is not expected to have more than short-term effects on individual ESA-listed marine mammal or sea turtle species. Harm under the ESA is not expected to occur with high probability given the mitigation and monitoring measures (e.g., proposed exclusion and buffer zones, shut-down procedures, pre-clearance and ramp-up procedures, vessel-based visual monitoring by NMFS-approved protected species observers, and vessel strike avoidance measures) in place for the proposed seismic survey activities to protect ESA-listed species.

Given that individual blue, fine, sei, sperm, and Central America DPS humpback whales, and Guadalupe fur seal seals may experience temporary responses from the proposed seismic survey activities and those exposures are a small percentage of the regional population (blue whales: 0.33%; fin whales: 0.02%; sei whales: 0.01%; Central America DPS humpback whales: 2.19%; sperm whales: 0.05%; Guadalupe fur seals: 2.91%), we do not expect any population level effects. Given that and leatherback, East Pacific DPS green, North Pacific Ocean DPS loggerhead, hawksbill, and olive ridley sea turtles may experience temporary responses from the proposed seismic survey activities and those exposures would occur over a relatively brief time period (19 days of seismic activity), we do not expect any population level effects. These estimates are conservative, that is, it is likely higher than the actual exposures and a fewer number are likely to be harassed given the mitigation and monitoring measures that will be implemented. Because of the large range of the ESA-listed marine mammals and sea turtles compared to the relatively small size of the action area, combined with the relatively short duration of the seismic survey activities, it is likely that there may be multiple exposures of a small number of individuals in the action area. As such, we believe the fitness consequences (temporary behavioral responses [e.g., avoidance, discomfort, loss of foraging opportunities, loss of mating opportunities, masking, alteration of vocalizations, and stress] and some potential for TTS) to ESA-listed marine mammals and sea turtles exposed to the sounds sources from the low-energy seismic survey will have a minimal effect on the populations those individuals represent or the species those populations comprise. No proposed or designated critical habitat for these species will be adversely affected by the seismic survey activities associated with the proposed actions because none is present in the action area (Section 7).

11 CUMULATIVE EFFECTS

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 C.F.R. §402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

During this consultation, we searched for information on future state, tribal, local, or private (non-Federal) actions that were reasonably certain to occur in the action area. We conducted electronic searches of *Google* and other electronic search engines for other potential future state or private activities that are likely to occur in the action area.

Future tribal, state, and local government actions will likely be in the form of legislation, administrative rules, or policy initiatives and fishing permits. Activities occurring in the action area are primarily those conducted under state and tribal management. These actions may include changes in ocean policy and increases and decreases in the types of activities currently seen in the action area, including changes in the types of fishing activities, resource extraction, and designation of marine protected areas, any of which could influence the status of listed species in the action area in the future. Government actions are subject to political, legislative and fiscal uncertainties. As a result, any analysis of cumulative effects is difficult, particularly when taking into account the geographic scope of the action area, the various authorities involved in the action, and the changing economies of the region.

We expect that those aspects described in the *Environmental Baseline* (Section 9) will continue to impact ESA-listed resources into the foreseeable future. We expect climate change, oceanic temperature regimes, vessel strikes, whale watching, fisheries (fisheries interactions and aquaculture), pollution (marine debris, pesticides and contaminants, and hydrocarbons), aquatic nuisance species, anthropogenic sound (vessel sound and commercial shipping, aircraft, seismic surveys, and marine construction), military activities, and scientific research activities to continue into the future with continuing impacts to marine mammals and sea turtles. Because of recent trends and based on available information, we expect the amount and frequency of vessel activity to persist in the action area, and that ESA-listed species will continue to be impacted. Different aspects of vessel activity can impact ESA-listed species, such as vessel noise, disturbance, and the risk of vessel strike causing injury or mortality to marine mammals, especially large whales, and to a lesser extent, sea turtles. However, movement towards bycatch reduction and greater foreign protections of sea turtles are generally occurring throughout the eastern Pacific Ocean waters of Mexico, which may aid in abating the downward trajectory of sea turtle populations due to activities such as incidental bycatch in fisheries in the action area.

12 INTEGRATION AND SYNTHESIS

The *Integration and Synthesis* section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the *Effects of the Action* (Section 10) to the *Environmental Baseline* (Section 9) and the *Cumulative Effects* (Section 11) to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a ESA-listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated or proposed critical habitat for the conservation of the species. These assessments are made in full consideration of the *Status of the Species and Critical Habitat* (Section 8).

Some ESA-listed species are located within the action area but are not expected to be affected by the action, or the effects of the action on these ESA resources were determined to be insignificant or discountable. Some activities evaluated individually were determined to have insignificant or discountable effects and thus to be not likely to adversely affect some ESA-listed species (Section 7).

The following discussions separately summarize the probable risks the proposed action poses to threatened and endangered marine mammals and ESA-listed sea turtles. These summaries integrate the exposure profiles presented previously with the results of our response analyses for each of the activities considered further in this opinion; specifically seismic survey activities and associated equipment sound levels.

12.1 Jeopardy Analysis

The jeopardy analysis relies upon the regulatory definition of "to jeopardize the continued existence of a listed species," which is "to engage in an action that 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 C.F.R. §402.02). Therefore, the jeopardy analysis considers both the survival and recovery of the species.

Based on our effects analysis, adverse effects to ESA-listed species are likely to result from the action. The following discussions summarize the probable risks that seismic survey activities pose to ESA-listed species that are likely to be exposed over the approximately 20 days of the seismic survey activities. These summaries integrate our exposure, response, and risk analyses from Section 10.

12.1.1 Blue Whale

Adult and juvenile blue whales are present in the action area and are expected to be exposed to noise from the seismic survey activities. The severity of an animal's response to noise associated with the seismic survey will depend on the duration and severity of exposure.

The minimum population size for Eastern North Pacific Ocean blue whales is 1,050; the more recent abundance estimate is 1,496 whales (Carretta et al. 2020), with older population estimates for the Eastern Tropical Pacific at 1,415 blue whales (Wade and Gerrodette 1993). Current estimates indicate a growth rate of just under three percent per year (Calambokidis et al. 2009). We expect that adults and juveniles may be affected by take in the form of harassment from sound sources associated with the seismic survey. Take may have short- or long-term consequences, depending on the level of noise from detonations to which animals are exposed. The anticipated take of animals is not expected to result in the loss of reproduction at an individual level or to have a measurable effect on reproduction at the population level.

Harassment take of five individuals, adults and juveniles, is expected as a result of the proposed seismic survey activities. We anticipate temporary behavioral responses (e.g., avoidance, discomfort, loss of foraging opportunities, loss of mating opportunities, masking, alteration of vocalizations, and stress) with some potential for TTS, with individuals returning to normal shortly after the exposure has ended, and thus do not anticipate any delay in reproduction as a result. No reduction in the distribution of blue whales from the Pacific Ocean or changes to the geographic range of the species are expected because of the NSF and L-DEO's seismic survey activities and the Permits Division's issuance of an incidental harassment authorization. No reduction in reproduction is expected as a result of the proposed actions. Therefore, no reduction in numbers is anticipated due to the proposed actions. Because we do not anticipate a reduction in numbers or reproduction of blue whales as a result of the proposed seismic survey activities and the Permits Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

The Final Recovery Plan for the blue whale lists recovery objectives for the species. The following recovery objectives are relevant to the impacts of the proposed actions:

- Reduce or eliminate human-caused injury and mortality of blue whales.
- Minimize detrimental effects of directed vessel interactions with blue whales.
- Coordinate state, federal, and international efforts to implement recovery actions for blue whales.

Because no mortalities or effects on the abundance, distribution, and reproduction of blue whale populations are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the Permits Division's issuance of an incidental harassment authorization will impede the recovery objectives for blue whales. In conclusion, we believe the effects associated with the proposed actions are not expected to cause a reduction in the likelihood of survival and recovery of blue whales in the wild.

12.1.2 Fin Whale

Adult and juvenile fin whales are present in the action area and are expected to be exposed to noise from the seismic survey activities. The severity of the individual's response to noise associated with the seismic survey will depend on the duration and severity of the exposure.

Current estimates indicate approximately 10,000 fin whales in U.S. Pacific Ocean waters, with an annual growth rate of 7.5 percent in the Northeast Pacific and a stable population abundance in the California/Oregon/Washington stock (Nadeem et al. 2016).

We expect that up to two adults and juveniles may be affected by take in the form of harassment (behavioral changes) from sound sources associated with the seismic survey. We anticipate temporary behavioral responses (e.g., avoidance, discomfort, loss of foraging opportunities, loss of mating opportunities, masking, alteration of vocalizations, and stress) with some potential for TTS, with individuals returning to normal shortly after the exposure has ended, and thus do not anticipate any delay in reproduction as a result.

No reduction in the distribution of fin whales from the Pacific Ocean is expected because of the NSF and L-DEO's seismic survey activities and the Permits Division's issuance of an incidental harassment authorization. No reduction in reproduction is expected because of the proposed actions. Therefore, no reduction in numbers is anticipated due to the proposed actions. Because we do not anticipate a reduction in numbers, distribution, or reproduction of fin whales as a result of the proposed seismic survey activities and the Permits Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

The 2010 Final Recovery Plan for the fin whale lists recovery objectives for the species. The following recovery objectives are relevant to the impacts of the proposed actions:

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

Because no mortalities or effects on the distribution of fin whale populations are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the Permits Division's issuance of an incidental harassment authorization will impede the recovery objectives for fin whales. In conclusion, we believe the effects associated with the proposed actions are not expected to cause a reduction in the likelihood of survival and recovery of fin whales in the wild.

12.1.3 Humpback Whale—Central America Distinct Population Segment

Adult and juvenile Central America DPS humpback whales are present in the action area and are expected to be exposed to noise from the seismic survey activities. The severity of the individual's response to noise associated with the seismic survey will depend on the duration and severity of the exposure.

The global, pre-exploitation estimate for humpback whales is 1,000,000 (Roman and Palumbi 2003). The current abundance of the Central America DPS is 411. A population growth rate is currently unavailable for the Central America DPS of humpback whales.

We expect that nine adults and juveniles may be affected by take in the form of harassment from sound sources associated with the seismic survey. We anticipate temporary behavioral responses (e.g., avoidance, discomfort, loss of foraging opportunities, loss of mating opportunities, masking, alteration of vocalizations, and stress) with some potential for TTS, with individuals returning to normal shortly after the exposure has ended, and thus do not anticipate any delay in reproduction as a result. No reduction in the distribution of Central America DPS of humpback whales from the Pacific Ocean is expected because of the NSF and L-DEO's seismic survey activities and the Permits Division's issuance of an incidental harassment authorization.

No reduction in reproduction is expected because of the proposed actions. Therefore, no reduction in numbers is anticipated due to the proposed actions. There are expected to be nine individuals harassed, adults and juveniles, because of the proposed seismic surveys. Because we do not anticipate a reduction in numbers or reproduction of Central DPS of humpback whales as a result of the proposed seismic survey activities and the Permits Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

The 1991 Final Recovery Plan for the humpback whale lists recovery objectives for the species. The following recovery objectives are relevant to the impacts of the proposed actions:

- Maintain and enhance habitats used by humpback whales currently or historically.
- Identify and reduce direct human-related injury and morality.
- Measure and monitor key population parameters.
- Improve administration and coordination of recovery program for humpback whales.

Because no mortalities or effects on the distribution of Central America DPS of humpback whales are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the Permits Division's issuance of an incidental harassment authorization will impede the recovery objectives for Central America DPS of humpback whales. In conclusion, we believe the effects associated with the proposed actions are not expected to cause a reduction in the likelihood of survival and recovery of Central America of DPS of humpback whales in the wild.

12.1.4 Sei Whale

Adult and juvenile sei whales are present in the action area and are expected to be exposed to noise from the seismic survey activities. The severity of an individual's response to noise associated with the seismic survey will depend on the duration and severity of exposure.

Models indicate that total abundance declined from 42,000 to 8,600 individuals between 1963 and 1974 in the North Pacific Ocean. More recently, the North Pacific Ocean population was estimated to be 29,632 (95 percent confidence intervals 18,576 to 47,267) between 2010 and 2012 (IWC 2016; Thomas et al. 2016). Population growth rates for sei whales are not available at this time as there are little to no systematic survey efforts to study sei whales.

We expect that three individuals, adults and juveniles, may be affected by take in the form of harassment from sound sources associated with the seismic survey. We anticipate temporary behavioral responses (e.g., avoidance, discomfort, loss of foraging opportunities, loss of mating opportunities, masking, alteration of vocalizations, and stress) with some potential for TTS, with individuals returning to normal shortly after the exposure has ended, and thus do not anticipate any delay in reproduction as a result. No reduction in the distribution of sei whales from the Pacific Ocean is expected because of the NSF and L-DEO's seismic survey activities and the Permits Division's issuance of an incidental harassment authorization. No reduction in reproduction is expected because of the proposed actions. Therefore, no reduction in numbers is anticipated due to the proposed actions. Because we do not anticipate a reduction in numbers or reproduction of sei whales as a result of the proposed seismic survey activities and the Permits Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

The 2001 Final Recovery Plan for the sei whale lists recovery objectives for the species. The following recovery objectives are relevant to the impacts of the proposed actions:

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

Because no mortalities or effects on the distribution of sei whales are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the Permits Division's issuance of an incidental harassment authorization will impede the recovery objectives for sei whales. In conclusion, we believe the effects associated with the proposed actions are not expected to cause a reduction in the likelihood of survival and recovery of sei whales in the wild.

12.1.5 Sperm Whale

Adult and juvenile sperm whales are present in the action area and are expected to be exposed to noise from the seismic survey activities.

The sperm whale is the most abundant of the large whale species, with total abundance estimates between 200,000 and 1,500,000. The most recent estimate indicated a global population of between 300,000 and 450,000 individuals (Whitehead 2009). The higher estimates may be approaching population sizes prior to commercial whaling. In the northeast Pacific Ocean, the abundance of sperm whales was estimated to be between 26,300 and 32,100 in 1997. There is insufficient data to evaluate trends in abundance and growth rates of sperm whales at this time.

There are expected to be 13 individuals, adults and juveniles, harassed because of the proposed seismic survey activities. We anticipate temporary behavioral responses (e.g., avoidance, discomfort, loss of foraging opportunities, loss of mating opportunities, masking, alteration of vocalizations, and stress) with some potential for TTS, with individuals returning to normal shortly after the exposure has ended, and thus do not anticipate any delay in reproduction as a result. No reduction in the distribution of sperm whales from the Pacific Ocean is expected because of the NSF and L-DEO's seismic survey activities and the Permits Division's issuance of an incidental harassment authorization. No reduction in reproduction is expected due to the proposed actions. Therefore, no reduction in numbers is anticipated as part of the proposed actions. Because we do not anticipate a reduction in numbers or reproduction of sperm whales as a result of the proposed seismic survey activities and the Permits Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

The 2010 Final Recovery Plan for the sperm whale lists recovery objectives for the species. The following recovery objectives are relevant to the impacts of the proposed actions:

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

Because no mortalities or effects on the distribution of sperm whales are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the Permits Division's issuance of an incidental harassment authorization will impede the recovery objectives for sperm whales. In conclusion, we believe the effects associated with the proposed actions are not expected to cause a reduction in the likelihood of survival and recovery of sperm whales in the wild.

12.1.6 Guadalupe Fur Seal

Adult Guadalupe fur seals are present in the action area and are expected to be exposed to noise from the seismic survey activities.

All Guadalupe fur seals represent a single population, with two known breeding colonies in Mexico, and a purported breeding colony in the United States. When the more recent NMFS stock assessment report for Guadalupe fur seals was published in 2000, the breeding colonies in Mexico were increasing; evidence that is more recent indicates that this trend is continuing (Aurioles-Gamboa et al. 2010; Esperon-Rodriguez and Gallo-Reynoso 2012). After compiling data from counts over 30 years, Gallo calculated that the population of Guadalupe fur seals in Mexico was increasing, with an average annual growth rate of 13.3 percent on Guadalupe Island (Gallo-Reynoso 1994). More recent estimates of the Guadalupe fur seal population of the San Benito Archipelago (from 1997 through 2007) indicates that it is increasing as well at an annual rate of 21.6 percent (Esperon-Rodriguez and Gallo-Reynoso 2012), and that this population is at a phase of exponential increase (Aurioles-Gamboa et al. 2010). The most recent NMFS stock assessment report states that Guadalupe fur seals are increasing at an average rate of 10.3 percent. Direct counts of animals at Isla Guadalupe and Isla San Benito during 2010 resulted in a minimum of 13,327 animals and 2,503 animals respectively, for a minimum population size of 15,380 animals (Carretta et al. 2017).

There are expected to be 448 adults harassed because of the proposed seismic survey activities. We anticipate temporary behavioral responses (e.g., avoidance, discomfort, loss of foraging opportunities, loss of mating opportunities, masking, alteration of vocalizations, and stress) with some potential for TTS, with individuals returning to normal shortly after the exposure has ended, and thus do not anticipate any delay in reproduction as a result. No reduction in the distribution of Guadalupe fur seals from the Pacific Ocean is expected because of the NSF and L-DEO's seismic survey activities and the Permits Division's issuance of an incidental harassment authorization.

No reduction in reproduction is expected because of the proposed actions. Therefore, no reduction in numbers is anticipated due to the proposed actions. Because we do not anticipate a reduction in numbers or reproduction of Guadalupe fur seals as a result of the proposed seismic survey activities and the Permits Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

There has been no Recovery Plan prepared for Guadalupe fur seals.

Because no mortalities or effects on the distribution of Guadalupe fur seals are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the Permits Division's issuance of an incidental harassment authorization will impede the recovery objectives for Guadalupe fur seals. In conclusion, we believe the effects associated with the proposed actions are not expected to cause a reduction in the likelihood of survival and recovery of Guadalupe fur seals in the wild.

12.1.7 Green Turtle—East Pacific Distinct Population Segment

Adult, juvenile, and hatchling green sea turtles from the East Pacific DPS are present in the action area and are expected to be exposed to noise from the seismic survey activities.

There are thirty-nine 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 fifty-eight percent of the nesting females (11,588) for the DPS (Seminoff et al. 2015). There are no estimates of population growth. Monitoring at nesting beaches in Michoacán, Mexico indicates that the population there is increasing. Incidental bycatch in commercial fishing gear, continued harvest, coastal development and beachfront lighting are all continuing threats for the East Pacific DPS.

Individual adult or juvenile green sea turtles within the extent of the ensonified area (18,149.3 km^2) would be harassed because of the proposed seismic survey activities. We anticipate temporary behavioral responses (e.g., avoidance, discomfort, loss of foraging opportunities, and stress), with individuals returning to normal shortly after the exposure has ended, and thus do not anticipate any delay in reproduction as a result. No reduction in numbers is anticipated due to the proposed actions. No reduction in the distribution of green sea turtles from the East Pacific DPS is expected because of the NSF and L-DEO's seismic survey activities and the Permits Division's issuance of an incidental harassment authorization. Because we do not anticipate a reduction in numbers or reproduction of East Pacific DPS of green turtles as a result of the proposed seismic survey activities and the Permits Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

The 1998 recovery plan for Pacific populations of green sea turtles 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. Since we do not expect mortalities or effects on the distribution of East Pacific DPS green sea turtle populations as a result of the proposed actions, we do not anticipate the proposed seismic survey activities, the Permits, and Conservation Division's issuance of an incidental harassment authorization will impede the recovery objectives for East Pacific DPS of green sea turtles. In conclusion, we believe the effects associated with the proposed actions are not expected to cause a reduction in the likelihood of survival and recovery of East Pacific DPS of green sea turtles in the wild.

12.1.8 Hawksbill Sea Turtle

Adult and juvenile hawksbill sea turtles are present in the action area and are expected to be exposed to noise from the seismic survey activities.

Hawksbill sea turtles were once common in the eastern Pacific from Mexico to Ecuador, but due largely to commercial exploitation, now is rare (Gaos et al. 2010). The greatest threats to hawksbill sea turtles are overharvesting of turtles and eggs, degradation of nesting habitat, and fisheries interactions. Adult hawksbills are harvested for their meat and carapace, which is sold as tortoiseshell.

Individual adult or juvenile hawksbill sea turtles within the extent of the ensonified area (18,149.3 km^2) would be harassed because of the proposed seismic survey activities. We anticipate temporary behavioral responses (e.g., avoidance, discomfort, loss of foraging opportunities, and stress), with individuals returning to normal shortly after the exposure has ended. No reduction in the distribution of hawksbill sea turtles is expected because of the NSF and L-DEO's seismic survey activities and the Permits Division's issuance of an incidental harassment authorization. We do not anticipate any delay in or reduction in reproduction as a result of the proposed actions. Therefore, we do not anticipate a reduction in numbers of hawksbill sea turtles as a result of the proposed seismic survey activities and the Permits Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

In the 1998 Recovery Plan for U.S. Pacific populations of hawksbill sea turtles, NMFS identified the following items as top recovery actions to support species' recovery:

- Identify important nesting beaches.
- Ensure long-term protection and management of important nesting beaches.
- Protect and manage nesting habitat; prevent the degradation of nesting habitat caused by seawalls, revetments, sand bags, other erosion-control measures, jetties and breakwaters.
- Identify important marine habitats; protect and manage populations in marine habitat.
- Protect and manage marine habitat; prevent the degradation or destruction of important [marine] habitats caused by upland and coastal erosion.

- Prevent the degradation of reef habitat caused by sewage and other pollutants.
- Monitor nesting activity on important nesting beaches with standardized index surveys.
- Evaluate nest success and implement appropriate nest-protection on important nesting beaches.
- Ensure that law-enforcement activities prevent the illegal exploitation and harassment of sea turtles and increase law-enforcement efforts to reduce illegal exploitation.
- Determine nesting beach origins for juvenile and sub adult populations.

However, since we do not expect mortalities or effects on the distribution of hawksbill sea turtle populations as a result of the proposed actions, we do not anticipate the proposed seismic survey activities, the Permits, and Conservation Division's issuance of an incidental harassment authorization will impede the recovery objectives for hawksbill sea turtles. In conclusion, we believe the effects associated with the proposed actions are not expected to cause a reduction in the likelihood of survival and recovery of hawksbill sea turtles in the wild.

12.1.9 Leatherback Sea Turtle

Adult, juvenile, and hatchling leatherback sea turtles are present in the action area and are expected to be exposed to noise from the seismic survey activities.

Leatherback turtle populations in the Pacific Ocean are low. Overall populations in the Pacific Ocean have declined from an estimated 81,000 individuals to less than 3,000 total adults and sub adults (Spotila et al. 2000). In the eastern Pacific, there are an estimated 755 nesting females, with 572 nesting in Mexico. Due to intense harvesting, and bycatch in pelagic fisheries, leatherback abundance in the action area has declined precipitously (Martínez et al. 2007; NMFS 2020c); the population remains at risk due to these ongoing threats.

Individual adult, juvenile, and hatchling leatherback sea turtles within the extent of the ensonified area (18,149.3 km^2) would be harassed because of the proposed seismic survey activities. We anticipate temporary behavioral responses (e.g., avoidance, discomfort, loss of foraging opportunities, and stress), with individuals returning to normal shortly after the exposure has ended. No reduction in the distribution of leatherback turtles from the Pacific Ocean is expected because of the NSF and L-DEO's seismic survey activities and the Permits Division's issuance of an incidental harassment authorization. We do not anticipate any delay in reproduction as a result of the proposed actions. No reduction in numbers is anticipated due to the proposed actions. Therefore, no reduction in reproduction is expected because of the proposed actions. Because we do not anticipate a reduction in the numbers or reproduction of leatherback turtles as a result of the proposed seismic survey activities and the Permits Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

The Pacific Recovery Plan for the population of leatherback turtles lists recovery objectives for the species. The following recovery objective is relevant to the impacts of the proposed action:

- Monitoring and research.

Because no mortalities or effects on the distribution of leatherback turtle populations are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the Permits Division's issuance of an incidental harassment authorization will impede the recovery objectives for leatherback turtles. In conclusion, we believe the effects associated with the proposed actions are not expected to cause a reduction in the likelihood of survival and recovery of leatherback turtles in the wild.

12.1.10 Loggerhead Turtle—North Pacific Ocean Distinct Population Segment

Adult and juvenile loggerhead sea turtles from the North Pacific Ocean DPS are present in the action area and are expected to be exposed to noise from the seismic survey activities.

Overall, Gilman (2009) estimated that the number of loggerheads nesting in the Pacific has declined by eighty percent in the past twenty years. Neritic juveniles and adults in this 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 an ongoing threat to nesting females.

Individual adult or juvenile loggerhead sea turtles within the extent of the ensonified area (18,149.3 km^2) would be harassed because of the proposed seismic survey activities. We anticipate temporary behavioral responses (e.g., avoidance, discomfort, loss of foraging opportunities, and stress), with individuals returning to normal shortly after the exposure has ended. No reduction in the distribution of loggerhead sea turtles from the North Pacific Ocean DPS is expected because of the NSF and L-DEO's seismic survey activities and the Permits Division's issuance of an incidental harassment authorization. We do not anticipate any delay in reproduction as a result of the proposed actions. Therefore, no reduction in numbers is anticipated due to the proposed actions. Because we do not anticipate a reduction in numbers or reproduction of North Pacific Ocean DPS of loggerhead turtles as a result of the proposed seismic survey activities and the Permits Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

NMFS has not prepared a Recovery Plan for the North Pacific Ocean DPS of loggerhead turtle. However, since we do not expect mortalities or effects on the distribution of North Pacific Ocean DPS loggerhead turtle populations as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the Permits Division's issuance of an incidental harassment authorization will impede the recovery objectives for North Pacific Ocean DPS of loggerhead turtles. In conclusion, we believe the effects associated with the proposed actions are not expected to cause a reduction in the likelihood of survival and recovery of North Pacific Ocean DPS of loggerhead turtles in the wild.

12.1.11 Olive Ridley Sea Turtle—Mexico's Breeding Population

Adult, juvenile, and hatchling olive ridley sea turtles are present in the action area and are expected to be exposed to noise from the seismic survey activities.

The olive ridley was listed under the ESA on July 28, 1978. 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).

In the first half of the twentieth century, there were an estimated ten million olive ridleys nesting on the Pacific coast of Mexico. Olive ridleys became targeted in a fishery in Mexico and Ecuador, which severely depleted the population. By 1969, there were an estimated one million olive ridleys. Ongoing threats to this population include incidental capture in fisheries, exposure to pollutants and climate change. Despite severe population declines, the olive ridley breeding populations on the Pacific coast of Mexico appear to be resilient, as evidenced by the increasing population. There are six primary arribada nesting beaches in Mexico, the largest being La Escobilla, with an increasing abundance trend and an estimated one million nesting females annually (NMFS and USFWS 2014b). At-sea estimates of olive ridleys off of Mexico and Central America also support an increasing population trend.

Individual adult, juvenile, or hatchling olive ridley sea turtles within the extent of the ensonified area (18,149.3 km^2) would be harassed because of the proposed seismic survey activities. We anticipate temporary behavioral responses (e.g., avoidance, discomfort, loss of foraging opportunities, and stress), with individuals returning to normal shortly after the exposure has ended. No reduction in the distribution of olive ridley sea turtles from the Mexico Pacific breeding population is expected because of the NSF and L-DEO's seismic survey activities and the Permits Division's issuance of an incidental harassment authorization. We do not anticipate any delay in reproduction as a result of the proposed action. Therefore, no reduction in reproduction is expected because of the proposed actions. No reduction in numbers is anticipated due to the proposed actions. Because we do not anticipate a reduction in the numbers or reproduction of olive ridley sea turtles as a result of the proposed seismic survey activities and the Permits Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

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.

Because no mortalities or effects on the distribution of olive ridley sea turtle Mexico Pacific populations are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the Permits Division's issuance of an incidental harassment authorization will impede the recovery objectives for olive ridley sea turtles. In conclusion, we believe the effects associated with the proposed actions are not expected to cause a reduction in the likelihood of survival and recovery of olive ridley sea turtles of the Mexico Pacific breeding population in the wild.

13 CONCLUSION

After reviewing the current status of the ESA-listed species, the environmental baseline within the action area, the effects of the proposed action, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of: blue whale, fin whale, humpback whale (Central America DPS), sei whale, sperm whale, Guadalupe fur seal, leatherback sea turtle, green sea turtle (East Pacific DPS), hawksbill sea turtle, olive ridley sea turtle (Mexico's Pacific Coast Breeding Colonies), and loggerhead sea turtle (North Pacific Ocean DPS).

It is also NMFS' biological opinion that the action is not likely to adversely affect the following ESA-listed species: humpback whale (Mexico DPS); giant manta ray, oceanic whitetip shark, and scalloped hammerhead shark (Eastern Pacific DPS).

14 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. Harm is further defined by regulation to include significant habitat modification or degradation that results in death or injury to ESA-listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering.

Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this incidental take statement. NMFS has not yet defined "harass" under the ESA in regulation. On December 21, 2016, NMFS issued interim guidance on the term "harass," defining it as to "create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering," For purposes of this consultation, we relied on NMFS' interim definition of harassment to evaluate when the proposed seismic survey activities are likely to harass ESA-listed marine mammals (cetaceans and pinnipeds).

ESA section 7(b)(4) states that take of ESA-listed cetaceans and pinnipeds must be authorized under MMPA section 101(a)(5) before the Secretary can issue an incidental take statement for ESA-listed marine mammals. NMFS' implementing regulations for MMPA section 101(a)(5)(D) specify that an incidental harassment authorization is required to conduct activities pursuant to any incidental take authorization for a specific activity that will "take" marine mammals. Once NMFS has authorized the incidental take of marine mammals under an incidental harassment authorization for the tentative period of May 1, 2022, through May 1, 2023 (valid for a period of one year from the date of issuance), under the MMPA, the incidental take of ESA-listed marine mammals is exempt from the ESA take prohibitions as stated in this incidental take statement pursuant to section 7(b)(4) and 7(o)(2).

14.1 Amount or Extent of Take

Section 7 regulations require NMFS to specify the impact of any incidental take of endangered or threatened species; that is, the amount or extent of such incidental taking on the species (50 C.F.R. §402.14(i)(1)(i)). The amount of take represents the number of individuals that are expected to be taken by actions while the extent of take specifies the impact, i.e., the amount or extent of such incidental taking on the species, which may be used if we cannot assign numerical limits for animals that could be incidentally taken during the course of an action (see 80 FR 26832).

If the amount or location of tracklines during the seismic survey changes, or the number of seismic survey days is increased, then incidental take for marine mammals and sea turtles may be exceeded. As such, if more tracklines are conducted during the seismic survey, an increase in the number of days beyond the 25 percent contingency, greater estimates of sound propagation, and/or increases in airgun array source levels occur, reinitiation of consultation will be necessary.

14.1.1 Marine Mammals

We anticipate the proposed seismic survey is likely to result in the incidental take of ESA-listed marine mammals by harassment. Behavioral harassment is expected to occur at received levels at or above 160 dB re: 1 μPa (rms) for airgun array operations for ESA-listed marine mammals. For all species of ESA-listed marine mammals, this incidental take will result from exposure to acoustic energy during airgun array operations and will be in the form of ESA harassment, and is not expected to result in the death or injury of any individuals that will be exposed.

Specifically, we anticipate the take of marine mammals in the action area as detailed in Table 10 below. The numbers presented here represent the individuals expected to be exposed in the non-territorial waters of the action (i.e., these numbers exclude the number of exposed marine mammals that would occur in the territorial seas of Mexico).

Table 10. Estimated amount of incidental take of Endangered Species Act-listed marine mammals authorized in the Eastern Tropical Pacific Ocean by the incidental take statement.

Species	Authorized Incidental Take by Harassment (Potential Temporary Threshold Shift and Behavioral)
Blue Whale	5
Fin Whale	2
Humpback Whale – Central America DPS	8

Sei Whale	3
Sperm Whale	12
Guadalupe Fur Seal	416

DPS=Distinct Population Segment

14.1.2 Sea Turtles

We anticipate noise from seismic survey activities is reasonably likely to result in the incidental take of ESA-listed leatherback sea 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 (50 CFR 402. §14(i)(1)(i)) as long as the surrogate describes the causal link between the surrogate and the take of listed species; explains why it is not practicable to express the amount or extent of anticipated take or to monitor take-related impacts in terms of individuals of listed species, and sets a clear standard for determining when the level of take has been exceeded. These three criteria are met by the surrogate described below. Because there are no reliable estimates of olive ridley, leatherback, hawksbill, green (East Pacific DPS), or loggerhead (North Pacific Ocean DPS) sea turtle population densities in the action area, it is not practical to develop numerical estimates of olive ridley, leatherback, hawksbill, green, or loggerhead sea turtle exposure or to monitor take-related impacts to individuals of these listed turtle 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 and DPSs. 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 in the non-territorial seas of the action area (17,252.8 km^2). A leatherback, olive ridley, hawksbill, green, or loggerhead 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 water depth (intermediate or deep water), and the vessel speed during acquisition, a sea turtle could be exposed for up to 20 minutes (intermediate depth), or 13 minutes (in deep water). This explanation demonstrates the causal link between the surrogate and the take of listed sea turtle species.

If the amount or location of trackline surveyed changes, or the number of seismic survey days is increased, then incidental take for leatherback, olive ridley, hawksbill, green (East Pacific DPS), or loggerhead sea turtle (North Pacific Ocean DPS) may be exceeded. As such, if more tracklines are surveyed, there is an increase in the number of survey days beyond 24 days (20 days of seismic activity, plus the 25 percent contingency, or 5 days), there are greater estimates of sound propagation, and/or increases in source levels from the airgun array occur, reinitiation of consultation will be necessary. The surrogate therefore sets a clear standard for determining when the level of take has been exceeded

14.2 Reasonable and Prudent Measures

The measures described below are nondiscretionary, and must be undertaken by the NSF and the Permits Division so that they become binding conditions for the exemption in section 7(o)(2) to apply. Section 7(b)(4) of the ESA requires that when a proposed agency action is found to be consistent with section 7(a)(2) of the ESA and the proposed action may incidentally take individuals of ESA-listed species, NMFS will issue a statement that specifies the impact of any incidental taking of endangered or threatened species. To minimize such impacts, reasonable and prudent measures, and terms and conditions to implement the measures, must be provided. Where incidental take of listed marine mammals is reasonably certain to occur, the ITS must also specify those measures that are necessary to comply with section 101(a)(5) of the Marine Mammal Protection Act of 1972 and applicable regulations with regard to such taking. Only incidental take resulting from the agency actions and any specified reasonable and prudent measures, and terms and conditions identified in the incidental take statement are exempt from the taking prohibition of section 9(a), pursuant to section 7(o) of the ESA.

The minimization measures discussed in Section 3 were included as part of the proposed action, will be implemented by the action agencies and were thus not restated as reasonable and prudent measures and terms and conditions. However, to the extent that measures overlap with IHA requirements (Appendix A, Section 17), those requirements are included in the ITS pursuant to 50 CFR 402.14(i)(iii).

Reasonable and prudent measures are nondiscretionary measures to minimize the amount or extent of incidental take (50 C.F.R. §402.02). The reasonable and prudent measures apply to the high seas (i.e., the waters outside the territorial seas of Mexico). NMFS believes the reasonable and prudent measures described below are necessary and appropriate to minimize the impacts of incidental take on the ESA-listed marine mammals and sea turtles discussed in detail in this opinion:

1. The NMFS Permits Division must ensure that the NSF and L-DEO implement a program to mitigate, monitor, and report the potential effects of seismic survey activities as well as the effectiveness of mitigation measures incorporated as part of the proposed incidental harassment authorization for the incidental taking of blue, fin, Central America DPS of humpback, sei, and sperm whales and Guadalupe fur seals pursuant to section

101(a)(5)(D) of the MMPA, and as outlined in the final IHA (Appendix A, Section 17). In addition, the NMFS Permits Division must ensure that the provisions of the incidental harassment authorization are carried out, and to inform the NMFS ESA Interagency Cooperation Division if take is exceeded.

2. NSF and L-DEO must comply with the measures of the final IHA, if issued, as outlined in Appendix A, Section 17.
3. The NSF and the L-DEO must implement a program to mitigate and report the potential effects of seismic survey activities as well as the effectiveness of mitigation measures for endangered and threatened sea turtles.

14.3 Terms and Conditions

To be exempt from the prohibitions of section 9 of the ESA and regulations issued pursuant to section 4(d), the NSF, L-DEO and Permits Division must comply with the following terms and conditions, which implement the RPMs described above. These include the take minimization, monitoring and reporting measures required by the section 7 regulations (50 C.F.R. §402.14(i)). If the NSF, L-DEO and Permits Division fail to ensure compliance with these terms and conditions to implement the RPMs applicable to the authorities of the agencies, the protective coverage of section 7(o)(2) may lapse.

The terms and conditions detailed below for each of the RPMs include monitoring and minimization measures where needed:

1. A copy of the draft comprehensive report on all seismic survey activities and monitoring results must be provided to the ESA Interagency Cooperation Division within 90 days of the completion of the seismic survey, or expiration of the incidental harassment authorization, whichever comes sooner.
    a. The report must contain the elements required in the IHA for reporting the effects on marine mammals (Appendix A, Section 17).
    b. For sea turtles, the report must detail the species taken, number of species taken, the time and date of 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 L-DEO and NSF to the ESA Interagency Cooperation Division within 24 hours to Cathy Tortorici, Chief, ESA Interagency Cooperation Division by e-mail at cathy.tortorici@noaa.gov.

15 CONSERVATION RECOMMENDATION

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on ESA-listed species or critical habitat, to help implement recovery plans or develop information (50 C.F.R. §402.02).

We recommend the following discretionary conservation recommendations that we believe are consistent with this obligation and therefore may be considered by NSF and the Permits Division in relation to their 7(a)(1) responsibilities. These recommendations will provide information for future consultations involving seismic surveys and the issuance of IHAs that may affect ESA-listed species:

1. We recommend that the NSF promote and fund research examining the potential effects of seismic surveys on ESA-listed sea turtle and fish species.
2. We recommend that the NSF 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 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.
4. 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.
5. We recommend the NSF use (and Permits Division require in MMPA incidental take authorizations) thermal imaging cameras, in addition to 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.
6. We recommend the NSF 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.
7. We recommend the NSF and 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.
8. 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).
9. We recommend the NSF use real-time cetacean sighting services such as the WhaleAlert application (http://www.whalealert.org/). We recognize that the research vessel may not have reliable internet access during operations far offshore, but nearshore, where many of the cetaceans considered in this opinion are likely found in greater numbers, 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 cetacean sightings, and may also be valuable during other activities to alert others of ESA-listed cetaceans within the area, which they can then avoid.

10. We recommend the NSF 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.
11. We recommend the vessel operator and other relevant vessel personnel (e.g., crewmembers) on the R/V *Marcus G. 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 ESA Interagency Cooperation Division to be kept informed of actions minimizing or avoiding adverse effects on, or benefiting, ESA-listed species or their critical habitat, the Permits Division should notify the ESA Interagency Cooperation Division of any conservation recommendations they implement in their final action.

16 REINITIATION NOTICE

This concludes formal consultation for the NSF and L-DEO's proposed high-energy marine seismic survey by the R/V *Marcus G. Langseth* in the Eastern Tropical Pacific Ocean and Permits Division's issuance of an incidental harassment authorization for the proposed high-energy marine seismic survey pursuant to section 101(a)(5)(D) of the MMPA. Consistent with 50 C.F.R. §402.16, reinitiation of formal consultation is required and shall be requested by the Federal agency or by the Service, where discretionary Federal agency involvement or control over the action has been retained or is authorized by law and:

1. The amount or extent of taking specified in the incidental take statement is exceeded.
2. New information reveals effects of the agency action that may affect ESA-listed species or critical habitat in a manner or to an extent not previously considered.
3. The identified action is subsequently modified in a manner that causes an effect to ESA-listed species or designated critical habitat that was not considered in this opinion.
4. A new species is listed or critical habitat designated under the ESA that may be affected by the action.

If the amount of tracklines, location of tracklines, acoustic characteristics of the airgun arrays, timing of the survey, or any other aspect of the proposed action changes in such a way that the incidental take of ESA-listed species can be greater than estimated in the incidental take statement of this opinion, then one or more of the reinitiation triggers above may be met and reinitiation of consultation may be necessary.

17 APPENDIX A: DRAFT FINAL INCIDENTAL HARASSMENT AUTHORIZATION

INCIDENTAL HARASSMENT AUTHORIZATION

The Lamont-Doherty Earth Observatory of Columbia University (L-DEO) is hereby authorized under section 101(a)(5)(D) of the Marine Mammal Protection Act (MMPA; 16 U.S.C. 1371(a)(5)(D)) to incidentally harass marine mammals, under the following conditions.

1. This Incidental Harassment Authorization (IHA) is valid for one year from the date of issuance.
2. This IHA authorizes take incidental to geophysical survey activity in the Eastern Tropical Pacific, as specified in L-DEO’s IHA application.
3. General Conditions
   (a) A copy of this IHA must be in the possession of L-DEO, the vessel operator, the lead protected species observer (PSO) and any other relevant designees of L-DEO operating under the authority of this IHA.
   (b) The species authorized for taking are listed in Table 1. The taking, by Level A and Level B harassment only, is limited to the species and numbers listed in Table 1.
   (c) The taking by serious injury or death of any of the species listed in Table 1 or any taking of any other species of marine mammal is prohibited and may result in the modification, suspension, or revocation of this IHA. Any taking exceeding the authorized amounts listed in Table 1 is prohibited and may result in the modification, suspension, or revocation of this IHA.
   (d) During use of the acoustic source, if any marine mammal species that are not listed in Table 1, or a species for which authorization has been granted but the takes have been met, appears within or enters the Level B harassment zone (Table 2) the acoustic source must be shut down.
   (e) L-DEO must ensure that relevant vessel personnel and PSO team participate in a joint onboard briefing led by the vessel operator and lead PSO to ensure that responsibilities, communication procedures, protected species monitoring protocols, operational procedures, and IHA requirements are clearly understood.
4. Mitigation Requirements

L-DEO must limit their surveys of nearshore tracklines to between May 1 and October 31. In this authorization, "nearshore" tracklines are defined as those tracklines planned to occur in, or where the associated estimated Level B harassment zone (see Table 2) would overlap with, waters within 33.4 kilometers of shore. This definition includes the long multi-channel and ocean bottom seismometer trackline running parallel to shore off Guerrero, as well as all connector lines and portions of tracklines landward of that trackline (see Figure 1).

(a) L-DEO must use independent, dedicated, trained visual and acoustic PSOs, meaning that the PSOs must be employed by a third-party observer provider, must not have tasks other than to conduct observational effort, collect data, and communicate with and instruct relevant vessel crew with regard to the presence of protected species and mitigation requirements (including brief alerts regarding maritime hazards), and must have successfully completed an approved PSO training course appropriate for their designated task (visual or acoustic). Individual PSOs may perform acoustic and visual PSO duties (though not at the same time).

(b) At least one visual and two acoustic PSOs must have a minimum of 90 days at- sea experience working in those roles, respectively, during a deep penetration seismic survey, with no more than 18 months elapsed since the conclusion of the at-sea experience.

(c) Visual Observation

  (i) During survey operations (e.g., any day on which use of the acoustic source is planned to occur, and whenever the acoustic source is in the water, whether activated or not), a minimum of two PSOs must be on duty and conducting visual observations at all times during daylight hours (i.e., from 30 minutes prior to sunrise through 30 minutes following sunset) and 30 minutes prior to and during ramp-up of the airgun array. Visual monitoring of the exclusion and buffer zones must begin no less than 30 minutes prior to ramp-up and must continue until one hour after use of the acoustic source ceases or until 30 minutes past sunset.

(ii) Visual PSOs must coordinate to ensure 360° visual coverage around the vessel from the most appropriate observation posts, and must conduct visual observations using binoculars and the naked eye while free from distractions and in a consistent, systematic, and diligent manner. Estimated harassment zones are provided in Table 2 for reference.

(iii) Visual PSOs must immediately communicate all observations to the acoustic PSO(s) on duty, including any determination by the PSO regarding species identification, distance, and bearing and the degree of confidence in the determination.

(iv) During good conditions (e.g., daylight hours; Beaufort sea state (BSS) 3 or less), visual PSOs must conduct observations when the acoustic source is not operating for comparison of sighting rates and behavior with and without use of the acoustic source and between acquisition periods, to the maximum extent practicable.

(v) Visual PSOs may be on watch for a maximum of four consecutive hours followed by a break of at least one hour between watches and may conduct a maximum of 12 hours of observation per 24-hour period. Combined observational duties (visual and acoustic but not at same time) may not exceed 12 hours per 24-hour period for any individual PSO.

(d) Acoustic Monitoring

(i) The source vessel must use a towed passive acoustic monitoring system (PAM) which must be monitored by, at a minimum, one on-duty acoustic PSO beginning at least 30 minutes prior to ramp-up and at all times during use of the acoustic source.

(ii) When both visual and acoustic PSOs are on duty, all detections must be immediately communicated to the remainder of the on-duty PSO team for potential verification of visual observations by the acoustic PSO or of acoustic detections by visual PSOs.

(iii) Acoustic PSOs may be on watch for a maximum of four consecutive hours followed by a break of at least one hour between watches and may conduct a maximum of 12 hours of observation per 24-hour period. Combined observational duties may not exceed 12 hours per 24-hour period for any individual PSO.

(iv) Survey activity may continue for 30 minutes when the PAM system malfunctions or is damaged, while the PAM operator diagnoses the issue. If the diagnosis indicates that the PAM system must be repaired to solve the problem, operations may continue for an additional five hours without acoustic monitoring during daylight hours only under the following conditions:

a. Sea state is less than or equal to BSS 4;

b. With the exception of delphinids, no marine mammals detected solely by PAM in the applicable exclusion zone in the previous two hours;

c. NMFS is notified via email as soon as practicable with the time and location in which operations began occurring without an active PAM system; and

d. Operations with an active acoustic source, but without an operating PAM system, do not exceed a cumulative total of five hours in any 24-hour period.

(e) Exclusion zone and buffer zone

(i) Except as provided below in 4(e)(ii), the PSOs must establish and monitor a 500-m exclusion zone and additional 500-m buffer zone (total 1,000 m). The 1,000-m zone shall serve to focus observational effort but not limit such effort; observations of marine mammals beyond this distance shall also be recorded as described in 5(d) below and/or trigger shutdown as described in 4(g)(iv) below, as appropriate. The exclusion zone encompasses the area at and below the sea surface out to a radius of 500 m from the edges of the airgun array (rather than being based on the center of the array or around the vessel itself) (0–500 m). The buffer zone encompasses the area at and below the sea surface from the edge of the exclusion zone, out to a radius of 1,000 meters from the edges of the airgun array (500–1,000 m). During use of the acoustic source, occurrence of marine mammals within the buffer zone (but outside the exclusion zone) must be communicated to the operator to prepare for the potential shutdown of the acoustic source. PSOs must monitor the exclusion zone and buffer zone for a minimum of 30 minutes prior to ramp-up (i.e., pre- start clearance).

(ii) An extended 1,500-m exclusion zone must be established for all beaked whales and *Kogia* species. No buffer zone is required.

(f) Pre-start clearance and Ramp-up

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

(ii) Ramp-up must not be initiated if any marine mammal is within the exclusion or buffer zone. If a marine mammal is observed within the exclusion zone or the buffer zone during the 30 minute pre-start clearance period, ramp-up may not begin until the animal(s) has been observed exiting the zone or until an additional time period has elapsed with no further sightings (15 minutes for small odontocetes and pinnipeds, and 30 minutes for mysticetes and all other odontocetes, including sperm whales, beaked whales, *Kogia* species, killer whales, and Risso's dolphins).

(iii) Ramp-up must begin by activating a single airgun of the smallest volume in the array and must continue in stages by doubling the number of active elements at the commencement of each stage, with each stage of approximately the same duration. Duration must not be less than 20 minutes.

(iv) PSOs must monitor the exclusion and buffer zones during ramp-up, and ramp-up must cease and the source must be shut down upon visual observation or acoustic detection of a marine mammal within the exclusion zone. Once ramp-up has begun, observations of marine mammals within the buffer zone do not require shutdown, but such observation must be communicated to the operator to prepare for the potential shutdown.

(v) Ramp-up may occur at times of poor visibility, including nighttime, if appropriate acoustic monitoring has occurred with no detections in the 30 minutes prior to beginning ramp-up.

(vi) If the acoustic source is shut down for brief periods (i.e., less than 30 minutes) for reasons other than that described for shutdown (e.g., mechanical difficulty), it may be activated again without ramp-up if PSOs have maintained constant visual and/or acoustic observation and no visual or acoustic detections of marine mammals have occurred within the applicable exclusion zone. For any longer shutdown, pre-start clearance observation and ramp-up are required. For any shutdown at night or in periods of poor visibility (e.g., BSS 4 or greater), ramp-up is required, but if the shutdown period was brief and constant observation was maintained, pre-start clearance watch is not required.

(vii) Testing of the acoustic source involving all elements requires ramp-up. Testing limited to individual source elements or strings does not require ramp-up but does require pre-start clearance watch.

(g) Shutdown

(i) Any PSO on duty has the authority to delay the start of survey operations or to call for shutdown of the acoustic source.

(ii) The operator must establish and maintain clear lines of communication directly between PSOs on duty and crew controlling the acoustic source to ensure that shutdown commands are conveyed swiftly while allowing PSOs to maintain watch.

(iii) When the airgun array is active (i.e., anytime one or more airguns is active, including during ramp-up) and (1) a marine mammal (excluding delphinids of the species described in 4(g)(v)) appears within or enters the exclusion zone and/or (2) a marine mammal is detected acoustically and localized within the exclusion zone, the acoustic source must be shut down. When shutdown is called for by a PSO, the airgun array must be immediately deactivated. Any dispute regarding a PSO shutdown must be resolved after deactivation.

(iv) The airgun array must be shut down if any of the following are detected at any distance:

1. Large whale (defined as a sperm whale or any mysticete species) with a calf (defined as an animal less than two-thirds the body size of an adult observed to be in close association with an adult).
2. Aggregation of six or more large whales.

(v) The shutdown requirement shall be waived for dolphins of the following genera: *Delphinus, Lagenodelphis, Lissodelphis, Stenella, Steno, and Tursiops.*

a. If a dolphin of these genera is visually and/or acoustically detected and localized within the exclusion zone, no shutdown is required unless the acoustic PSO or a visual PSO confirms the individual to be of a species other than those listed above, in which case a shutdown is required.

b. If there is uncertainty regarding identification, visual PSOs may use best professional judgment in making the decision to call for a shutdown.

(vi) Upon implementation of shutdown, the source may be reactivated after the marine mammal(s) has been observed exiting the applicable exclusion zone (i.e., animal is not required to fully exit the buffer zone where applicable) or following a clearance period (15 minutes for small odontocetes and pinnipeds, and 30 minutes for mysticetes and all other odontocetes, including sperm whales, beaked whales, *Kogia* species, killer whales, and Risso's dolphins) with no further observation of the marine mammal(s).

(h) Vessel strike avoidance:

(i) Vessel operator and crew must maintain a vigilant watch for all marine mammals and slow down, stop their vessel, or alter course, as appropriate and regardless of vessel size, to avoid striking any marine mammals. A visual observer aboard the vessel must monitor a vessel strike avoidance zone around the vessel (distances stated below). Visual observers monitoring the vessel strike avoidance zone may be third-party observers (i.e., PSOs) or crew members, but crew members responsible for these duties must be provided sufficient training to 1) distinguish marine mammals from other phenomena and 2) broadly to identify a marine mammal as a right whale, other whale (defined in this context as sperm whales or baleen whales other than right whales), or other marine mammal.

(ii) Vessel speeds must be reduced to 10 knots or less when mother/calf pairs, pods, or large assemblages of cetaceans are observed near a vessel.

        (iii) The vessel must maintain a minimum separation distance of 100 m from sperm whales and all other 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 shall take action as necessary to avoid violating the relevant separation distance (e.g., attempt to remain parallel to the animal's course, avoid excessive speed or abrupt changes in direction until the animal has left the area). If marine mammals are sighted within the relevant separation distance, the vessel must reduce speed and shift the engine to neutral, not engaging the engines until animals are clear of the area. This does not apply to any vessel towing gear or any vessel that is navigationally constrained.
        (vi) These requirements do not apply in any case where compliance would create an imminent and serious threat to a person or vessel or to the extent that a vessel is restricted in its ability to maneuver and, because of the restriction, cannot comply.

5. Monitoring Requirements
    (a) The operator must provide PSOs with bigeye binoculars (e.g., 25 x 150; 2.7 view angle; individual ocular focus; height control) of appropriate quality solely for PSO use. These must be pedestal-mounted on the deck at the most appropriate vantage point that provides for optimal sea surface observation, PSO safety, and safe operation of the vessel.
    (b) The operator must work with the selected third-party observer provider to ensure PSOs have all equipment (including backup equipment) needed to adequately perform necessary tasks, including accurate determination of distance and bearing to observed marine mammals. Such equipment, at a minimum, must include:
        (i) PAM must include a system that has been verified and tested by an experienced acoustic PSO that will be using it during the trip for which monitoring is required.
        (ii) Reticle binoculars (e.g., 7 x 50) of appropriate quality (at least one per PSO, plus backups).
        (iii) Global Positioning Unit (GPS) (plus backup).

  - (iv) Digital single-lens reflex cameras of appropriate quality that capture photographs and video (plus backup).
  - (v) Compass (plus backup).
  - (vi) Radios for communication among vessel crew and PSOs (at least one per PSO, plus backups).
  - (vii) Any other tools necessary to adequately perform necessary PSO tasks.
- (c) Protected Species Observers (PSOs, Visual and Acoustic) Qualifications
  - (i) PSOs must have successfully completed an acceptable PSO training course appropriate for their designated task (visual or acoustic). Acoustic PSOs are required to complete specialized training for operating PAM systems and are encouraged to have familiarity with the vessel with which they will be working.
  - (ii) NMFS must review and approve PSO resumes.
  - (iii) NMFS shall have one week to approve PSOs from the time that the necessary information is submitted, after which PSOs meeting the minimum requirements shall automatically be considered approved.
  - (iv) One visual PSO with experience as shown in 4(b) shall be designated as the lead for the entire protected species observation team. The lead must coordinate duty schedules and roles for the PSO team and serve as primary point of contact for the vessel operator. (Note that the responsibility of coordinating duty schedules and roles may instead be assigned to a shore-based, third-party monitoring coordinator.) To the maximum extent practicable, the duty schedule must be devised such that experienced PSOs are on duty with those PSOs with appropriate training but who have not yet gained relevant experience.
  - (v) PSOs must successfully complete relevant training, including completion of all required coursework and passing (80 percent or greater) a written and/or oral examination developed for the training program.
  - (vi) PSOs must have successfully attained a bachelor’s degree from an accredited college or university with a major in one of the natural sciences, a minimum of 30 semester hours or equivalent in the biological sciences, and at least one undergraduate course in math or statistics.
  - (vii) The educational requirements may be waived if the PSO has acquired the relevant skills through alternate experience. Requests for such a waiver must be submitted to NMFS and must include written justification.

Requests must be granted or denied (with justification) by NMFS within one week of receipt of submitted information. Alternate experience that may be considered includes, but is not limited to (1) secondary education and/or experience comparable to PSO duties; (2) previous work experience conducting academic, commercial, or government-sponsored protected species surveys; or (3) previous work experience as a PSO; the PSO should demonstrate good standing and consistently good performance of PSO duties.

(d) Data Collection

(i) PSOs must use standardized data collection forms, whether hard copy or electronic. PSOs must record detailed information about any implementation of mitigation requirements, including the distance of animals to the acoustic source and description of specific actions that ensued, the behavior of the animal(s), any observed changes in behavior before and after implementation of mitigation, and if shutdown was implemented, the length of time before any subsequent ramp-up of the acoustic source. If required mitigation was not implemented, PSOs should record a description of the circumstances.

(ii) At a minimum, the following information must be recorded:

a. Vessel name and call sign;
b. PSO names and affiliations;
c. Date and participants of PSO briefings (as discussed in General Requirement);
d. Dates of departures and returns to port with port name;
e. Dates and times (Greenwich Mean Time) of survey effort and times corresponding with PSO effort;
f. Vessel location (latitude/longitude) when survey effort began and ended and vessel location at beginning and end of visual PSO duty shifts;
g. Vessel heading and speed at beginning and end of visual PSO duty shifts and upon any line change;
h. Environmental conditions while on visual survey (at beginning and end of PSO shift and whenever conditions changed significantly), including BSS and any other relevant weather conditions including cloud cover, fog, sun glare, and overall visibility to the horizon;

  - i. Factors that may have contributed to impaired observations during each PSO shift change or as needed as environmental conditions changed (e.g., vessel traffic, equipment malfunctions); and
  - j. Survey activity information, such as acoustic source power output while in operation, number and volume of airguns operating in the array, tow depth of the array, and any other notes of significance (i.e., pre-start clearance, ramp-up, shutdown, testing, shooting, ramp-up completion, end of operations, streamers, etc.).

- (iii) Upon visual observation of any marine mammal, the following information must be recorded:
  - a. Watch status (sighting made by PSO on/off effort, opportunistic, crew, alternate vessel/platform);
  - b. PSO who sighted the animal;
  - c. Time of sighting;
  - d. Vessel location at time of sighting;
  - e. Water depth;
  - f. Direction of vessel's travel (compass direction);
  - g. Direction of animal's travel relative to the vessel;
  - h. Pace of the animal;
  - i. Estimated distance to the animal and its heading relative to vessel at initial sighting;
  - j. Identification of the animal (e.g., genus/species, lowest possible taxonomic level, or unidentified) and the composition of the group if there is a mix of species;
  - k. Estimated number of animals (high/low/best);
  - l. Estimated number of animals by cohort (adults, yearlings, juveniles, calves, group composition, etc.);
  - m. Description (as many distinguishing features as possible of each individual seen, including length, shape, color, pattern, scars or

markings, shape and size of dorsal fin, shape of head, and blow characteristics);

n. Detailed behavior observations (e.g., number of blows/breaths, number of surfaces, breaching, spyhopping, diving, feeding, traveling; as explicit and detailed as possible; note any observed changes in behavior);
o. Animal's closest point of approach (CPA) and/or closest distance from any element of the acoustic source;
p. Platform activity at time of sighting (e.g., deploying, recovering, testing, shooting, data acquisition, other); and
q. Description of any actions implemented in response to the sighting (e.g., delays, shutdown, ramp-up) and time and location of the action.

(iv) If a marine mammal is detected while using the PAM system, the following information must be recorded:
a. An acoustic encounter identification number, and whether the detection was linked with a visual sighting;
b. Date and time when first and last heard;
c. Types and nature of sounds heard (e.g., clicks, whistles, creaks, burst pulses, continuous, sporadic, strength of signal);
d. Any additional information recorded such as water depth of the hydrophone array, bearing of the animal to the vessel (if determinable), species or taxonomic group (if determinable), spectrogram screenshot, and any other notable information.

6. Reporting
(a) L-DEO must submit a draft comprehensive report to NMFS on all activities and monitoring results within 90 days of the completion of the survey or expiration of the IHA, whichever comes sooner. A final report must be submitted within 30 days following resolution of any comments on the draft report. The draft report must include the following:
(i) Summary of all activities conducted and sightings of marine mammals near the activities;
(ii) Summary of all data required to be collected (see 5(d));

  - (iii) Full documentation of methods, results, and interpretation pertaining to all monitoring;
  - (iii) Summary of dates and locations of survey operations (including (1) the number of days on which the airgun array was active and (2) the percentage of time and total time the array was active during daylight vs. nighttime hours (including dawn and dusk)) and all marine mammal sightings (dates, times, locations, activities, associated survey activities);
  - (iv) Geo-referenced time-stamped vessel tracklines for all time periods during which airguns were operating. Tracklines should include points recording any change in airgun status (e.g., when the airguns began operating, when they were turned off, or when they changed from full array to single gun or vice versa);
  - (v) GIS files in ESRI shapefile format and UTC date and time, latitude in decimal degrees, and longitude in decimal degrees. All coordinates must be referenced to the WGS84 geographic coordinate system; and
  - (vi) Raw observational data.
- (b) Reporting Injured or Dead Marine Mammals
  - (i) Discovery of Injured or Dead Marine Mammal – In the event that personnel involved in the survey activities covered by the authorization discover an injured or dead marine mammal, L-DEO must report the incident to the NMFS Office of Protected Resources (OPR) and the NMFS West Coast Regional Stranding Coordinator as soon as feasible. The report must include the following information:
    - a. Time, date, and location (latitude/longitude) of the first discovery (and updated location information if known and applicable);
    - b. Species identification (if known) or description of the animal(s) involved;
    - c. Condition of the animal(s) (including carcass condition if the animal is dead);
    - d. Observed behaviors of the animal(s), if alive;
    - e. If available, photographs or video footage of the animal(s); and
    - f. General circumstances under which the animal was discovered.

(ii) Vessel Strike – In the event of a ship strike of a marine mammal by any vessel involved in the activities covered by the authorization, L-DEO must report the incident to NMFS OPR and to the West Coast Regional Stranding Coordinator as soon as feasible. The report must include the following information:

  a. Time, date, and location (latitude/longitude) of the incident;
  b. Species identification (if known) or description of the animal(s) involved;
  c. Vessel's speed during and leading up to the incident;
  d. Vessel's course/heading and what operations were being conducted (if applicable);
  e. Status of all sound sources in use;
  f. Description of avoidance measures/requirements that were in place at the time of the strike and what additional measures were taken, if any, to avoid strike;
  g. Environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover, visibility) immediately preceding the strike;
  h. Estimated size and length of animal that was struck;
  i. Description of the behavior of the marine mammal immediately preceding and following the strike;
  j. If available, description of the presence and behavior of any other marine mammals immediately preceding the strike;
  k. Estimated fate of the animal (e.g., dead, injured but alive, injured and moving, blood or tissue observed in the water, status unknown, disappeared); and
  l. To the extent practicable, photographs or video footage of the animal(s).

7. Actions to minimize additional harm to live-stranded (or milling) marine mammals – In the event of a live stranding (or near-shore atypical milling) event within 50 km of the survey operations, where the NMFS stranding network is engaged in herding or other interventions to return animals to the water, the NMFS Director of OPR (or designee) will advise L-DEO of the need to implement shutdown procedures for all active acoustic

sources operating within 50 km of the stranding. Shutdown procedures for live stranding or milling marine mammals include the following:

(a) If at any time, the marine mammal(s) die or are euthanized, or if herding/intervention efforts are stopped, the Director of OPR, NMFS (or designee) will advise L-DEO that the shutdown around the animals' location is no longer needed.

(b) Otherwise, shutdown procedures will remain in effect until the Director of OPR, NMFS (or designee) determines and advises L-DEO that all live animals involved have left the area (either of their own volition or following an intervention).

(c) If further observations of the marine mammals indicate the potential for re-stranding, additional coordination with L-DEO will be required to determine what measures are necessary to minimize that likelihood (*e.g.*, extending the shutdown or moving operations farther away) and to implement those measures as appropriate.

(d) Additional information requests – If NMFS determines that the circumstances of any marine mammal stranding found in the vicinity of the activity suggest investigation of the association with survey activities is warranted, and an investigation into the stranding is being pursued, NMFS will submit a written request to L-DEO indicating that the following initial available information must be provided as soon as possible, but no later than 7 business days after the request for information.

    (i) Status of all sound source use in the 48 hours preceding the estimated time of stranding and within 50 km of the discovery/notification of the stranding by NMFS; and

    (ii) If available, description of the behavior of any marine mammal(s) observed preceding (*i.e.*, within 48 hours and 50 km) and immediately after the discovery of the stranding.

In the event that the investigation is still inconclusive, the investigation of the association of the survey activities is still warranted, and the investigation is still being pursued, NMFS may provide additional information requests, in writing, regarding the nature and location of survey operations prior to the time period above.

8. This Authorization may be modified, suspended or revoked if the holder fails to abide by the conditions prescribed herein (including, but not limited to, failure to comply with monitoring or reporting requirements), or if NMFS determines: (1) the authorized taking is likely to have or is having more than a negligible impact on the species or stocks of affected marine mammals, 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.

9. Renewals – On a case-by-case basis, NMFS may issue a one-time, one-year Renewal IHA following notice to the public providing an additional 15 days for public comments when (1) up to another year of identical, or nearly identical, activities as described in the Specified Activities section of this notice is planned or (2) the activities as described in the Specified Activities section of this notice would not be completed by the time the IHA expires and a Renewal would allow for completion of the activities beyond that described in the Dates and Duration section of this notice, provided all of the following conditions are met:
    - (a) A request for renewal is received no later than 60 days prior to the needed Renewal IHA effective date (recognizing that the Renewal IHA expiration date cannot extend beyond one year from expiration of the initial IHA).
    - (b) The request for renewal must include the following:
        - (i) An explanation that the activities to be conducted under the requested Renewal IHA are identical to the activities analyzed under the initial IHA, are a subset of the activities, or include changes so minor (e.g., reduction in pile size) that the changes do not affect the previous analyses, mitigation and monitoring requirements, or take estimates (with the exception of reducing the type or amount of take).
        - (ii) A preliminary monitoring report showing the results of the required monitoring to date and an explanation showing that the monitoring results do not indicate impacts of a scale or nature not previously analyzed or authorized.
    - (c) Upon review of the request for Renewal, the status of the affected species or stocks, and any other pertinent information, NMFS determines that there are no more than minor changes in the activities, the mitigation and monitoring measures will remain the same and appropriate, and the findings in the initial IHA remain valid.

Kimberly Damon-Randall,
Director, Office of Protected Resources,
National Marine Fisheries Service.

Table 1. Numbers of Incidental Take of Marine Mammals Authorized

Species	Authorized Takes by Level B Harassment	Authorized Takes by Level A Harassment
Humpback whale	8	0
Minke whale	2	0
Bryde's whale	27	1
Fin whale	2	0
Sei whale	3	0
Blue whale	5	0
Sperm whale	12	0
Cuvier's beaked whale	69	0
Longman's beaked whale	3	0
Mesoplodon spp.	23	0
Risso's dolphin	328	0
Rough-toothed dolphin	597	0
Common bottlenose dolphin	2,274	0
Pantropical spotted dolphin	7,988	0
Spinner dolphin (whitebelly)	121	0
Spinner dolphin (eastern)	8,189	0
Striped dolphin	2,212	0
Short-beaked common dolphin	2,818	0
Fraser's dolphin	858	0
Short-finned pilot whale	244	0
Killer whale	25	0
False killer whale	118	0
Pgymy killer whale	116	0
Melon-headed whale	135	0
Kogia spp.	33	1
Guadalupe fur seal	416	0
California sea lion	365	0

Table 2. Level A and Level B Harassment Zones (m)

Water Depth (m)	Level B harassment zone (m)	Level A			
		Low-frequency cetaceans	Mid-frequency cetaceans	High-frequency cetaceans	Otariid Pinnipeds
>1,000	6,733	320	14	268	11
100-1,000	10,100				

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