NATIONAL MARINE FISHERIES SERVICE
ENDANGERED SPECIES ACT SECTION 7
BIOLOGICAL OPINION AND MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT ESSENTIAL FISH HABITAT RESPONSE

Title:	Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation on the National Science Foundation's Low-Energy Marine Geophysical Survey by the Research Vessel *Marcus G. Langseth* in the Northeast 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 Permits and Conservation Division, Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce
Publisher:	Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce
Approved:	DAMON RANDALL.KIMBERLY.BETH.1365821093 Digitally signed by DAMON RANDALL.KIMBERLY.BETH.1365821093 Date: 2022.08.01 14:25:25 -04'00'
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Date:	8/1/2022
Consultation Tracking number:	OPR-2021-03468
Digital Object Identifier (DOI):	https://doi.org/10.25923/n4q3-2h83

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TABLE OF CONTENTS

Page

1 Introduction ... 10
1.1 Background ... 11
1.2 Consultation History ... 11

2 The Assessment Framework ... 13

3 Description of the Proposed Actions ... 16
3.1 National Science Foundation and Lamont-Doherty Earth Observatory of Columbia University's Proposed Action ... 17
3.1.1 Seismic Survey Overview and Objectives ... 17
3.1.2 Research Vessel Specifications ... 19
3.1.3 Airgun Array and Acoustic Receivers Description ... 20
3.1.4 Sub-Bottom Profiler, Multi-Beam Echosounder, and Acoustic Doppler Current Profiler ... 22
3.1.5 Heat Flow Measurements ... 23
3.2 National Marine Fisheries Service's Proposed Action ... 25
3.2.1 Proposed Incidental Harassment Authorization ... 25
3.2.2 Revision to Proposed Incidental Harassment Authorization ... 27
3.2.3 Overview of Proposed Mitigation, Monitoring, and Reporting in the Incidental Harassment Authorization ... 27
3.3 National Science Foundation, Lamont-Doherty Earth Observatory of Columbia University, and National Marine Fisheries Service's Mitigation, Monitoring, and Reporting ... 29
3.3.1 Proposed Exclusion and Buffer Zones ... 30
3.3.2 Shut-Down Procedures ... 37
3.3.3 Pre-Start Clearance and Ramp-Up Procedures ... 38
3.3.4 Vessel-Based Visual Mitigation Monitoring ... 40
3.3.5 Vessel Strike Avoidance Measures ... 45
3.3.6 Additional Mitigation Measures Considered ... 46
3.3.7 Reporting ... 47

4 Action Area ... 49

5 Endangered Species Act-Listed Species and Designated Critical Habitat Present in the Action Area ... 51

6 Potential Stressors ... 55
6.1 Pollution ... 55
6.2 Vessel Strike ... 55
6.3 Acoustic Noise from Airgun Array, Vessel Noise, and Visual Disturbance ... 57

6.4 Acoustic Noise from the Sub-Bottom Profiler, Multi-Beam Echosounder, and Acoustic Doppler Current Profiler, and Pinger 59
6.5 Gear Entanglement and Interaction 62

7 Species and Critical Habitat Not Likely to be Adversely Affected 64
7.1 Potential Stressors to Endangered Species Act-Listed Marine Mammals, Sea Turtles, and Fishes 65
7.1.1 Pollution 65
7.1.2 Vessel Strike 66
7.1.3 Vessel Noise and Visual Disturbance 67
7.1.4 Acoustic Noise from the Airgun Array 68
7.1.5 Acoustic Noise from Sub-Bottom Profiler, Multi-Beam Echosounder, and Acoustic Doppler Current Profiler, and Pinger 68
7.1.6 Gear Entanglement and Interaction 69
7.1.7 Potential Stressors Considered Further 70
7.2 Marine Mammals – Cetaceans 70
7.2.1 Gray Whale – Western North Pacific Distinct Population Segment 70
7.2.2 Killer Whale – Southern Resident Distinct Population Segment 72
7.2.3 North Pacific Right Whale 73
7.3 Marine Reptiles 75
7.4 Fishes 76
7.4.1 Eulachon – Southern Distinct Population Segment 77
7.4.2 Green Sturgeon – Southern Distinct Population Segment 78
7.4.3 Salmonids – Chinook Salmon, Chum Salmon, Coho Salmon, Sockeye Salmon, and Steelhead Trout 79
7.5 Designated Critical Habitat 86
7.5.1 Humpback Whale – Central America and Mexico Distinct Population Segment Critical Habitat 86
7.5.2 Killer Whale – Southern Resident Distinct Population Segment Critical Habitat 89
7.5.3 Leatherback Turtle Critical Habitat 93
7.5.4 Green Sturgeon – Southern Distinct Population Segment Critical Habitat 94
7.5.5 Effects to Designated Critical Habitat 95
7.6 Summary of Effects Determinations for Potential Stressors Associated with the Proposed Actions 97

8 Species Likely to be Adversely Affected 105
8.1 Status of Species Likely to be Adversely Affected 105
8.2 Blue Whale 105
8.2.1 Life History 106
8.2.2 Population Dynamics 107
8.2.3 Vocalization and Hearing 108

8.2.4 Status ... 110
8.2.5 Critical Habitat ... 110
8.2.6 Recovery Goals ... 110
8.3 Fin Whale ... 111
8.3.1 Life History ... 111
8.3.2 Population Dynamics ... 112
8.3.3 Vocalization and Hearing ... 113
8.3.4 Status ... 114
8.3.5 Critical Habitat ... 114
8.3.6 Recovery Goals ... 115
8.4 Humpback Whale – Central America Distinct Population Segment ... 115
8.4.1 Life History ... 116
8.4.2 Population Dynamics ... 116
8.4.3 Vocalization and Hearing ... 117
8.4.4 Status ... 118
8.4.5 Critical Habitat ... 119
8.4.6 Recovery Goals ... 119
8.5 Humpback Whale – Mexico Distinct Population Segment ... 119
8.5.1 Life History ... 119
8.5.2 Population Dynamics ... 120
8.5.3 Vocalization and Hearing ... 120
8.5.4 Status ... 122
8.5.5 Critical Habitat ... 122
8.5.6 Recovery Goals ... 123
8.6 Sei Whale ... 123
8.6.1 Life History ... 124
8.6.2 Population Dynamics ... 124
8.6.3 Vocalization and Hearing ... 125
8.6.4 Status ... 125
8.6.5 Critical Habitat ... 125
8.6.6 Recovery Goals ... 125
8.7 Sperm Whale ... 126
8.7.1 Life History ... 126
8.7.2 Population Dynamics ... 127
8.7.3 Vocalization and Hearing ... 128
8.7.4 Status ... 129
8.7.5 Critical Habitat ... 130
8.7.6 Recovery Goals ... 130
8.8 Guadalupe Fur Seal ... 130
8.8.1 Life History ... 131

8.8.2 Population Dynamics ... 132
8.8.3 Vocalization and Hearing ... 133
8.8.4 Status ... 133
8.8.5 Critical Habitat ... 134
8.8.6 Recovery Goals ... 134

9 Environmental Baseline ... 135
9.1 Climate Change ... 135
9.2 Oceanic Temperature Regimes ... 139
9.3 Unusual Mortality Events ... 140
9.4 Vessel Interactions ... 141
9.4.1 Vessel Strike ... 142
9.4.2 Whale Watching ... 143
9.5 Fisheries ... 144
9.5.1 Fisheries Interactions ... 145
9.6 Pollution ... 147
9.6.1 Marine Debris ... 147
9.6.2 Pollutants and Contaminants ... 148
9.6.3 Hydrocarbons ... 149
9.7 Aquatic Nuisance Species ... 151
9.8 Anthropogenic Sound ... 152
9.8.1 Vessel Sound and Commercial Shipping ... 153
9.8.2 Aircraft ... 155
9.8.3 Seismic Surveys ... 156
9.8.4 Marine Construction ... 157
9.8.5 Active Sonar ... 157
9.8.6 Military Activities ... 157
9.9 Scientific Research Activities ... 159
9.10 Impact of the Baseline on Endangered Species Act-Listed Species ... 160

10 Effects of the Actions ... 160
10.1 Stressors Associated with the Proposed Actions ... 161
10.2 Mitigation to Minimize or Avoid Exposure ... 162
10.3 Exposure and Response Analysis ... 162
10.3.1 Exposure Analysis ... 162
10.3.2 Response Analysis ... 173
10.4 Risk Analysis ... 202

11 Cumulative Effects ... 203

12 Integration and Synthesis ... 205
12.1 Jeopardy Analysis ... 205
12.2 Blue Whale ... 206

12.3 Fin Whale 207
12.4 Humpback Whale – Central America Distinct Population Segment 208
12.5 Humpback Whale – Mexico Distinct Population Segment 209
12.6 Sei Whale 211
12.7 Sperm Whale 212
12.8 Guadalupe Fur Seal 213

13 Conclusion 215

14 Incidental Take Statement 216
14.1 Amount or Extent of Take 217
14.2 Reasonable and Prudent Measures 218
14.3 Terms and Conditions 219

15 Conservation Recommendations 219

16 Reinitiation Notice 221

17 Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response 223
17.1 Essential Fish Habitat Affected by the Project 223
17.2 Adverse Effects on Essential Fish Habitat 224
17.3 Essential Fish Habitat Conservation Recommendations 225
17.4 Statutory Response Requirement 225
17.5 Supplemental Consultation 226
17.6 Essential Fish Habitat Consultation References 226

18 References 227

19 Appendices 277

LIST OF TABLES

Page

Table 1. Additional details of the Research Vessel *Marcus G. Langseth* 20

Table 2. Specifications of the source airgun array to be used by the Research Vessel *Marcus G. Langseth* during the proposed low-energy seismic survey in the Northeast Pacific Ocean. 21

Table 3. Proposed mitigation and monitoring protocols for the low-energy airgun array in the National Marine Fisheries Service Permits and Conservation Division's proposed incidental harassment authorization and possible renewal. 28

Table 4. Predicted distances to permanent threshold shift for impulsive sources for various marine mammal hearing groups and sea turtles that could be received

from the two Generator Injector airgun array during the proposed low-energy seismic survey in the Northeast Pacific Ocean (NSF 2021). 35

Table 5. Predicted distances to which sound levels of 160 re: 1 µPa (rms) for harassment (Marine Mammal Protection Act Level B harassment) for impulsive sound sources will be received from the two Generator Injector airgun array in deep water depths for marine mammals during the proposed low-energy seismic survey in the Northeast Pacific Ocean (NSF 2021). 36

Table 6. Predicted distances to which sound levels of 175 re: 1 µPa (rms) for harassment for impulsive sound sources will be received from the two Generator Injector airgun array in deep water depths for sea turtles during the proposed low-energy seismic survey in the Northeast Pacific Ocean. 36

Table 7. Endangered Species Act-listed threatened and endangered species and designated critical habitat potentially occurring in the action area that may be affected by the National Science Foundation and Lamont-Doherty Earth Observatory's low-energy seismic survey in the Northeast Pacific Ocean and National Marine Fisheries Service Permits Division's proposed issuance of an incidental harassment authorization and possible renewal. 51

Table 8. Spawning Migration and Entry Timing for Distinct Population Segments/Evolutionarily Significant Units of Chinook Salmon. 80

Table 9. Spawning Migration and Entry Timing for Distinct Population Segments/Evolutionarily Significant Units of Coho Salmon. 81

Table 10. Spawning Migration and Entry Timing for Distinct Population Segments/Evolutionarily Significant Units of Chum Salmon. 82

Table 11. Spawning Migration and Entry Timing for Distinct Population Segments/Evolutionarily Significant Units of Sockeye Salmon. 82

Table 12. Spawning Migration and Entry Timing for Distinct Population Segments/Evolutionarily Significant Units of Steelhead Trout. 82

Table 13. Summary of Endangered Species Act-listed species effects determination by potential stressor associated with the proposed actions. 98

Table 14. Five-year annual average mortalities and serious injuries related to vessel strikes for Endangered Species Act-listed marine mammals for stocks in the Pacific Ocean within the action area. 143

Table 15. Five-year average mortalities and serious injuries related to fisheries interactions for Endangered Species Act-listed marine mammals within the action area. 146

Table 16. Densities of Endangered Species Act-listed marine mammals in the action area during National Science Foundation and Lamont-Doherty Earth Observatory's low-energy seismic survey in the Northeast Pacific Ocean and National Marine Fisheries Service Permits Division's proposed issuance of an incidental harassment authorization and possible renewal. 168

Table 17. Relevant isopleths, trackline distance, ensonified area, percent increase, and total ensonified areas during the National Science Foundation and Lamont-Doherty Earth Observatory's low-energy seismic survey in the Northeast Pacific Ocean and National Marine Fisheries Service Permits Division's proposed issuance of an incidental harassment authorization and possible renewal. 169

Table 18. Probability of encountering humpback whales from each distinct population segment in the North Pacific Ocean found off the U.S. West Coast. Adapted from Wade et al. (2021). 172

Table 19. 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 underwater (NOAA 2018). 176

Table 20. Predicted radial distances in meters from the Research Vessel *Marcus G. Langseth* seismic sound sources to isopleth corresponding to the harassment (160 dB re: 1 μPa [rms]) threshold. 178

Table 21. Modeled radial distances in meters from the Research Vessel *Marcus G. Langseth*'s two Generator Injector airgun array corresponding to harm thresholds. 178

Table 22. Total ensonified areas (with 25 percent increase) for Endangered Species Act-listed marine mammals in the action area during National Science Foundation and Lamont-Doherty Earth Observatory's low-energy seismic survey in the Northeast Pacific Ocean and National Marine Fisheries Service Permits Division's proposed issuance of an incidental harassment authorization and possible renewal. 179

Table 23. Density, total ensonified area, and calculated exposures during the National Science Foundation and Lamont-Doherty Earth Observatory's low-energy seismic survey in the Northeast Pacific Ocean and National Marine Fisheries Service Permits on Division's proposed issuance of an incidental harassment authorization and possible renewal. 179

Table 24. Estimated exposure of Endangered Species Act-listed marine mammals calculated by the National Marine Fisheries Service Endangered Species Act Interagency Cooperation Division to the airgun arrays during the low-energy seismic survey in the Northeast Pacific Ocean. 180

Table 25. Estimated exposure of Endangered Species Act-listed marine mammals calculated by the National Science Foundation, Lamont-Doherty Earth Observatory, and National Marine Fisheries Service Permits Division to the airgun arrays during the low-energy seismic survey in the Northeast Pacific Ocean. 180

Table 26. Estimated amount of incidental take of Endangered Species Act-listed marine mammals anticipated as a result of the proposed actions in the Northeast Pacific Ocean. 218

LIST OF FIGURES

Page

Figure 1. Photograph of the heat flow probe used for measurements. 24

Figure 2. Photograph of the medium frequency-directional ultra-short baseline transducer at the end on the pole of the heat flow probe used for measurements. 25

Figure 3. Map of the National Science Foundation and Lamont-Doherty Earth Observatory's low-energy seismic survey in the Northeast Pacific Ocean and National Marine Fisheries Service Permits Division's proposed issuance of an incidental harassment authorization and possible renewal for this consultation. 50

Figure 4. Overview map of critical habitat for the endangered Central America distinct population segment, threatened Mexico distinct population segment, and endangered Western North Pacific distinct population segment of humpback whales. 89

Figure 5. Map identifying designated critical habitat for the endangered Southern Resident distinct population segment of killer whale. 90

Figure 6. Existing and revised designated critical habitat for endangered Southern Resident distinct population segment of killer whales. 93

Figure 7. Map identifying designated critical habitat for the endangered leatherback turtle along the United States Pacific Coast. 94

Figure 8. Map of geographic range (within the contiguous United States) and designated critical habitat for the threatened Southern distinct population segment of green sturgeon. 95

Figure 9. Map identifying the range of the endangered blue whale. 106

Figure 10. Map identifying the range of the endangered fin whale. 111

Figure 11. Map identifying 14 distinct population segments with one threatened and four endangered, based on primarily breeding location of the humpback whale, their range, and feeding areas (Bettridge et al. 2015a). 115

Figure 12. Map identifying the range of the endangered sei whale. 123

Figure 13. Map identifying the range of the endangered sperm whale. 126

Figure 14. Map identifying the range of the threatened Guadalupe fur seal. 131

Figure 15. Guadalupe fur seal annual strandings in Oregon and Washington, 2013 through 2021. 141

Figure 16. Trend in confirmed whale entanglements per year detected off the West Coast of the United States from 2001 through 2016, and estimated humpback whale population size (Santora et al. 2020). 145

Figure 17. Map of vessel traffic density in the Northeast Pacific Ocean off Oregon and Washington. Image retrieved from Marine Traffic. 155

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 threatened or endangered 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 concurs with that determination for species under NMFS jurisdiction, consultation concludes informally (50 C.F.R. §402.13(c)).

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 reasonable and prudent measures to minimize such impacts and terms and conditions to implement the reasonable and prudent measures. NMFS, by regulation, has determined that an incidental take statement must be prepared when take is "reasonably certain to occur" as a result of the proposed action (50 C.F.R. §402.14(g)(7)).

The Federal action agencies for this consultation are the National Science Foundation (NSF) and the NMFS, Office of Protected Resources, Permits and Conservation Division (Permits Division). Two Federal actions are considered in this biological opinion (opinion). The first is the NSF's proposal to sponsor (fund) (and conducted by the Lamont-Doherty Earth Observatory of Columbia University [L-DEO]) a marine geophysical (seismic) survey in the Northeast Pacific Ocean in summer (tentatively scheduled for August) 2022. The second is the NMFS Permits Division's proposal to issue an incidental harassment authorization (IHA) authorizing non-lethal "takes" by 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 formal consultation, opinion, and incidental take statement, were completed in accordance with section 7(a)(2) of the statute (16 U.S.C. §1536 (a)(2)), associated implementing regulations (50 C.F.R. §§402.01-402.16), and agency policy and guidance. On July 5, 2022, the United States District Court for the Northern District of California issued an order vacating the 2019

regulations adopting changes to 50 C.F.R. §402 (84 FR 44976, August 27, 2019). This consultation was initiated when the 2019 regulations were still in effect. As reflected in this document, we are now applying the section 7 regulations that governed prior to adoption of the 2019 regulations (https://www.govinfo.gov/content/pkg/CFR-2018-title50-vol11/pdf/CFR-2018-title50-vol11-part402.pdf). For purposes of this consultation, we considered whether the substantive analysis and its conclusions regarding the effects of the proposed actions articulated in the opinion and incidental take statement would be any different under the 2019 regulations. We have determined that our analysis and conclusions would not be any different. This consultation was conducted and this opinion and incidental take statement were prepared by NMFS, Office of Protected Resources, ESA Interagency Cooperation Division (hereafter referred to as "we") in accordance with section 7(b) of the ESA and implementing regulations at 50 C.F.R. Part 402, and agency policy and guidance. We also completed an Essential Fish Habitat (EFH) consultation on the proposed actions in accordance with section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA; 16 U.S.C. §1801 et seq.) and implementing regulations at 50 C.F.R. Part 600.

This document represents the NMFS ESA Interagency Cooperation Division's opinion on the effects of these actions on threatened and endangered species and critical habit that has been designated for those species (see Table 7). 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 sponsor a low-energy marine seismic survey for scientific research purposes and data collection in the Northeast Pacific Ocean in summer (tentatively scheduled for August) 2022. The low-energy seismic survey will be conducted by L-DEO. In conjunction with this action, the NMFS Permits Division proposes to issue an IHA under the MMPA for incidental takes of marine mammals that could occur during the NSF and L-DEO's low-energy seismic survey. Both the NSF and the NMFS Permits Division have conducted similar actions in the past that have been the subject of ESA section 7 consultations that addressed seismic surveys throughout the world, including several in the Northeast Pacific Ocean (e.g., in the Northeast Pacific Ocean [2004], Northeast Pacific Ocean [2007], Northeast Pacific Ocean [2008], Northeast Pacific Ocean [2009], Vancouver and Oregon [2009], North Pacific Ocean [2010], Northeast Pacific Ocean [2012], Oregon [2017], Northeast Pacific Ocean [2019], Cascadia Subduction Zone [2021], and Queen Charlotte Fault [2021]) and the issuance of an IHA by the NMFS Permits Division determined that the authorized activities are not likely to jeopardize the continued existence of proposed or ESA-listed species, or the destruction or adverse modification of designated critical habitat.

1.2 Consultation History

This opinion is based on information provided in the NSF's *Draft Environmental Assessment of Marine Geophysical Surveys by R/V Marcus G. Langseth of the Cascadia Subduction Zone in the*

Northeast Pacific Ocean, 2022 prepared pursuant to the National Environmental Policy Act, L-DEO's MMPA IHA application, the public notice for the proposed IHA and possible renewal prepared pursuant to the requirements of the MMPA, monitoring reports from similar activities, published and unpublished scientific information on threatened and endangered species and their surrogates, scientific and commercial information such as reports from government agencies and peer-reviewed literature, opinions on similar activities, and other sources of information. Our communication with the NSF and NMFS Permits Division regarding this consultation is summarized as follows:

- On December 14, 2021, the L-DEO submitted an IHA application to us and the NMFS Permits Division. NMFS Permits Division deemed the IHA application adequate and complete on April 4, 2022.
- On December 14, 2021, we received a request from the NSF for ESA section 7 consultation for a proposed low-energy seismic survey to be undertaken in the Northeast Pacific Ocean in summer (tentatively scheduled for August) of 2022. The NSF provided a letter and draft environmental assessment, in support of the request.
- On February 18, 2022, we provided the NSF with questions on their draft environmental assessment and IHA application. The NSF responded to the questions on February 24, 2022.
- On February 28, 2022, we provided the NSF with additional questions. The NSF responded to the questions on March 4, 2022.
- On March 4, 2022, we determined there was sufficient information to initiate formal consultation. We provided the NSF with an initiation letter on March 9, 2022.
- On March 25, 2022, we participated in the NMFS Permits Division's Early Review Team meeting to discuss the NSF and L-DEO's low-energy seismic survey on the Research Vessel (R/V) *Marcus G. Langseth* in the Northeast Pacific Ocean.
- On April 4, 2022, we received the EFH consultation for the NSF and L-DEO's low-energy seismic survey on the R/V *Marcus G. Langseth* in the Northeast Pacific Ocean that was prepared by the NMFS West Coast Regional Office.
- On June 17, 2022, we received a request for formal consultation pursuant to section 7 of the ESA from the NMFS Permits Division to authorize the incidental harassment of marine mammal species during the NSF and L-DEO's low-energy seismic survey on the R/V *Marcus G. Langseth* in the Northeast Pacific Ocean. The consultation request package included an initiation memorandum, IHA application, and draft IHA.
- On June 23, 2022, NMFS Permits Division published a notice of a proposed IHA and request for comments on proposed authorization and possible renewal in the *Federal Register* soliciting public comment on their intent to issue an IHA for NSF and L-DEO's low-energy marine seismic survey on the R/V *Marcus G. Langseth* in the Northeast Pacific Ocean.

- On June 23, 2022, we determined there was sufficient information to initiate formal consultation. We provided NMFS Permits Division with an initiation letter on June 27, 2022.
- On June 27, 2022, we provided comments and edits on the draft IHA to the NMFS Permits Division.
- On July 12, 2022, we received a revised IHA from the NMFS Permits Division addressing comments and edits we provided on the draft IHA.
- On July 26, 2022, NMFS Permits Division notified us that they did not receive any public comments on the proposed IHA and possible renewal.

2 THE ASSESSMENT FRAMEWORK

Section 7(a)(2) of the ESA requires Federal agencies, in consultation with NMFS, to ensure that their actions are not likely to jeopardize the continued existence of threatened or endangered 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 for the conservation of an ESA-listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features (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 critical habitat regulation revisions (81 FR 7414; February 11, 2016) have since replaced 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 assessment involves the following steps:

Description of the Proposed Actions (Section 3): We describe the proposed actions and those aspects (or stressors) of the proposed actions that may have direct or indirect effects on the physical, chemical, and biotic environment. This section also includes the avoidance and minimization measures that have been incorporated into the project to reduce the effects to ESA-listed species.

Action Area (Section 4): We describe the action area with the spatial extent of those stressors.

Endangered Species Act-Listed Species and Designated Critical Habitat Present in the Action Area (Section 5): We identify the ESA-listed species and designated critical habitat that are subject this consultation because they co-occur with the stressors produced by the proposed actions in space and time.

Potential Stressors (Section 6): 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.

Species and Critical Habitat Not Likely to be Adversely Affected (Section 7): We identify the ESA-listed species and designated critical habitat that are not likely to be adversely affected by the stressors produced by the proposed actions.

Species Likely to be Adversely Affected (Section 8): During the ESA section 7 consultation process, we identify the ESA-listed species that are likely be adversely affected and detail our effects analysis for these species. We examine the status of ESA-listed species that may be adversely affected by the proposed actions throughout the action area in the Status of the Species Likely to be Adversely Affected (Section 8.1).

Environmental Baseline *(*Section 9): We describe the environmental baseline in the action area that 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 (50 C.F.R. §402.02).

Effects of the Actions (Section 10): Effects of the action refers to the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline. 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. Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur. Interrelated actions are those that are part of a larger action and depend on the larger action for their justification. Interdependent actions are those that have no independent utility part from the action under consideration. These are broken into analyses of exposure, response, and risk. To characterize exposure, we identify the number, age (or life stage), and gender of ESA-listed individuals that are likely to be exposed to the stressors and the populations or sub-populations to which those individuals belong. We also consider whether the action "may affect" designated critical habitat. 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 the action may

affect designated critical habitat. This is our response analysis. We characterize risk to federally-listed species by assessing 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. This is our risk analysis. The adverse modification analysis considers the impacts of the proposed actions on the essential features and conservation value of designated critical habitat.

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): In this section we integrate the analyses in the opinion to summarize the consequences to ESA-listed species and designated critical habitat under NMFS' jurisdiction.

With full consideration of the status of the species and the designated critical habitat, we consider the effects of the actions within the action area on populations or subpopulations and on physical and biological features of designated critical habitat 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; 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 (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 (50 C.F.R. §402.14).

In addition, we include an Incidental Take Statement (Section 14), if necessary, that specifies the impact of the take, reasonable and prudent measures to minimize the impact of the take, 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 Reinitiation of Consultation is required (Section 16) (50 C.F.R. §402.16).

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 NMFS Permits Division;
- Government reports (including NMFS biological opinions and stock assessment reports);
- National Oceanic and Atmospheric Administration (NOAA) technical memorandums;
- Monitoring reports; 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 actions 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 ACTIONS

"Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by federal agencies (50 C.F.R. §402.02).

Two Federal proposed actions were evaluated during consultation. The first proposed action addressed by this consultation is the NSF's proposal to sponsor a low-energy marine seismic survey on the R/V *Marcus G. Langseth* in the Northeast Pacific Ocean in summer (tentatively scheduled for August) 2022. The low-energy seismic survey will be conducted by L-DEO, which owns and operates the R/V *Marcus G. Langseth*. The NSF and L-DEO's proposed action will occur at the Cascadia Subduction Zone and Juan de Fuca Plate. The second proposed action addressed by this consultation is NMFS Permits Division's proposed issuance of a proposed IHA authorizing non-lethal "takes" by MMPA Level B harassment and possible renewal pursuant to section 101(a)(5)(D) of the MMPA for the NSF and L-DEO's low-energy marine seismic survey in the Northeast Pacific Ocean.

The NSF and L-DEO's proposed action includes a high-resolution, two-dimensional seismic survey in the United States (U.S.) Exclusive Economic Zone in the Northeast Pacific Ocean. The seismic survey activities will collect data to understand the thermal structure of the Juan de Fuca plate as it enters the Cascadia subduction zone. 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 low-energy seismic survey will collect data in support of a research proposal that has been reviewed under the NSF merit review process and has been identified as a NSF program priority to meet the agency's critical need to foster an understanding of Earth processes.

The information presented here is based primarily on the draft environmental assessment, IHA application, and *Federal Register* notice on the request for comments on the proposed IHA and possible renewal provided by the NSF, L-DEO, and NMFS Permits Division as part of their initiation packages.

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

The NSF proposes to fund a low-energy seismic survey in the Northeast Pacific Ocean on the R/V *Marcus G. Langseth*. The low-energy seismic survey will be conducted by L-DEO. An airgun array, sub-bottom profiler, and multi-beam echosounder, and acoustic Doppler current profiler will be deployed as an energy source.

3.1.1 Seismic Survey Overview and Objectives

The NSF was established by Congress with the National Science Foundation Act of 1950 (Public Law 810507, as amended) and is the only Federal agency dedicated to the support of fundamental research and education in all scientific and engineering disciplines. The NSF has a continuing need to fund seismic surveys that enable scientists to collect data essential to understanding the complex Earth processes beneath the ocean floor.

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

Researchers from the Oregon State University and New Mexico Institute of Mining and Technology, propose to conduct a low-energy marine seismic survey for scientific research purposes using an airgun array and other acoustic sound sources in conjunction with heat flow measurements in the waters of the Northeast Pacific Ocean in summer (tentatively scheduled for August) 2022. The principal investigators are Drs. R. Harris (Oregon State University), A. Trehu (Oregon State University), and G. Spinelli (New Mexico Institute of Mining and Technology). To achieve the goals of the project, the principal investigators will utilize the two-dimensional

seismic reflection capabilities of the R/V *Marcus G. Langseth* in conjunction with densely-spaced heat flow measurements. The two-dimensional seismic reflection data are required to contain basement depth and other structural features that affect the heat flow measured near the seafloor and are critical for accurately modeling the heat flow observations.

The two-dimensional seismic survey will use a towed two airgun array with a maximum discharge volume of approximately 1,474.8 cubic centimeters (90 cubic inches) at a depth of 2 to 4 meters (6.6 to 13.1 feet). The low-energy seismic survey will take place in the U.S. Exclusive Economic Zone in the Northeast Pacific Ocean in (deep) waters depths greater than approximately 1,600 meters (5,249.3 feet). The seismic survey activities will consist of a total of approximately 23 days, including approximately six days of airgun array operations, 14 days of heat flow measurements, and approximately three days of transit. Equipment deployment and recovery can occur anytime during the seismic survey activities except it will not occur during transit. The order of the seismic survey activities will be determined when operations commence and will depend on a variety of factors including science drivers, weathers, mechanical issues, etc. It is assumed the airgun array will be active up to 24 hours per day (possibly 21 hours per day, with three hours per day allotted for repair and regular maintenance) to meet science objectives. The R/V *Marcus G. Langseth* is tentatively planning to depart from Newport, Oregon on approximately August 3, 2022, and return to Newport, Oregon on approximately August 26, 2022. The schedule for the R/V *Marcus G. Langseth* is available online at: https://www.mfp.us/programme/shipview/marcus%20g.%20langseth. Some minor deviation from the dates is possible, depending on logistics and weather. Due to uncertainties associated with the schedule, sail dates were not provided and likely occurring in June, July, or August.

The NSF will use conventional seismic survey methodology and the procedures will be similar to those used during previous NSF-funded seismic surveys. Seismic survey protocols generally involve a predetermined set of tracklines. The seismic data 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 (see Figure 3).

The R/V *Marcus G. Langseth* will deploy an airgun array consisting of two Generator Injector (GI) airguns, with one towed hydrophone streamer behind the R/V *Marcus G. Langseth* to conduct the two-dimensional seismic survey. The location of the tracklines are considered representative and may shift from what is depicted in Figure 1 depending on factors such as science drivers, poor data quality, weather, ice conditions, mechanical issues with the research vessel and/or equipment, etc.

The seismic survey activities will be conducted along a total of approximately 1,135 kilometers (612.9 nautical miles) of tracklines. The tracklines will occur in four survey regions in the Northeast Pacific Ocean: Coast (200 kilometers [108 nautical miles], Nubbin (95 kilometers [51.3 nautical miles]), Pseudofault (440 kilometers [237.6 nautical miles]), and Oregon (400 kilometers [216 nautical miles]). The Coast survey region is approximately 148.4 to 174.3 kilometers (80.1 to 94.1 nautical miles) from shore; the Nubbin survey region is approximately

165.1 to 171 kilometers (89.1 to 92.3 nautical miles) from shore; the Pseudofault survey region is approximately 149.2 to 164.7 kilometers (80.6 to 88.9 nautical miles) from shore; and the Oregon survey region is approximately 46.9 to 96.6 kilometers (25.3 to 52.1 nautical miles) from shore. The closest point of approach between Newport, Oregon and the Coast, Nubbin, Pseudofault, and Oregon survey regions are 273.1 kilometers (147.5 nautical miles), 170.1 kilometers (91.8 nautical miles), 168.6 kilometers (91 nautical miles), and 113.6 kilometers (61.3 nautical miles), respectively. All of the seismic survey activities will occur in deep water depths (greater than 1,600 meters [5,249.3 feet]).

The proposed activities will occur 24 hours per day during the proposed low-energy seismic survey. There will be additional airgun array operations in the seismic survey area associated with start-ups, line changes and turns, airgun array testing, recovery, and repeat coverage of any areas where initial data quality is considered sub-standard by the project scientists. A section of a trackline may need to be repeated for reasons such as when data quality is poor or missing due to equipment failure (e.g., airgun array or towed hydrophone streamer problems; data acquisition system issues, research vessel issues); data degradation due to poor weather; interruption due to shut-downs or ramp-ups or trackline deviation for protected species, which will tie into good data on the other side of the trackline. To account for these additional airgun array operations in the estimate of incidental takes of marine mammals that will occur as a result of the seismic survey activities, the NSF and L-DEO added 25 percent to the total number of operational days (which is the equivalent to adding 25 percent to the total proposed trackline kilometers) to the low-energy seismic survey for their calculations of marine mammal exposures to sounds exceeding the MMPA Level B harassment thresholds. All planned seismic data acquisition activities will be conducted by the NSF, L-DEO, and researchers from the Oregon State University and New Mexico Institute of Mining and Technology, 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 R/V *Marcus G. Langseth* for the entire seismic survey. The NSF and L-DEO's draft environmental assessment and IHA application present more detailed information on the project.

3.1.2 Research Vessel Specifications

The low-energy seismic survey will involve one source vessel, the U.S.-flagged R/V *Marcus G. Langseth*. The R/V *Marcus G. Langseth* is owned and operated by L-DEO. The R/V *Marcus G. Langseth* will tow a source airgun array as a sound source along tracklines (not predetermined). 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). Its propulsion system consists of two diesel Bergen BRG-6 engines, each producing 3,550 horsepower, and an 800 horsepower bowthruster. 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. The operating speed during seismic data acquisition is typically 7.8 to 8 kilometers per hour (4.2 to 4.5 knots). When not towing seismic survey gear, the R/V *Marcus G. Langseth* typically cruises at 20.4 kilometers

per hour (11 knots). The maximum speeds is approximately 24.1 kilometers per hour (13 knots). During the two-dimensional low-energy seismic survey, the vessel will attempt to maintain a constant speed of approximately 7.8 kilometers per hour (4.2 knots). It has an operating range of approximately 13,500 kilometers (7,289.4 nautical miles) and an endurance of approximately 30 days. 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 (PSO) (visual) will watch for animals (e.g., marine mammals, sea turtles, and fishes). See Table 1 for additional details regarding the R/V *Marcus G. Langseth*.

Table 1. Additional details of the Research Vessel *Marcus G. Langseth*.

Research Vessel *Marcus G. Langseth* Specifications	
Owner	Lamont-Doherty Earth Observatory of Columbia University
Operator	Lamont-Doherty Earth Observatory of Columbia University
Flag	United States of America
Date Built or Modified	Built in 1991 Modified in 2004
Gross Tonnage	3,834
Accommodation Capacity	55 including approximately 20 Crew and 35 Scientists/Researchers

3.1.3 Airgun Array and Acoustic Receivers Description

The energy source for the low-energy seismic survey was chosen by the NSF to be the lowest practical to meet the scientific objectives. During the low-energy seismic survey, marine technicians on 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.

The airgun array for the two-dimensional low-energy seismic survey will consist of up to two GI airguns (each airgun is 737.4/1,720.6 [45/105] cubic inches) with a total discharge volume of

approximately 1,474.8 cubic centimeters (90 cubic inches) (Table 2). All airguns in the array will be fired simultaneously. The airgun array will be towed behind the R/V *Marcus G. Langseth*. The shot interval will be approximately 5.3 to 10.6 seconds (approximately 12.5 to 25 meters [41 to 82 feet] per second) for the two-dimensional low-energy seismic survey. The firing pressure of the airgun array will be approximately 1,900 to 1,950 pounds per square inch (psi). The airgun array will be towed approximately 217 meters (711.9 feet) behind the research vessel (depending on Beaufort sea state) at a tow depth of 2 to 4 meters (6.6 to 13.1 feet) and spaced in-line approximately 2.46 meters (8.1 feet) apart for the low-energy seismic survey. Weather conditions permitting, it is anticipated that seismic survey activities will not exceed approximately 144 hours of airgun array operations. It is expected that the airgun array will be active 24 hours per day during the seismic survey. Airguns will operate continually during the seismic survey period except for unscheduled shut-downs. See Table 2 for the specifications of the R/V *Marcus G. Langseth*'s airgun array configurations, source output, position, tow depths, air discharge volume, dominant frequency components, pulse duration, and shot interval associated with the low-energy seismic survey in the Northeast Pacific Ocean.

Table 2. Specifications of the source airgun array to be used by the Research Vessel *Marcus G. Langseth* during the proposed low-energy seismic survey in the Northeast Pacific Ocean.

Source Airgun Array Specifications	
Energy Source – Number of Airguns	2 GI Airguns (45/105 in^3 each for 90 in^3 total) (1,900 to 1,950 psi)
Source Output (Downward) of 2 Airgun Array	Peak-to-Peak = 7.2 bar-m (237.1 dB re: 1 μPa [rms]) 0-to-Peak = 3.6 bar-m (231.1 dB re: 1 μPa [rms])
Position	2 GI Airgun Array – In-Line Approximately 2.46 m (8.1 ft) Apart Approximately 217 m (711.9 ft) Astern
Tow Depth	2 to 4 m (6.6 to 13.1 ft)
Air Discharge Volume of 2 GI Airgun Array	Approximately 90 in^3
Dominant Frequency Components	0 to 188 Hz
Pulse Duration	Approximately 0.01 Seconds

Source Airgun Array Specifications	
Shot Interval	Approximately 12.5 to 25 m or 5.3 to 10.6 Seconds

GI=generator injector, in^3=cubic inches, psi=pounds per square inch, NA=not available, dB=decibel, µPa=micro Pascal, rms=root mean square, m=meters, ft=feet, Hz=Hertz,

The receiving system will consist of a one 800 to 1,400 meter (2,624.7 to 4,593.2 nautical mile) long towed hydrophone streamer during the low-energy seismic survey. The towed hydrophone streamer is a Sercel Sentinel solid flexible polymer streamer (i.e., not filled with gel or oil). As the airgun array is towed along the tracklines, the towed hydrophone streamer will receive the returning acoustic signals and transfer the data to the onboard processing system. The turning rate of the R/V *Marcus G. Langseth* with the airgun array and towed hydrophone streamer deployed is slow and the maneuverability of the research vessel will be limited during seismic survey activities.

3.1.4 Sub-Bottom Profiler, Multi-Beam Echosounder, and Acoustic Doppler Current Profiler

Along with operations of the airgun array, three additional acoustical data acquisition systems will operate during the low-energy seismic survey from the R/V *Marcus G. Langseth*. The Knudsen Chirp 3260 sub-bottom profiler at 3.5 kilohertz and Kongsberg EM 122 multi-beam echosounder at 10.5 to 13 kilohertz will map the ocean floor during the low-energy seismic survey. The Teledyne RDI Ocean Surveyor acoustic Doppler current profiler at 75 kilohertz will measure water current velocities. The sub-bottom profiler, multi-beam echosounder, and acoustic Doppler current profiler sound sources will operate continuously from the R/V *Marcus G. Langseth*, including simultaneously with the airgun array as well as during transit to and from the seismic survey area.

3.1.4.1 Sub-Bottom Profiler

The ocean floor will be mapped with a Knudsen Chirp 3260 sub-bottom profiler. The sub-bottom profiler is normally operated to provide information about the near seafloor 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 kilohertz transducer mounted to the hull of the research vessel. The nominal power output is 10 kilowatts, but the actual maximum radiated power is 3 kilowatts or 222 decibels (dB) re: 1 µPa at 1 meter (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). A sub-bottom profiler will be operated continuously during the seismic survey activities and transits.

3.1.4.2 Multi-Beam 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) kilohertz. The transmitting beamwidth is very narrow, 0 or two degrees fore-aft and 150 degrees (maximum) athwartship (i.e., perpendicular to the research vessel's line of travel). The maximum sound source level is 242 dB re: 1 μPa at 1 meter (rms). Each ping consists of eight (in water greater than 1,000 meters [3,280.8 feet] successive fan-shaped transmissions, each ensonifying a sector that extends one degree fore-aft. Continuous-wave signals increase from two to 15 milliseconds long in water depths up to 2,600 meters (8,530.2 feet) and frequency modulated chirp signals up to 100 milliseconds long are used in water greater than 2,600 meters (8,530.2 feet). The successive transmissions span an overall cross-track angular extent of about 150 degrees, with two milliseconds gaps between the pings for successive sectors. The multi-beam echosounder emits a series of 0.7 to 200 millisecond pulses. A multi-beam echosounder will be operated continuously during the seismic survey activities and transits.

3.1.4.3 Acoustic Doppler Current Profiler

The Teledyne RDI Ocean Surveyor acoustic Doppler current profilers will be mounted on the hull of the R/V *Marcus G. Langseth* to measure the speed (velocity), direction, and depth of the water currents. The Teledyne RDI Ocean Surveyor acoustic Doppler current profiler will operate at a frequency of 75 kilohertz and a maximum sound source level of 227 dB re: 1 μPa at 1 meter (rms) over a conically-shaped 30 degree beam. The transmitting beamwidth is 30 degrees. The acoustic Doppler current profiler emits a series of 11 to 37 millisecond pulses and has a ping rate is 0.7 seconds. An acoustic Doppler current profiler will be operated continuously during the seismic survey activities and transits.

3.1.5 Heat Flow Measurements

Heat flow measurement data will be acquired with a new heat flow probe. The heat flow probe is a passive system that takes the temperature of the sediments like a thermometer. The heat flow probe will be suspended from the research vessel using a wire which will be kept taught by the weight of the heat flow probe. The heat flow probe is lowered into the seafloor sediment, penetrating up to 6 meters (19.7 feet) into the sediment. The heat flow measurements along a transect line will be acquired in "pogo" mode, in which the probe is left in the water between sites on a particular transect as the research vessel moves from site to site along the transect line. Heat flow transects will be along new or existing transect lines for airgun array operations with additional seismic survey data acquired to determine the basement structure perpendicular to the heat flow transects, allowing for incorporation of three-dimensional effects in the modeling of heat and fluid transport.

Measurements using the heat flow probe will be made by lowering the heat flow probe through the water column and letting it plunge into the sediment. Heat flow measurements consist of two parts, thermal gradient and conductivity. Generally, heat flow measurements will be

approximately 500 to 1,000 meters (1,640.4 to 3,280.8 feet) apart (with some variation) on a given trackline. At each measurement site the heat flow probe is left in the seafloor for approximately 15 minutes. After the measurement is taken the heat flow probe is pulled out of the sediment and raised about 200 meters (656.2 feet) above the seafloor, the research vessel then moves position, and the process is repeated (previously referred to as "pogo" mode). Standard heat flow probes are 2.5 to 6 meters (11.5 to 19.7 feet) and weigh approximately 453.6 kilograms (1,000 pounds).

The heat flow probe will be deployed over the side of the research vessel using standard oceanographic techniques and wire. The research vessel will be stationary when the heat flow probe is deposited into the sediment and will move very slowly during transits with towed gear (approximately 1.9 to 2.8 kilometers per hour [1 to 1.5 knots]).

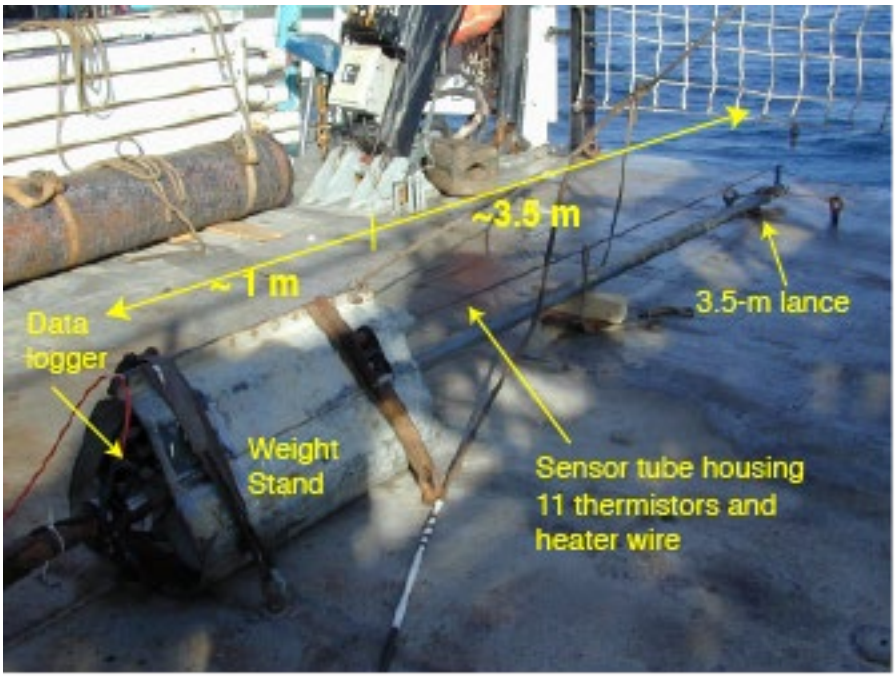

Figure 1. Photograph of the heat flow probe used for measurements.

The heat flow probe will be equipped with a medium frequency-directional ultra-short baseline transducer acoustic positioning system (referred to as a pinger below) to allow it to "talk" with the research vessel. A pole-mounted on the side of the research vessel will be deployed and extended below the hull with the corresponding medium frequency-directional ultra-short baseline transducer on the end. The pole-mounted medium frequency-directional ultra-short baseline transducer will ping to the receiver to locate the heat flow probe location and vice versa. The acoustic characteristics of the transducer include a directional 25 degree beam shape at a frequency range of 19 to 34 kilohertz. The transmitting sound source level is 190 to 202 dB re: 1 μPa (rms) with a wideband pulse length of 8 to 16 milliseconds.

Figure 2. Photograph of the medium frequency-directional ultra-short baseline transducer at the end on the pole of the heat flow probe used for measurements.

3.2 National Marine Fisheries Service's Proposed Action

On December 14, 2021, NMFS Permits Division received a request from the NSF and L-DEO for an IHA to take marine mammals incidental to conducting a low-energy marine seismic survey in the Northeast Pacific Ocean. On April 4, 2022, NMFS Permits Division deemed the NSF and L-DEO's application for an IHA to be adequate and complete. The NSF and L-DEO's request is for take of a small number of 23 species of marine mammals by MMPA Level B harassment. Neither the NSF and L-DEO, nor NMFS Permits Division expects serious injury or mortality to result from the proposed seismic survey activities, therefore, an IHA is appropriate. The planned low-energy seismic survey is not expected to exceed one year; hence, the NMFS Permits Division does not expect subsequent MMPA IHAs will be issued for this proposed action. The IHA will be valid for a period of one year from the date of issuance (July 2022 through July 2023). The NMFS Permits Division proposes to issue the IHA on or after July 26, 2022, so that the NSF and L-DEO will have the IHA prior to the start of the proposed low-energy seismic survey.

3.2.1 Proposed Incidental Harassment Authorization

The NMFS Permits Division is proposing to issue an IHA authorizing non-lethal "takes" by MMPA Level B harassment of marine mammals incidental to the planned low-energy seismic survey. The IHA will be valid for a period of one year from the date of issuance. The IHA will

authorize the incidental harassment of the following threatened and endangered species: blue whale (*Balaenoptera musculus*), fin whale (*Balaenoptera physalus*), Central America DPS and Mexico DPS of humpback whale (*Megaptera novaeangliae*), sei whale (*Balaenoptera borealis*), sperm whale (*Physeter macrocephalus*), and Guadalupe fur seal (*Arctocephalus townsendi*). The proposed IHA identifies requirements that the NSF and L-DEO must comply with as part of its authorization. The NMFS Permits Division does not expect the NSF and L-DEO's planned low-energy seismic survey to exceed one year and do not expect subsequent MMPA IHAs will be issued for this particular specified activity. Nevertheless, NMFS Permits Division recognizes that delays to the specified activity have the potential to occur and as a result, may issue a one-year renewal to the IHA.

On a case-by-case basis, NMFS Permits Division may issue a one-time, one-year IHA renewal following notice to the public providing an additional 15-days for public comment when (1) up to another year of identical, or nearly identical, activities as described in the description of the proposed activity section of the *Federal Register* notice (87 FR 37560 to 37598) is planned or (2) the activities as described in the description of the proposed activity section of the *Federal Register* notice (87 FR 37560 to 37598) will not be completed by the time the IHA expires and a second incident harassment authorization (renewal) will allow for completion of the activities beyond the original dates and duration, provided all of the following conditions are met:

- 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 the expiration of the initial IHA;
- The request for renewal must include the following: (1) an explanation that the activities to be conducted under the proposed 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); and (2) 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.
- Upon review of the request for renewal, the status of the affected species or stocks, and any other pertinent information, NMFS Permits Division 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.

On June 23, 2022, NMFS Permits Division published a notice of proposed IHA and request for comments on proposed IHA and possible renewal in the *Federal Register* (87 FR 37560 to 37598). The public comment period closed on July 25, 2022. The NMFS Permits Division did not receive any public comments. Appendix A (see Section 19) contains the NMFS Permits Division's proposed IHA and possible renewal. The text in Appendix A (see Section 19) was

taken directly from the proposed IHA and possible renewal provided to us in the consultation initiation package.

3.2.2 Revision to Proposed Incidental Harassment Authorization

The NMFS Permits Division has made revisions to the proposed IHA since the notice was published in the *Federal Register* on June 23, 2022 (87 FR 37560 to 37598). The revisions to the proposed IHA include modifications to the requirement that PSOs are used for nighttime ramp-up procedures and the use of night vision devices.

3.2.3 Overview of Proposed Mitigation, Monitoring, and Reporting in the Incidental Harassment Authorization

In order to issue an IHA under section 101(a)(5)(D) of the MMPA, NMFS Permits Division must set forth permissible methods of taking pursuant to the activity, and other means of effecting the least practicable impact on the species or stock and its habitat, paying particular attention to rookeries, mating grounds, and areas of similar significance, and on the availability of the species or stock for taking for certain subsistence uses (latter not applicable for the proposed actions). NMFS Permits Division regulations require applicants for incidental take authorizations to include information about the availability and feasibility (economic and technological) of equipment, methods, and manner of conducting the activity or other means of effecting the least practicable adverse impact upon the affected species or stocks and their habitat (50 C.F.R. §216.104(a)(11)).

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

- The manner in which, and the degree to which, the successful implementation of the measure(s) is expected to reduce impacts to marine mammals, marine mammal species or stocks, and their habitat, as well as subsistence uses. This considers the nature of the potential adverse impact being mitigated (likelihood, scope, range). It further considers the likelihood that the measure will be effective if implemented (probability of accomplishing the mitigating result if implemented as planned), the likelihood of effective implementation (probability implemented as planned), and;
- The practicability of the measures for applicant implementation, which may consider such things as cost and impact on operations.

In order to satisfy the MMPA's least practicable adverse impact standard, NMFS Permits Division has evaluated a suite of basic mitigation protocols for seismic surveys that are required regardless of the status of a stock. Additional or enhanced protections may be required for species whose stocks are in particularly poor health and/or subject to some significant additional stressor that lessens that stock's ability to weather the effects of the specified activities without worsening its status. The NMFS Permits Division reviewed seismic mitigation protocols required or recommended elsewhere (HESS 1999; JNCC 2017; Kyhn et al. 2011; Nowacek et al. 2013),

recommendations received during public comment periods for previous actions, and the available scientific literature. The NMFS Permits Division also considered recommendations given in a number of review articles (Compton et al. 2008; Parsons et al. 2009a; Weir and Dolman 2007; Wright and Cosentino 2015). This exhaustive review and consideration of public comments regarding previous similar activities has led to development of the protocols included here.

Table 3. Proposed mitigation and monitoring protocols for the low-energy airgun array in the National Marine Fisheries Service Permits and Conservation Division's proposed incidental harassment authorization and possible renewal.

Mitigation and Monitoring Protocols	Low-Energy Airgun Array (2 Airguns with 90 in^3 Total Discharge Volume)
Vessel-Based Visual Mitigation Monitoring	Minimum of two NMFS-approved PSOs on duty during daylight hours (30 minutes before sunrise through 30 minutes after sunset); General limit of two consecutive hours on watch followed by a break of at least one hour; Maximum of 12 hours on watch per 24-hour period.
Passive Acoustic Monitoring	Not required.
Buffer Zones	200 m
Exclusion Zones	100 m (all marine mammals) 500 m (all beaked whales and *Kogia* species, large whales with calf, and an aggregation [i.e., six or more animals] of large whales)
Pre-Start Clearance and Ramp-Up Procedures	Required; 30 minute clearance period of the following zones: 200 m (all marine mammals) Following detection within zone, animal must be observed exiting or additional period of 15 or 30 minutes.
Ramp-Up Procedures	Required; activation of one airgun with the second airgun added after five minutes.
Shut-Down Procedures	Shut-down required for marine mammals detected within defined exclusion zones; re-start allowed following clearance period of 15 or 30 minutes.

Mitigation and Monitoring Protocols	Low-Energy Airgun Array (2 Airguns with 90 in^3 Total Discharge Volume)
Vessel Strike Avoidance Measures	Vigilant watch by PSOs and crew; vessel speeds reduced when assemblages of marine mammals observed near the research vessel; maintain a minimum separation distance between species of concern; avoid vessel course changes in the vicinity of marine mammals.

in^3=cubic inches; m=meters; PSO=protected species observer.

3.3 National Science Foundation, Lamont-Doherty Earth Observatory of Columbia University, and National Marine Fisheries Service's Mitigation, Monitoring, and Reporting

The NSF and L-DEO must implement mitigation measures (pre-planning and during seismic survey activities), monitoring, and reporting measures to have their action result in the least practicable adverse impact on marine mammal species or stocks and to reduce the likelihood of adverse effects to ESA-listed marine species or adverse effects on their designated critical habitats. Mitigation is a measure that avoids or reduces the severity of the effects of the action on ESA-listed species. Monitoring is used to observe or check the progress of the mitigation over time and to ensure that any measures implemented to reduce or avoid adverse effects on ESA-listed species are successful.

NSF and L-DEO indicate that it reviewed monitoring and mitigation measures implemented during seismic surveys authorized by NMFS Permits Division under previous IHAs, as well as recommended best practices in Richardson et al. (1995), Pierson et al. (2007), Weir and Dolman (2007), Nowacek et al. (2013), Wright (2014), and Wright and Consentino (2015), and has incorporated a suite of monitoring and mitigation measures into their proposed actions based on the above sources.

Under the MMPA, the NMFS Permits Division requires mitigation, monitoring, and reporting measures that the NSF and L-DEO will implement during the low-energy seismic survey, which are listed below. Additional detail for each mitigation and monitoring measure is described in subsequent sections of this consultation:

- Proposed exclusion and buffer zones;
- Shut-down procedures;
- Pre-start clearance and ramp-up procedures;
- Vessel-based visual monitoring by NMFS-approved PSOs;
- Vessel strike avoidance measures;
- Additional mitigation measures considered; and
- Reporting.

We discuss the proposed exclusion and buffer zones in more detail in the next section (see below). Additional details for the other mitigation and monitoring measures (e.g., shut-down and ramp-up procedures) as well as reporting can be found in NMFS Permits Division *Federal Register* notice of proposed IHA and possible renewal (87 FR 37560 to 37598) and Appendix A (Section 19).

3.3.1 Proposed Exclusion and Buffer Zones

The NMFS Permits Division will require, and the NSF and L-DEO will implement, exclusion and buffer 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 species. The NSF and L-DEO included mitigation and monitoring 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 shut-down of the airgun array, to reduce exposure of marine mammals or sea turtles to sound levels expected to have adverse effects on the species or habitats. 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 threshold for ESA harm (e.g., injury) and harassment. 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.

3.3.1.1 Ensonified Area

When the NMFS *Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing* (NOAA 2016) and *NOAA 2018 Revision to Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing* (NOAA 2018) were published, in recognition of the fact that ensonified area/volume can be more technically challenging to predict because of the duration component in the new thresholds, we developed a user spreadsheet that includes tools to help predict a simple isopleth that can be used in conjunction with marine mammal density or occurrence to help predict takes. We note that because of some of the assumptions included in the methods used for these tools, we anticipate that isopleths produced are typically going to be overestimates of some degree, which may result in some degree of overestimate of MMPA Level A harassment. However, these tools offer the best way to predict appropriate isopleths when more sophisticated three-dimensional modeling methods are not available, and NMFS continues to develop ways to quantitatively refine these tools, and will qualitatively address the output where appropriate. For moving sound sources such as seismic surveys, the user spreadsheet predicts the closest distance at which a stationary animal will not incur permanent threshold shift (PTS) if the sound source traveled by the animal in a straight line at a constant speed. Inputs used in the user spreadsheet and the resulting isopleths are described further in the NSF's environmental assessment and L-DEO's IHA application and NMFS Permits Division's proposed IHA and possible renewal (87 FR 37560 to 37598).

The L-DEO conducted modeling on behalf of the NSF, Oregon State University, and New Mexico Institute of Mining and Technology. The L-DEO model results are used to determine the

160 dB re: 1 µPa (rms) radius for the two GI-airgun array in deep water (greater than 1,000 meters [3,280.8 feet]) down to a maximum water depth of 2,000 meters (6,561.7 feet). 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). 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). 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 (Diebold et al. 2010; Tolstoy et al. 2009). 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 6 meters [19.7 feet]) from in the proposed seismic survey activities (2 to 4 meters [6.6 to 13.1 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 depths, the field measurements in the Gulf of Mexico cannot be used readily to derive ESA 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) (Costa and Williams 1999). 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.

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. 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). No seismic survey activities will occur in water depths less than 1,000 meters (3,280.8 feet); therefore, no shallow or intermediate water radii were obtained. A simple scaling factor is calculated from the ratios of the isopleths determined by the deep-water mode, which are essentially a measure of the energy radiated by the airgun array. The estimated distances to the 160 dB re: 1 µPa (rms) isopleths for the two GI airgun array in the deep water depth category are in Table 5.

The sound source levels (values for cumulative sound exposure level [SEL_{cum}] and peak sound pressure level [SPL]) were derived from calculating the modeled farfield signature. The farfield signature is often used as a theoretical representation of the source level. To compute the farfield signature, the source level is estimated at a large distance below the airgun array and this source level is back projected mathematically to a notional distance of 1 meter (3.3 feet) from the airgun arrays geometrical center. However, when the sound source is an airgun array of multiple airguns separated in space, the source level from the theoretical farfield signature is not necessarily the best measurement of the source level that is physically achieved at the sound source (Tolstoy et al. 2009). Near the sound source (at short ranges, distances less than 1 kilometer [0.54 nautical miles]), the pulses of sound pressure from each individual airgun in the airgun array of the sound source do not stack constructively, as they do for the theoretical farfield signature. The pulses from the different airguns spread out in time such that the sound source levels observed or modeled are the result of the summation of pulses from a few airguns, not the full airgun array (Tolstoy et al. 2009). At larger distances, away from the center of the airgun array, sound pressure of all the airguns in the airgun array stack coherently, but not within one time sample, resulting in smaller sound source levels (a few dB) than the sound source level derived from the farfield signature. Because the farfield signature does not take into account the large airgun array effect near the sound source and is calculated as a point source, the modified farfield signature is a more appropriate measure of the sound source level for distributed sound sources, such as airgun arrays. For this smaller airgun array, the modified farfield changes will be correspondingly smaller as well, but we use this method for consistency across all airgun array sizes.

NSF and L-DEO used the same acoustic modeling methodology as used for estimating the 160 dB re: 1 µPa (rms) isopleths with a small grid step of 1 meters (3.3 feet) in both the inline and depth directions to estimate the SEL_{cum} and peak SPL. The propagation modeling takes into account all airgun array interactions at short distances from the sound source, including interactions between subarrays, which are modeled using NUCLEUS software to estimate the notional signature and MATLAB software to calculate the pressure signal at each mesh point of the grid.

In order to more realistically incorporate the NMFS' technical guidance for auditory injury of marine mammals (NOAA 2018) weighting functions over the airgun array's full acoustic band,

unweighted spectrum data (modeled in 1 Hertz bands) were used to make adjustments (dB) to unweighted spectrum levels, by frequency, according to the weighting functions for each relevant marine mammal hearing group. These adjusted and weighted spectrum levels were then converted to pressures (µPa) in order to integrate them over the entire broadband spectrum, resulting in broadband weighted sound source levels by hearing group that can be directly incorporated within the user spreadsheet (i.e., to override the user spreadsheet's more simple weighting factor adjustment). Using the user spreadsheet's "safe distance" methodology for mobile sound sources (Sivle et al. 2014) with the hearing group-specific weighted sound source levels, and inputs assuming spherical spreading propagation and sound source velocities and shot intervals specific to the planned seismic survey activities, potential radial distances to auditory injury isopleths were then calculated for SEL_{cum} thresholds. The estimated distances to the isopleths for ESA harm for the two GI airgun array in each water depth category are in Table 4. More details of the modeling methodology and inputs to the user spreadsheet are in Appendix A of the NSF's IHA application.

Note that because of some of the assumptions included in the methods used (e.g., stationary receiver with no vertical or horizontal movement in response to the sound source), isopleths produced may be overestimates to some degree, which will ultimately result in some degree of overestimation of adverse effects. However, these tools offer the best way to predict appropriate isopleths when more sophisticated modeling methods are not available. NMFS continues to develop ways to quantitatively refine these tools and will qualitatively address the output where appropriate. For mobile sound sources, such as the seismic survey activities, the user spreadsheet predicts the closest distance at which a stationary animal will not incur PTS if the sound source traveled by the animal in a straight line at a constant speed.

Auditory injury is unlikely to occur for low-frequency and mid-frequency cetaceans and otariid pinnipeds given very small modeled isopleths of injury for those species (up to a maximum of 28.6 meters [93.8 feet] for low-frequency cetaceans, 0 meters (0 feet) for mid-frequency cetaceans, 0 meters [0 feet] for otariid pinnipeds, and 0.3 meters (1 feet) for sea turtles for the two GI airgun array), in context of distributed sound source dynamics. The sound source level of the airgun array is a theoretical definition assuming a point source and measurement in the farfield of the sound source (MacGillivray 2006). As described by Caldwell and Dragoset (2000a), an airgun array is not a point source, but one that spans a small area. In the farfield, individual elements in airgun arrays will effectively work as one sound source because individual pressure peaks will have coalesced into one relatively broad pulse. The airgun array can then be considered a "point source." For distances within the nearfield, i.e., approximately two to three times the airgun array dimensions, pressure peaks from individual elements do not arrive simultaneously because the observation point is not equidistant from each element. The effect is destructive interference of the outputs of each element, so that peak pressures in the nearfield will be significantly lower than the output of the largest individual element. Here, the estimated MMPA Level A harassment isopleth distances will in all cases be expected to be within the nearfield of the airgun array where the definition of sound source level breaks down.

Therefore, actual locations within this distance of the center of the airgun array where the sound level exceeds relevant criteria for MMPA Level B harassment will not necessarily exist. The NMFS Permits Division do not propose to authorize any MMPA Level A harassment for these species.

3.3.1.2 Establishment of Proposed Exclusion and Buffer Zones

An exclusion zone is a defined area within which occurrence of a marine mammal or sea turtle triggers mitigation action intended to reduce the potential for certain outcomes (e.g., auditory injury, disruption of critical behaviors or behavioral patterns). PSOs will establish a default (minimum) exclusion zone with a 100 meter (328.1 feet) radius for visual monitoring for the two GI airgun arrays during the low-energy seismic survey. The exclusion zones 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 research vessel itself).

The buffer zone means an area beyond the exclusion zone to be monitored for the presence of marine mammals that may enter the exclusion zone. PSOs will also establish and monitor a 200 meter (656.2 feet) buffer zone for the low-energy seismic survey. During use of the sound source, occurrence of marine mammals and sea turtles within the buffer zone (but outside the exclusion zone) will be communicated to the operator to prepare for potential shut-down of the airgun array.

The 100 meter (328.1 feet) exclusion zone, with additional 100 meter (328.1 feet) buffer zone, are intended to be precautionary in the sense that it will be expected to contain sound exceeding the injury criteria for all cetacean and pinniped hearing groups (based on the dual criteria of SEL_{cum} and peak SPL), while also providing a consistent, reasonably observable zone within which PSOs will typically be able to conduct effective observational effort. Additionally, the exclusion zone is expected to minimize the likelihood that marine mammals will be exposed to sound levels likely to result in more severe behavioral responses. Although significantly greater distances may be observed from an elevated platform under good conditions, we believe that this distance is regularly attainable for PSOs using binoculars and the naked eye during typical conditions. In this case, the 100 meter (328.1 feet) radial distance will also be expected to contain sound levels that will exceed the ESA harm threshold based on SEL_{cum} criteria for all marine mammal hearing groups and sea turtles. In the 2011 *Final Programmatic Environmental Impact Statement/Overseas Environmental Impact Statement for Marine Seismic Research Funded by the National Science Foundation or Conducted by the U.S. Geological Survey* (USGS and NSF 2011), Alternative B (the Preferred Alternative) conservatively applied a 100 meter (328.1 feet) exclusion zone for all low-energy sound sources in water depths greater than 100 meters (328.1 feet), with low-energy sound sources defined as any towed acoustic source with a single or a pair of clustered airguns with individual volumes of less than or equal to 250 cubic inches. Thus, the 100 meter (328.1 feet) exclusion zone proposed for this low-energy seismic survey is consistent.

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

Table 4. Predicted distances to permanent threshold shift for impulsive sources for various marine mammal hearing groups and sea turtles that could be received from the two Generator Injector airgun array during the proposed low-energy seismic survey in the Northeast Pacific Ocean (NSF 2021).

Threshold	Low Frequency Cetaceans (m)	Mid-Frequency Cetaceans (m)	Otariid Pinnipeds (m)	Sea Turtles (m)
Source – 2 GI Airgun Array				
SEL_{cum}	28.6	0	0	0.3
Peak SPL_{flat}	5.6	1.1	0.4	0.4

m=meters, SEL_{cum}=cumulative sound exposure level, SPL=sound pressure level

The NSF and L-DEO's draft environmental assessment and IHA application have a detailed description of the modeling for the R/V *Marcus G. Langseth*'s two GI airgun array at a tow depth of 2 to 4 meters (6.6 to 13.1 feet) as well as the resulting isopleths to thresholds for the various marine mammal hearing groups (Table 5). The sound levels and distances for this airgun array configuration will be used in the ensuing analysis, as it has the greatest energy output of the proposed configurations (2 to 4 meters [6.6 to 13.1 feet]); therefore, it is the most conservative approach. Predicted distances to MMPA Level A harassment isopleths, which vary based on marine mammal hearing groups, were calculated based on modeling performed by L-DEO using the NUCLEUS source modeling software program and the NMFS user spreadsheet (https://www.fisheries.noaa.gov/action/user-manual-optional-spreadsheet-tool-2018-acoustic-technical-guidance). The largest distance of the dual criteria (SEL_{cum} or Peak SPL_{flat}) was used to calculate MMPA Level A harassment and threshold distances for marine mammals. The 160 dB re: 1 µPa (rms) isopleth is the distance at which MMPA Level B harassment is expected to occur (see Table 5). The 175 dB re: 1 µPa (rms) isopleth represents our best understanding of the threshold at which sea turtles exhibit behavioral responses to seismic airgun arrays (see Table 6).

Table 5. Predicted distances to which sound levels of 160 re: 1 µPa (rms) for harassment (Marine Mammal Protection Act Level B harassment) for impulsive sound sources will be received from the two Generator Injector airgun array in deep water depths for marine mammals during the proposed low-energy seismic survey in the Northeast Pacific Ocean (NSF 2021).

Source	Volume (in^3)	Tow Depth (m)	Water Depth (m)	Predicted Distance to Threshold (160 dB re: 1 µPa [rms]) (m)
2 (45/105 in^3) GI Airgun Array	90	4	Greater than 1,000	553

in^3=cubic inches, m=meters, GI=Generator Injector

The NSF and L-DEO will implement an exclusion zone for sea turtles. An exclusion zone of 100 meters (328.1 feet) will be used as a shutdown distance for sea turtles for the two GI airgun array. 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 PTS. The buffer zone will correspond to the predicted 175 dB re: 1 Pa (rms) behavioral threshold distances to which sound source levels will be received from the two GI airgun array in deep water depths described in Table 6.

Table 6. Predicted distances to which sound levels of 175 re: 1 µPa (rms) for harassment for impulsive sound sources will be received from the two Generator Injector airgun array in deep water depths for sea turtles during the proposed low-energy seismic survey in the Northeast Pacific Ocean.

Source	Volume (in^3)	Tow Depth (m)	Water Depth (m)	Predicted Distance to Threshold (175 dB re: 1 µPa [rms]) (m)
2 (45/105 in^3) GI Airgun Array	90	4	Greater than 1,000	98

in^3=cubic inches, m=meters, GI=Generator Injector

An extended exclusion zone of 500 meters (1,640.4 feet) for the low-energy seismic survey, will be implemented for all beaked whales, dwarf and pygmy sperm whales, killer whales, aggregations of six or more large whales (i.e., any baleen whale or sperm whale) and/or a large whale with a calf (calf is defined as an animal less than two-thirds the body size of an adult observed to be in close association with an adult). No buffer of this extended exclusion zone is required.

A recent retrospective analysis of acoustic propagation of the sound sources on the R/V *Marcus G. Langseth* in a coastal/continental shelf environment from the Cascadia Margin off Washington suggests that predicted (modeled) isopleths were two to three times larger than measured in shallow water, so they are expected to be very conservative (Crone et al. 2014). Similarly, data collected by Crone et al. (2017) during a high-energy seismic survey off New Jersey in 2014 and 2015 confirmed that in situ measurements and estimates of the 160 dB re: 1 µPa (rms) distances collected by the towed hydrophone streamer on the R/V *Marcus G. Langseth* were two to three times smaller than the predicted isopleths. These comparisons of the modeling done by L-DEO with in situ received sound levels have confirmed that the isopleths generated for this low-energy seismic survey are conservative and likely larger (more protective) than those described in the NMFS *Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing* (NOAA 2016) and *NOAA 2018 Revision to Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing* (NOAA 2018).

3.3.2 Shut-Down Procedures

The shut-down of the airgun array requires the immediate de-activation of all individual elements of the airgun array. Any PSO on duty will have the authority to delay the start of seismic survey activities or to call for shut-down of the airgun array if a marine mammal 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 shut-down commands are conveyed swiftly while allowing PSOs to maintain watch. When the airgun array is active (i.e., anytime one or more airgun is active, including during ramp-up) and a marine mammal appears within or enters the applicable exclusion zone the airgun array will be shut-down. When shut-down is called for by a PSO, the airgun array will be immediately deactivated and any dispute resolved only following deactivation.

Following a shut-down, airgun array activity will not resume until the marine mammal has cleared the exclusion zone. The animal will be considered to have cleared the exclusion zone if it is visually observed to have departed the exclusion zone, or if it has not been seen within the 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, beaked whales, dwarf and pygmy sperm whales, pilot whales, killer whales, and Risso's dolphins, with no further observation of the marine mammal(s).

This shut-down procedure requirement will be in place for all marine mammals, with the exception of small delphinids under certain circumstances.

As described above, auditory injury is extremely unlikely to occur for mid-frequency cetaceans (e.g., sperm whales and most delphinids), as this group is relatively insensitive to sound produced at the predominant frequencies in an airgun pulse while also having a relatively high threshold for the onset of auditory injury (i.e., PTS).

Visual PSOs will use best professional judgement in making the decision to call for a shut-down if there is uncertainty regarding identification (i.e., whether the observed marine mammal[s] belongs to one of the delphinid genera for which shut-down is waived or one of the species with a larger exclusion zone).

Upon implementation of shut-down, the airgun array 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 all mysticetes and large odontocetes [including sperm whales, beaked whales, dwarf and pygmy sperm whales, pilot whales, killer whales, and Risso's dolphins]) with no further observation of marine mammal(s). Shut-down of the airgun array will also be required upon observation of a marine mammal species for which authorization has not been granted, or a marine mammal species for which authorization has been granted but the authorized number of takes are met, observed approaching, or within MMPA Level A and Level B harassment zones.

In addition to the shut-down procedure described above, the NMFS Permits Division's MMPA IHA will require the airgun array be shut-down at a distance of 500 meters (1,640.4 feet) when:

- any large whale (defined as 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); and/or
- an aggregation of six or more large whales is observed; and/or
- a North Pacific right whale is observed.

The NSF and L-DEO will implement a shut-down at any distance when:

- a large whale with calf; and/or
- a concentrations of large whales (group of six or more); and/or
- a North Pacific right whale is observed.

More details on shut-down procedures can be found in Appendix A, which contains the NMFS Permits Division's proposed IHA and possible renewal, (Section 19) of this consultation.

3.3.3 Pre-Start Clearance and Ramp-Up Procedures

Ramp-up (sometimes referred to as "soft-start") means the gradual and systematic increase of emitted sound levels from an airgun array. The intent of ramp-up is to warn protected species of pending seismic survey activities (if the sound source is sufficiently aversive) and to allow sufficient time for those animals to leave the immediate vicinity prior to the sound source reaching full intensity. 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. 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 airgun arrays are active (e.g.,

for the low-energy seismic survey, the second airgun will be activated after five minutes). The intent of pre-start 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-start clearance is the only time observations of protected species in the buffer zone will prevent operations (i.e., the beginning of ramp-up). Two PSOs will be required to monitor during ramp-up. Operators must adhere to the following pre-start clearance and ramp-up requirements:

- Thirty minutes of pre-start clearance observation of the exclusion and buffer zone is required prior to ramp-up for any shut-down of longer than 30 minutes (e.g., when the airgun array is shut-down during transits from one trackline to another). This pre-start clearance period may occur during any vessel activity (e.g., transit). If any marine mammal is observed within or approaching the exclusion or buffer zone during the 30 minute pre-start clearance period, ramp-up may not begin until the animal(s) has been observed exiting the exclusion zone or until an additional time period has elapsed with no further sightings (i.e., 15 minutes for small odontocetes, and 30 minutes for all other odontocetes, including sperm whales and beaked whales).
- The operator must notify a designated PSO of the planned start of ramp-up as agreed upon with the lead PSO;
- The notification time must not be less than 60 minutes prior to the planned ramp-up in order to allow the PSOs time to monitor the exclusion zone and buffer zone for 30 minutes prior to the initiation of ramp-up (pre-start clearance);
- Ramp-ups must 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-start 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 mammal is within or approaching the applicable exclusion zone or buffer zone. If a marine mammal is observed within the applicable exclusion zone or the buffer zone during ramp-up, a shut-down must be implemented as though the full airgun array were operational. Ramp-up may not begin until the animal(s) has been observed exiting the exclusion or buffer zones 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 large odontocetes [including sperm whales, dwarf sperm whales, pygmy sperm whales, beaked whales, pilot whales, killer whales, and Risso's dolphins]).
- Ramp-up will begin by activating a single airgun, and the second airgun will be added after a five minute duration;
- PSOs must monitor the exclusion and buffer zones during ramp-up, and ramp-up may not be initiated or must cease and the airgun array must be shut-down upon observation of a marine mammals within the applicable exclusion zone. Once ramp-up has begun,

detections 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, where operational planning cannot reasonably avoid such circumstances. Ramp-up may occur at night and during poor visibility if the exclusion and buffer zone have been continually monitored by PSOs for 30 minutes prior to ramp-up;
- 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 monitoring and no visual detections of marine mammals have occurred within the applicable exclusion zone. For any longer shut-down, pre-start clearance observation and ramp-up are required. For any shut-down at night or in periods of poor visibility (e.g., Beaufort sea state four or greater), ramp-up is required, but if the shut-down period was brief and constant observation was maintained, pre-start clearance watch of 30 minutes is not required; and
- Testing of the airgun array involving all elements requires normal mitigation protocols (e.g., ramp-up). Testing limited to individual sound source elements of the airgun array does not require ramp-up but does require pre-start clearance (visual monitoring).

More details on pre-start clearance and ramp-up procedures can be found in Appendix A, which contains the NMFS Permits Division's proposed IHA and possible renewal (Section 19), of this consultation.

3.3.4 Vessel-Based Visual Mitigation Monitoring

Visual monitoring requires the use of trained PSOs to scan the ocean surface visually for the presence of protected species (e.g., marine mammals, sea turtles, and fish). The area to be scanned visually includes primarily the exclusion zone, within which observation of certain protected species requires shut-down of the airgun array, but also the buffer zone. The buffer zone means an area beyond the exclusion zone to be monitored for the presence of marine mammals that may enter the exclusion zone. During pre-start 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 within the buffer zone will also prevent airgun array operations from beginning (i.e., ramp-up). The standard exclusion zone is 100 meters (328.1 feet) for low-energy seismic surveys from the edges of the airgun array. For low-energy seismic surveys, the buffer zone encompasses the area at and below the sea surface from the edge of the 0 to 100 meter (0 to 328.1 feet) exclusion zone, out to a radius of 200 meters (656.2 feet) from the edges of the airgun array (100 to 200 meters [1,640.4 to 3,280.8 feet]).

Visual monitoring of the exclusion zones and adjacent waters (buffer zone) is intended to establish and, when visual conditions allow, maintain zones around the sound source that are clear of marine mammals, thereby reducing or eliminating the potential for injury and minimizing the potential for more severe behavioral reactions for animals occurring closer to the research 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-start 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 that are outside of, but may approach and enter, the exclusion zone.

The NSF and L-DEO must use at least three independent, dedicated, trained, NMFS-approved PSOs aboard the R/V *Marcus G. Langseth*. The PSOs will have rotating shifts to monitor for protected species. Two PSOs will be on visual watch at all times during daytime hours (and nighttime ramp-ups, if applicable). A third PSO will be available on standby via radio to assist with sighting documentation if needed. The operator will work with the selected third-party PSO provider to ensure the PSOs have all the equipment (including backup equipment) needed to adequately perform necessary tasks, including accurate determination of distance and bearing to observed marine mammals.

PSOs must have the following requirements and qualifications:

- PSOs must be independent, dedicated, trained visual PSOs and must be employed by a third-party observer provider;
- PSOs must have no tasks other than to conduct observational effort, collect and record observation data, and communicate with and instruct relevant vessel crew with regard to the presence of protected species (marine mammals, sea turtles, and fish) and mitigation requirements (including brief alerts regarding maritime hazards);
- PSO must have successfully completed an approved PSO training course. PSOs must have successfully completed relevant training, including completion of all required coursework and passing a written and/or oral examination developed for the training program;
- NMFS must review and approve PSO resumes accompanied by a relevant training course information packet that includes the name and qualifications (i.e., experience, training completed, or educational background) of the instructor(s), the course outline or syllabus, and course reference material as well as a document stating successful completion of the course;
- NMFS should have one week to approve PSOs from the time that the necessary information is submitted, after which PSOs meeting the minimum requirements must automatically be considered approved;
- PSOs must successfully complete relevant training, including completion of all required coursework and passing (80 percent or greater) a written and/or oral examination developed for the training program;
- PSOs must have successfully attained a bachelor's degree from an accredited college or university with a major in one of the natural sciences, a minimum of 30 semester hours or equivalent in the biological sciences, and at least one undergraduate courses in math or statistics; and

- The educational requirements may be waived if the PSO has acquired the relevant skills through alternate experience. Requests for such a waiver should be submitted to NMFS and must include written justification. Requests should 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 must demonstrate good standing and consistently good performance of PSO duties.

At least one of the visual PSOs aboard the research vessel must have a minimum of 90 days at-sea experience working in that role during shallow penetration or low-energy seismic surveys, with no more than 18 months elapsed since the conclusion of the at-sea experience. One visual PSO with such experience should be designated as the lead for the entire PSO team. The lead PSO should serve as the primary point of contact for the vessel operator and ensure all PSO requirements per the MMPA IHA 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 should coordinate to ensure 360 degree visual coverage around the research vessel from the most appropriate observation positions, and must conduct visual observations using reticled binoculars and the naked eye while free from distractions and in a consistent, systematic, and diligent manner.

PSOs will establish and monitor the buffer and exclusion zones. The buffer and exclusion zones will be based upon the radial distance from the edges of the airgun array (rather than being based on the center of the airgun array or around the research vessel itself). During use of the airgun array (i.e., anytime the airgun array is active, including ramp-up), occurrences of marine mammals within the buffer zone (but outside the exclusion zone) will be communicated to the operator to prepare for the potential shut-down of the airgun array.

Any observations of marine mammals by crew members will be relayed to the PSO team. During good conditions (e.g., daylight hours, Beaufort sea state three or less), visual PSOs will conduct visual observations when the airgun array is not operating (e.g., while the airgun array and towed hydrophone streamer are being deployed or recovered from the water, during transits) 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 general limit of two consecutive hours (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. However, during off-hours the resting PSO may be called for consultation if a second opinion be needed. Other vessel crew will also be instructed to assist in detecting marine mammals and implementing mitigation requirements, if practical. Before the start of the low-energy seismic survey, the crew will be given additional instruction in detecting marine mammals and implementing mitigation measures. PSOs will be in communication (e.g., direct radio contact) with the research vessel's officers on the bridge and scientists in the laboratory during seismic survey activities so that they can advise promptly of the need for the implementation of shut-down procedures of the airgun array or vessel strike avoidance measures. The vessel operators, science support personnel, and science party must comply immediately with the PSO's call to shut-down the airgun array or for vessel strike avoidance measures.

When visual PSOs are stationed on the observation platform of the R/V *Marcus G. Langseth*, eye level will be approximately 21.5 meters (70.5 feet) above sea level, and the position provides an approximate 360 degree view around the research vessel. Visual PSOs will systematically scan around the research vessel with Big-Eye reticle binoculars (25 x 150), handheld reticle binoculars (e.g., 7 x 50 Fujinon), and with the naked eye. PSOs will also have night vision devices (ITT F500 Series Generation 3 binocular-image intensifier or equivalent) during darkness, if necessary. At a minimum the night, the night vision device should feature automatic brightness and gain control, bright light protection, infrared illumination, and optics suited for low-light situations. At least one PSO will conduct visual monitoring at all times during daytime periods when the R/V *Marcus G. Langseth* is underway when not conducting seismic survey activities, such as during transits.

For data collection purposes, 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 sound 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 shut-down was implemented, the length of time before any subsequent ramp-up of the airgun array. If required mitigation was not implemented, PSO shall record a description of the circumstances. At a minimum, the following information must be recorded:

- Vessel name and call sign;
- PSO names and affiliations;
- Dates of departures and returns to port with port name;
- Date and participants of PSO briefings;

- Dates and times (Greenwich Mean Time) of survey effort and times corresponding with PSO effort;
- Vessel location (latitude/longitude) when survey effort began and ended and vessel location at beginning and end of visual PSO duty shifts;
- Vessel heading and speed at beginning and end of visual PSO duty shifts and upon any line change;
- Environmental conditions while on visual survey (at beginning and end of PSO shift and whenever conditions changed significantly), including Beaufort sea state and any other relevant weather conditions including cloud cover, fog, sun glare, and overall visibility to the horizon;
- Factors that may have contributed to impaired observations during each PSO shift change or as needed as environmental conditions changed (e.g., vessel traffic, equipment malfunctions); and
- Survey activity information, such as sound source power output while in operation, number and volume of airguns operating in the airgun array, tow depth of the airgun array, and any other notes of significance (i.e., pre-start clearance, ramp-up, shut-down, testing, shooting, ramp-up completion, end of operations, streamers, etc.).

The following information must be recorded upon visual observation of any protected species:

- Watch status (sighting made by PSO on/off effort, opportunistic, crew, alternate vessel/platform);
- PSO who sighted the animal;
- Time of sighting;
- Vessel location at time of sighting;
- Water depth;
- Direction of vessel's travel (compass direction);
- Direction of animal's travel relative to the vessel;
- Pace of the animal;
- Estimated distance to the animal and its heading relative to vessel at initial sighting;
- 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;
- Estimated number of animals (high/low/best);
- Estimated number of animals by cohort (adults, yearlings, juveniles, calves, group composition, etc.);
- 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);
- 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);

- Animal's closest point of approach and/or closest distance from any element of the sound source;
- Platform activity at time of sighting (e.g., deploying, recovering, testing, shooting, data acquisition, other); and
- Description of any actions implemented in response to the sighting (e.g., delays, shut-down, ramp-up) and time and location of the action.

Mitigation and monitoring will be recorded in a standardized format and data will be entered into an electronic database. The accuracy of the data entry will be verified by computerized data validity checks as data are entered and by subsequent manual checking of the database. These procedures will allow initial summaries of the data to be prepared during and after the seismic survey activities, and will facilitate transfer of the data to statistical, graphical, and other programs for further processing and archiving.

More details on monitoring can be found in Appendix A, which contains NMFS Permits Division's proposed IHA and possible renewal (Section 19), of this consultation.

3.3.5 Vessel Strike Avoidance Measures

Vessel strike avoidance measures are intended to minimize the potential for collisions with marine mammals. These vessel strike avoidance measures include the following:

- The vessel operator (R/V *Marcus G. Langseth*) and crew will maintain a vigilant watch for all protected species and slow down or stop or alter course of the vessel, as appropriate and regardless of vessel size, to avoid striking any protected species 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 (specific distances detailed below), 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 from other phenomena and broadly to identify a marine mammal 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 any marine mammals are observed near the vessel.
- The vessel (R/V *Marcus G. Langseth*) must maintain a minimum separation distance of 500 meters (1,640.4 feet) from North Pacific right whales. If a whale is observed but cannot be confirmed as a species other than a North Pacific right whale, the vessel operator must assume that it is a North Pacific right whale and take appropriate action.

- The vessel (R/V *Marcus G. Langseth*) must maintain a minimum separation distance of 100 meters (1,640.2 feet) from large whales (i.e., all baleen whales and sperm whales). The following vessel avoidance measures will be taken if a large whale is within 100 meters (328.1 feet) of the vessel:
    - The vessel (R/V *Marcus G. Langseth*) will reduce speed and shift the engine to neutral, when feasible, and will not engage the engines until the whale has moved outside of the vessel's path and the minimum separation distance has been established.
    - If the vessel is stationary, the vessel will not engage engines until the whale(s) has moved out of the vessel's path.
- The vessel will maintain a minimum separation distance of 50 meters (164 feet) from all other marine mammals, with an understanding that at times this may not be possible (e.g., for animals that approach the vessel).
- When protected species are sighted while a vessel is underway, the vessel must take action as necessary to avoid violating the relevant separation distance (e.g., attempt to remain parallel to the animal's source, avoid excessive speed or abrupt changes in direction until the animal has left the area). If protected species are sighted within the relevant separation distance, the vessel must reduce speed and shift the engine to neutral, not engaging the engines until the animal(s) are clear of area. This recommendation does not apply to any vessel towing gear or any vessel that is navigationally constrained.
- 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.

3.3.6 Additional Mitigation Measures Considered

Additional mitigation measures were considered by the NSF and L-DEO during the planning phase of the proposed seismic survey activities to reduce the severity of the effects of the action on ESA-listed species. Additional detail is described below in this consultation.

3.3.6.1 Sound Source

The NSF and L-DEO considered and evaluated whether the research objectives could be met with a smaller sound source for the proposed low-energy seismic survey. The NSF and L-DEO determined that the sound source proposed already are relatively small (the data acquisition will use a two GI airgun array), and scientific objectives for the proposed low-energy seismic survey could not be met using smaller sound sources. The airgun array being used for the proposed action is one of the smaller sound sources used by the U.S. academic research community to conduct research during seismic survey activities. Based on experience, the principal investigators have found that this sound source (two GI airgun array) is considered the minimum that will provide sufficient energy to image the stratigraphy and underlying structure.

3.3.6.2 Speed or Course Alteration

The NSF will alter the R/V *Marcus G. Langseth*'s speed and course during seismic survey activities if a marine mammal, based on its position and relative motion, appears likely to enter the exclusion zone (100 meters [328.1 feet]). Speed and course alteration will be implemented if operationally practicable and meets safety requirements while minimizing the effect on the planned scientific objectives. The seismic survey activities and movements of the protected species (relative to the research vessel) will be closely monitored to determine whether the animal is approaching the applicable exclusion zone. If speed or course alteration is not safe or practical (e.g., without damaging deployed equipment) or, if after alteration, the marine mammal still appears likely to enter the exclusion zone (100 meters [328.1 feet]), further mitigation measures (such as shut-down procedures) will be taken. Typically, during seismic survey activities, the R/V *Marcus G. Langseth* is unable to change speed and course and one or more alternative mitigation measures will need to be implemented.

3.3.6.3 Location and Timing

The principal investigators worked with the NSF, L-DEO, and its contractors to consider and identify potential times to carry out the low-energy seismic survey, taking into consideration key factors such as environmental conditions (e.g., seasonal presence of marine mammals, sea turtles, and seabirds), weather conditions, equipment, and optimal timing for other proposed research cruises using the R/V *Marcus G. Langseth*. Although marine mammals (including baleen whales) and sea turtles are expected to occur regularly in the seismic survey area, the summer schedule (August) is proposed as it is the most practical season based on operational requirements and data quality concerns. The density of cetacean species is only available for combined summer/fall in the action area. A higher density of pinniped species, in particular Guadalupe fur seals, are expected to occur in the action area during the summer. Marine mammals (e.g., sperm whales) inhabit the action area year-round.

The seismic survey locations were chosen to provide a variety of fluid flow environments of the subducting tectonic plate along the Cascadia margin. The seismic survey activities are proposed to study geologic processes at the Cascadia Subduction Zone. At the Cascadia Subduction Zone, the slow ongoing descent of the Juan de Fuca plate beneath the northwestern coast of North America has generated large earthquakes and associated tsunamis in the past in the heavily population region of the Pacific Northwest which motivates significant scientific interest and public safety concerns. The proposed low-energy seismic survey underwent the NSF merit review process, and the science, including the site location, was determined to be meritorious.

3.3.7 Reporting

In order to issue an IHA for an activity, section 101(a)(5)(D) of the MMPA states that NMFS Permits Division must set forth requirements pertaining to the monitoring and reporting of such taking. The MMPA implementing regulations at 50 C.F.R. §216.104(a)(13) indicate that requests for IHAs must include the suggested means of accomplishing the necessary monitoring and

reporting that will result in increased knowledge of the species and of the level of taking or impacts on populations of marine mammals that are expected to be present in the action area while conducting the seismic survey activities. Effective reporting is critical both to compliance of the MMPA IHA as well as ensuring that the most value is obtained from the required monitoring.

Monitoring and reporting requirements prescribed by NMFS Permits Division will contribute improved understanding of one or more of the following:

- Occurrence of marine mammal species or stocks in the area in which take is anticipated (e.g., presence, abundance, distribution, density).
- Nature, scope, or context of likely marine mammal exposure to potential stressors/impacts (individual or cumulative, acute or chronic), through better understanding of (1) action or environment (e.g., source characterization, propagation, ambient noise); (2) affected species (life history, diver patterns); (3) co-occurrence of marine mammal species with the action; or (4) biological or behavioral context of exposure (e.g., age, calving, or feeding areas).
- Individual marine mammal responses (behavioral or physiological) to acoustic stressors (acute, chronic, or cumulative), other stressors, or cumulative impacts from multiple stressors.
- How anticipated responses to stressors impact either (1) long-term fitness and survival of individual marine mammals; or (2) populations, species, or stocks.
- Effects on marine mammal habitat (e.g., marine mammal prey species, acoustic habitat, or other important physical components of marine mammal habitat).
- Mitigation and monitoring effectiveness.

To support NMFS' goal of improving our understanding of occurrence of marine mammal species or stocks in the action area (e.g., presence, abundance, distribution, density), NSF and L-DEO will immediately report observations of Southern Resident DPS of killer whales or North Pacific right whales to NMFS Office of Protected Resources. Although the likelihood of encountering either species is considered to be rare and unexpected.

NSF and L-DEO must submit a draft comprehensive report to NMFS Permits Division within 90 days of the completion of the low-energy seismic survey or expiration of the IHA, whichever comes sooner. The report will describe the seismic survey activities that were conducted and sightings of marine mammals near the proposed actions. The report will provide full documentation of methods, results, and interpretation pertaining to all monitoring and will summarize the dates and locations of seismic survey activities, and all marine mammal sightings (dates, times, locations, activities, associated seismic survey activities). The report will also include estimates of the number and nature of exposures that occurred within estimated harassment zones based on PSO observations and including an estimate of those that were not detected, in consideration of both the characteristics and behaviors of the species of marine mammals that affect detectability as well as the environmental factors that affect detectability.

The draft report shall also include geo-referenced time-stamped vessel tracklines for all time periods during which the airgun array were operating. Tracklines shall include points recording any change in the airgun array status (e.g., when the airgun array began operating, when they were turned off, or when they changed from full airgun array to single airgun or vice versa). Geographic information system (GIS) files shall be provided in Esri (a GIS company) shapefile format and include the coordinated universal time (UTC) date and time, latitude in decimal degrees, and longitude in decimal degrees. All coordinates shall be referenced to the WGS84 geographic coordinate system. In addition to the report, all raw observational data shall be made available to NMFS Permits Division. The report must summarize the data collected as described above and in the IHA. A final report must be submitted within 30 days following resolution of any comments on the draft report.

More details on reporting (e.g., reporting injured or dead marine mammals) and actions to minimize additional harm to live-stranded (or milling) marine mammals can be found in Appendix A, which contains NMFS Permits Division's proposed IHA and possible renewal (Section 19), of this consultation.

4 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).

The proposed actions will take place between approximately 42 to 47 degrees North, 125 to 127 degrees West off the coastline of Oregon and Washington in the Northeast Pacific Ocean. The low-energy seismic survey will take place in the Exclusive Economic Zone of the U.S. in water depths greater than approximately 1,600 meters (5,249.3 feet). Tracklines could occur anywhere within the coordinates of the four survey regions, which are shown in Figure 3. No representative tracklines are shown in the boxes, as actual tracklines and order of seismic survey operations are dependent on data collected in situ and weather. The tracklines shown in the boxes in Figure 3 have a total length of approximately 1,135 kilometers (612.9 nautical miles. The tracklines will occur in four survey regions in the Northeast Pacific Ocean: Coast (200 kilometers [108 nautical miles], Nubbin (95 kilometers [51.3 nautical miles]), Pseudofault (440 kilometers [237.6 nautical miles]), and Oregon (400 kilometers [216 nautical miles]). The order of the seismic survey activities in the various survey regions will be determined when airgun array operations commence and will depend on a variety of reasons such as science drivers, poor data quality, inclement weather, or mechanical issues with the equipment and/or research vessel. The tracklines can occur anywhere within the coordinates of the survey regions noted in Figure 1. 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 low-energy seismic survey. The R/V *Marcus G. Langseth* is expected to leave from and return to the port of Newport, Oregon. The port locations may be subject to change. The action area (the study area and the transit to/from Newport, Oregon) will not extend beyond the area shown in Figure 1.

We do not anticipate any effects (see Sections 6, 7, and 10) outside the area shown on the maps in Figure 3.

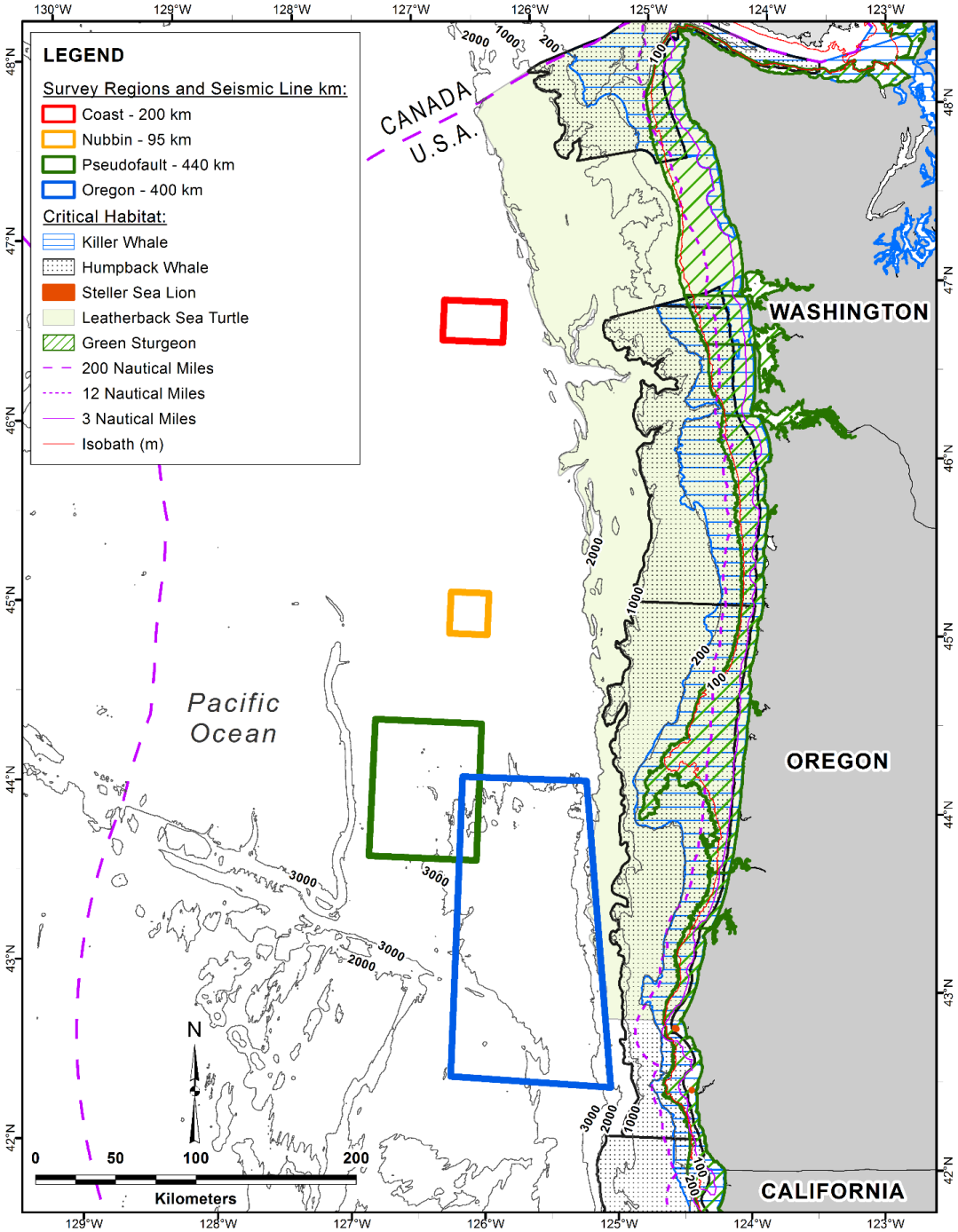

Figure 3. Map of the National Science Foundation and Lamont-Doherty Earth Observatory's low-energy seismic survey in the Northeast Pacific Ocean and National Marine Fisheries Service Permits Division's proposed issuance of an incidental harassment authorization and possible renewal for this consultation.

5 Endangered Species Act-Listed Species and Designated Critical Habitat Present in the Action Area

This section identifies the ESA-listed species and designated critical habitat that potentially occur within the action area (Table 7) that may be affected by the proposed actions. These ESA-listed species and designated critical habitat are subject in this consultation because they co-occur with the potential stressors produced by the proposed actions in space and time.

Marine mammals are expected to occur in the seismic survey area in both offshore and inshore waters. Migratory baleen whales, sperm whales, Guadalupe fur seals, and leatherback turtles are likely more common in the offshore region during summer, but other animals like Southern Resident DPS of killer whales and feeding humpback whales are expected to occur closer to shore.

Table 7. Endangered Species Act-listed threatened and endangered species and designated critical habitat potentially occurring in the action area that may be affected by the National Science Foundation and Lamont-Doherty Earth Observatory's low-energy seismic survey in the Northeast Pacific Ocean and National Marine Fisheries Service Permits Division's proposed issuance of an incidental harassment authorization and possible renewal.

Species	ESA Status	Critical Habitat	Recovery Plan
Marine Mammals – Cetaceans			
Blue Whale (*Balaenoptera musculus*)	E – 35 FR 18319	-- --	07/1998 10/2018 - Draft
Fin Whale (*Balaenoptera physalus*)	E – 35 FR 18319	-- --	75 FR 47538 07/2010
Gray Whale (*Eschrichtius robustus*) Western North Pacific DPS	E – 35 FR 18319	-- --	-- --
Humpback Whale (*Megaptera novaeangliae*) – Central America DPS	E – 81 FR 62259	86 FR 21082	11/1991 06/2022 (Outline)
Humpback Whale (*Megaptera novaeangliae*) – Mexico DPS	T – 81 FR 62259	86 FR 21082	11/1991 06/2022 (Outline)
Killer whale (*Orcinus orca*) – Southern Resident DPS	E – 70 FR 69903 Amendment 80 FR 7380	71 FR 69054 86 FR 41668	73 FR 4176 01/2008
North Pacific Right Whale (*Eubalaena japonica*)	E – 73 FR 12024	73 FR 19000	78 FR 34347 06/2013
Sei Whale (*Balaenoptera borealis*)	E – 35 FR 18319	-- --	12/2011

Species	ESA Status	Critical Habitat	Recovery Plan
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
Leatherback Turtle (*Dermochelys coriacea*)	E – 35 FR 8491	44 FR 17710 and 77 FR 4170	10/1991 – U.S. Caribbean, Atlantic, and Gulf of Mexico 63 FR 28359 05/1998 – U.S. Pacific
Loggerhead Turtle (*Caretta caretta*) – North Pacific Ocean DPS	E – 76 FR 58868	-- --	63 FR 28359
Olive Ridley Turtle (*Lepidochelys olivacea*) – Mexico's Pacific Coast Breeding Colonies	E – 43 FR 32800	-- --	63 FR 28359
Fishes			
Chinook Salmon (*Oncorhynchus tshawytscha*) – California Coastal ESU	T – 70 FR 37160	70 FR 52488	81 FR 70666
Chinook Salmon (*Oncorhynchus tshawytscha*) – Central Valley Spring-Run ESU	T – 70 FR 37160	70 FR 52488	79 FR 42504
Chinook Salmon (*Oncorhynchus tshawytscha*) – Lower Columbia River ESU	T – 70 FR 37160	70 FR 52629	78 FR 41911
Chinook Salmon (*Oncorhynchus tshawytscha*) – Puget Sound ESU	T – 70 FR 37160	70 FR 52629	72 FR 2493
Chinook Salmon (*Oncorhynchus tshawytscha*) – Sacramento River Winter-Run ESU	E – 70 FR 37160	58 FR 33212	79 FR 42504
Chinook Salmon (*Oncorhynchus tshawytscha*) – Snake River Fall-Run ESU	T – 70 FR 37160	58 FR 68543	80 FR 67386 (Draft)

Species	ESA Status	Critical Habitat	Recovery Plan
Chinook Salmon (*Oncorhynchus tshawytscha*) – Snake River Spring/Summer-Run ESU	T – 70 FR 37160	64 FR 57399	81 FR 74770 (Draft) 11-2017-Final
Chinook Salmon (*Oncorhynchus tshawytscha*) – Upper Columbia River Spring-Run ESU	E – 70 FR 37160	70 FR 52629	72 FR 57303
Chinook Salmon (*Oncorhynchus tshawytscha*) – Upper Willamette River ESU	T – 70 FR 37160	70 FR 52629	76 FR 52317
Chum Salmon (*Oncorhynchus keta*) – Columbia River ESU	T – 70 FR 37160	70 FR 52629	78 FR 41911
Chum Salmon (*Oncorhynchus keta*) – Hood Canal Summer-Run ESU	T – 70 FR 37160	70 FR 52629	72 FR 29121
Coho Salmon (*Oncorhynchus kisutch*) – Central California Coast ESU	E – 70 FR 37160	64 FR 24049	77 FR 54565
Coho Salmon (*Oncorhynchus kisutch*) – Lower Columbia River ESU	T – 70 FR 37160	81 FR 9251	78 FR 41911
Coho Salmon (*Oncorhynchus kisutch*) – Oregon Coast ESU	T – 73 FR 7816	73 FR 7816	81 FR 90780
Coho Salmon (*Oncorhynchus kisutch*) – Southern Oregon and Northern California Coasts ESU	T – 70 FR 37160	64 FR 24049	79 FR 58750
Eulachon (*Thaleichthys pacificus*) – Southern DPS	T – 75 FR 13012	76 FR 65323	9/2017
Green Sturgeon (*Acipenser medirostris*) – Southern DPS	T – 71 FR 17757	74 FR 52300	2010 (Outline) 8/2018- Final
Sockeye Salmon (*Oncorhynchus nerka*) – Ozette Lake ESU	T – 70 FR 37160	70 FR 52630	74 FR 25706
Sockeye Salmon (*Oncorhynchus nerka*) – Snake River ESU	E – 70 FR 37160	58 FR 68543	80 FR 32365
Steelhead Trout (*Oncorhynchus mykiss*) – California Central Valley DPS	T – 71 FR 834	70 FR 52487	79 FR 42504
Steelhead Trout (*Oncorhynchus mykiss*) – Central California Coast DPS	T – 71 FR 834	70 FR 52487	81 FR 70666
Steelhead Trout (*Oncorhynchus mykiss*) – Lower Columbia River DPS	T – 71 FR 834	70 FR 52629	78 FR 41911

Species	ESA Status	Critical Habitat	Recovery Plan
Steelhead Trout (*Oncorhynchus mykiss*) – Middle Columbia River DPS	T – 71 FR 834	70 FR 52629	74 FR 50165
Steelhead Trout (*Oncorhynchus mykiss*) – Northern California DPS	T – 71 FR 834	70 FR 52487	81 FR 70666
Steelhead Trout (*Oncorhynchus mykiss*) – Puget Sound DPS	T – 72 FR 26722	81 FR 9251	-- --
Steelhead Trout (*Oncorhynchus mykiss*) – Snake River Basin DPS	T – 71 FR 834	70 FR 52629	81 FR 74770 (Draft) 11-2017-Final
Steelhead Trout (*Oncorhynchus mykiss*) – South-Central California Coast DPS	T – 71 FR 834	70 FR 52487	78 FR 77430
Steelhead Trout (*Oncorhynchus mykiss*) – Southern California DPS	E – 71 FR 834	70 FR 52487	77 FR 1669
Steelhead Trout (*Oncorhynchus mykiss*) – Upper Columbia River DPS	T – 71 FR 834	70 FR 52629	72 FR 57303
Steelhead Trout (*Oncorhynchus mykiss*) – Upper Willamette River DPS	T – 71 FR 834	70 FR 52629	76 FR 52317
Designated Critical Habitat			
Humpback Whale – Central America DPS and Mexico DPS	E – 81 FR 62259 T – 81 FR 62259	86 FR 21082	11/1991
Killer Whale – Southern Resident DPS	E – 70 FR 69903 Amendment 80 FR 7380	71 FR 69054 86 FR 41668	73 FR 4176 01/2008
Leatherback Turtle	E – 35 FR 8491	44 FR 17710 and 77 FR 4170	10/1991 – U.S. Caribbean, Atlantic, and Gulf of Mexico 63 FR 28359 05/1998 – U.S. Pacific
Green Sturgeon – Southern DPS	T – 71 FR 17757	74 FR 52300	2010 (Outline) 8/2018- Final

ESA= Endangered Species Act, FR=*Federal Register*, DPS=Distinct Population Segment, T=Threatened, E=Endangered

6 POTENTIAL STRESSORS

The proposed actions involve multiple activities, each of which can create stressors. Stressors are any physical, chemical, or biological entity that may induce an adverse response either in an ESA-listed species or their designated critical habitat. During consultation, we deconstructed the proposed actions to identify stressors that are reasonably certain to occur from the proposed actions. These can be categorized as pollution (e.g., exhaust, fuel, oil, trash), vessel strikes, acoustic and visual disturbance (research vessel, seismic airgun array, sub-bottom profiler, and multi-beam echosounder, acoustic Doppler current profiler, pinger), and entanglement and interaction in towed seismic equipment (airgun array and hydrophone streamer) and heat flow measurement probe. Below we provide detailed information on the effects of these potential stressors. Furthermore, the proposed actions includes several conservation (monitoring and mitigation) 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 conservation 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 actions and fully consider them when evaluating the effects of the proposed actions (Section 3).

6.1 Pollution

The operation of the R/V *Marcus G. Langseth* 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 (Chance et al. 2015; Duce et al. 1991). Emissions also cause increased greenhouse gases (carbon dioxide, methane, nitrous oxide, and other fluorinated gases) that can deplete the ozone, affect natural earth cycles, and ultimately contribute to climate change (see https://www.epa.gov/ghgemissions/overview-greenhouse-gases for additional information). 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 research vessel can degrade habitat for marine life. While lethal and non-lethal effects to air breathing marine animals such sea turtles, birds, and marine mammals are well documented, marine debris also adversely affects marine fish (Gall and Thompson 2015).

The NSF and L-DEO proposes to include guidance on the handling and disposal of marine trash and debris during the low-energy seismic survey. While this is expected to reduce the amount of pollution that may result from the proposed actions, pollution remains a potential stressor.

6.2 Vessel Strike

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 (Brown and Murphy 2010; Laist et al. 2001; NMFS and USFWS 2008; Work et al. 2010). 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 (Conn and Silber 2013a; Hazel et al. 2007; Jensen and Silber 2004; Laist et al. 2001; Vanderlaan and Taggart 2007). If an animal is struck by a research vessel, it may experience minor, non-lethal injuries, serious injuries, or death.

Vessel traffic associated with the proposed actions carries the risk of vessel strikes of ESA-listed species (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 72 meters (235 feet) and the operating speed during seismic data acquisition is typically 7.8 to 8 kilometers per hour (4.2 to 4.5 knots). When not towing seismic survey gear, the R/V *Marcus G. Langseth* typically transits at 20.4 kilometers per hour (11 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 (Conn and Silber 2013a; Jensen and Silber 2004; Laist et al. 2001; Vanderlaan and Taggart 2007).

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. 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 (Conn and Silber 2013b; Jensen and Silber 2004; Laist et al. 2001; Vanderlaan and Taggart 2007).

Each of the ESA-listed fish species considered in this consultation 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' utilization 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 consultation 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 responss that 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 are attracted to different types of vessels (e.g., research vessels, commercial vessels) of varying sizes, noise levels, and habitat locations.

Several conservation measures (e.g., vessel strike avoidance measures) proposed by the NMFS Permits Division and/or NSF and L-DEO will minimize the risk of vessel strike (e.g., use of PSOs, vessel strike avoidance measures). In addition, the overall level of research vessel activity associated with the proposed actions is low relative to the large size of the action area, further reducing the likelihood of a vessel strike of an ESA-listed species. Nevertheless, vessel strike remains a potential stressor associated with the proposed actions.

6.3 Acoustic Noise from Airgun Array, Vessel Noise, and Visual Disturbance

The proposed actions will produce a variety of different sounds including those associated with vessel operations, sub-bottom profilers, multi-beam echosounders, acoustic Doppler current profilers, pinger, and airgun arrays that may produce an acoustic disturbance or otherwise affect ESA-listed species. It will also involve the presence of vessels (and associated equipment) that produce a visual disturbance that may affect ESA-listed marine mammals, sea turtles, and fishes. The acoustic noise from the sub-bottom profilers, multi-beam echosounders, and acoustic Doppler current profilers, and pinger will be discussed further in Section 6.4.

The research vessel associated with the proposed actions may cause visual or auditory disturbances to ESA-listed species that spend time near the water surface, such as marine mammals, sea turtles, and fishes which may generally disrupt their behavior. Studies have shown that vessel operations can result in changes in the behavior of marine mammals, sea turtles, and fishes (Hazel et al. 2007; Holt et al. 2009; Luksenburg and Parsons 2009; Noren et al. 2009; Patenaude et al. 2002; Richter et al. 2003; Smultea et al. 2008a). 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 (Blane and Jaakson 1994a; Evans et al. 1992; 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.

Unlike vessels, which produce sound as a byproduct of their operations, sub-bottom profilers, multi-beam echosounders, acoustic Doppler current profilers, pinger, and airgun arrays are designed to actively produce sound, and as such, the characteristics of these sound sources are deliberate and under control. 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 2005), 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 and how they use sound, the impacts of anthropogenic sound are difficult to assess (Nelms et al. 2016; Popper et al. 2014b). 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).

Several of the mitigation measures associated with the proposed actions such as ramp-up and shut-down procedures associated with the low-energy seismic survey procedures are specifically designed to minimize effects that may result from active acoustic sources used during the seismic survey activities (i.e., sounds from the seismic airgun array). In addition, while not specifically designed to do so, several aspects of the proposed vessel strike avoidance measures will minimize effects associated with vessel disturbance. However, even with these mitigation measures, visual and acoustic disturbances are considered a potential stressor.

The research vessel may cause auditory disturbance to ESA-listed marine mammals, sea turtles, and fishes, and more generally disrupt their behavior. In addition to the active sound sources mentioned above, we expect the R/V *Marcus G. Langseth* will add to the local noise environment in the action area due to the research vessel's propulsion and other noise characteristics of the research vessel's machinery.

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 (Kipple and Gabriele 2007; McKenna et al. 2012; Richardson et al. 1995c). Source levels for 593 container ships 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 five to ten 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 Hertz, 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) documented different acoustic levels and spectral shapes observed from different modern vessel-types in a study off Southern California.

Numerous studies of interactions between surface vessels and marine mammals have demonstrated that free-ranging marine mammals engage in avoidance behavior when surface vessels move toward them. It is not clear whether these responses are caused by the physical presence of a surface vessel, the underwater noise generated by the vessel or an interaction between the two (Amaral and Carlson 2005; Au and Green 2000; Bain et al. 2006; Bauer 1986; Bejder et al. 1999; Bejder and Lusseau. 2008; Bejder et al. 2009; Bryant et al. 1984; Corkeron 1995; Erbe 2002b; Félix 2001; Goodwin and Cotton 2004; Lemon et al. 2006; Lusseau 2003;

Lusseau 2006; Magalhaes et al. 2002; Nowacek et al. 2001; Richter et al. 2003; Scheidat et al. 2004; Simmonds 2005a; Watkins 1986b; Williams et al. 2002; Wursig et al. 1998). However, several authors suggest that the noise generated during motion is probably an important factor (Blane and Jaakson 1994b; Evans et al. 1992; Evans et al. 1994). These studies suggest that the behavioral responses of marine mammals to surface vessels are similar to their behavioral responses to predators.

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 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 sea 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. These responses appear limited to non-injurious, minor changes in behavior based on the limited information available on sea turtle response to vessel noise.

All fish species can detect vessel noise due to its low-frequency content and their hearing capabilities. Therefore, ESA-listed fishes could be exposed to a range of vessel noises, depending on the source and context of the exposure. Because of the characteristics of vessel noise, sound produced from seismic research vessels are unlikely to result in direct injury, hearing impairment, or other trauma to fishes. Plus, in the nearfield, 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. These reactions may include physiological stress responses, or avoidance behaviors.

6.4 Acoustic Noise from the Sub-Bottom Profiler, Multi-Beam Echosounder, and Acoustic Doppler Current Profiler, and Pinger

The sub-bottom profiler, multi-beam echosounder, acoustic Doppler current profiler, and pinger are four active acoustic systems that will operate during the proposed low-energy seismic survey on the R/V *Marcus G. Langseth*. As described above in Section 3.1.4, a sub-bottom profiler, multi-beam echosounder, and acoustic Doppler current profiler will be operated continuously during the proposed seismic survey activities as well as during transit to and from the seismic survey area or when the airgun array is not operating. The pinger will be used during heat flow measurements, as described in Section 3.1.5.

The sub-bottom profiler, multi-beam echosounder, and acoustic Doppler current profiler, and pinger (in addition to the airgun array) have the potential to expose ESA-listed marine mammal species to sound levels above the 160 dB re: 1 µPa (rms) threshold for ESA harassment. The sub-bottom profiler, multi-beam echosounder, acoustic Doppler current profiler, and pinger operate at a frequency of 3.5 kilohertz, 10.5 to 13 (usually 12) kilohertz, 75 kilohertz, and 19 to 34 kilohertz, respectively. These frequencies are generally higher frequencies than airgun array operations (6 to 20 Hertz for the two G airgun array). These frequencies are within the functional hearing range of baleen whales (7 Hertz to 35 kilohertz), such a blue, fin, gray, humpback, North Pacific right, and sei whales, sperm whales (150 Hertz to 160 kilohertz) as well as otariid pinnipeds (60 to 39 kilohertz) (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 kilohertz 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 kilohertz mid-frequency sonar at received levels below 90 dB re: 1 µPa (rms). Responses included cessation of foraging, increased swimming speed, and directed travel away from the sound 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 sub-bottom profiler, multi-beam echosounder, acoustic Doppler current profiler, and pinger (Ketten 1997a; Richardson et al. 1995e).

The frequencies from these devices will attenuate more rapidly than those from airgun array sound sources. For these reasons, ESA-listed species will likely experience higher levels of sound from the airgun array well before sounds of equal amplitude from the sub-bottom profiler, multi-beam echosounder, and acoustic Doppler current profiler since these other sound sources will drop off faster than the airgun arrays. In addition, the sub-bottom profiler, multi-beam echosounder, and acoustic Doppler current profiler are 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 a temporary threshold shift (TTS) in hearing or PTS for an animal. Therefore, sounds from the airgun array are expected to effectively cancel out sounds produced by the sub-bottom profiler, multi-beam echosounder, and acoustic Doppler current profiler.

For the sub-bottom profiler, the instrument emits energy in a 27 degree beam (cone) downward from the bottom of the research vessel with ping duration 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. For the multi-beam echosounder, the transmitting beamwidth is very narrow, 0 or 2 degrees fore-aft and 150 degrees (maximum) athwartship, and emits a series of 0.7 to 200 millisecond pulses. For the acoustic Doppler current profiler, the instrument will have a 30 degree conically-shaped beam, and emits a series of 11 to 37

millisecond pulses and has a ping rate of 0.7 seconds. For the pinger, the instrument will have a transmitting beam pattern of 25 degrees with a wideband pulse duration of 8 to 16 milliseconds. Given the movement and speed of the research vessel, the intermittent and narrow downward-directed nature of the sounds emitted by the sub-bottom profiler, multi-beam echosounder, and acoustic Doppler current profiler, and pinger will result in no more than one or two brief ping exposures of any individual marine mammal, sea turtle, or fish, if any exposure were to occur.

The response of a blue whale to 3.5 kilohertz sonar supports this species' ability to hear the signal from the sonar (Goldbogen 2013). Maybaum (1990; 1993) observed that Hawaiian humpback whales moved away and/or increased swimming speed upon exposure to 3.1 to 3.6 kilohertz 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, as the animal will have to pass at close range and be swimming at speeds similar to the vessel. The animal will 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. Assumptions for sperm whale hearing are much different than for ESA-listed baleen whales. Sperm whales vocalize between 3.5 to 12.6 kilohertz and an audiogram of a juvenile sperm whale provides direct support for hearing over this entire range (Au 2000; Au et al. 2006a; Carder and Ridgway 1990; Erbe 2002a; Frazer and Mercado 2000a; Goold and Jones 1995a; Levenson 1974; Payne and Payne 1985; Payne 1970; Richardson et al. 1995e; Silber 1986a; Thompson et al. 1986a; Tyack 1983a; Tyack and Whitehead 1983; Weilgart and Whitehead 1993; Weilgart and Whitehead 1997c; Weir et al. 2007a; Winn et al. 1970a). Sperm whales have stopped vocalizing in response to 6 to 13 kilohertz pingers, but did not respond to 12 kilohertz echosounders (Backus and Schevill 1966; Watkins 1977a; Watkins and Schevill 1975b). Sperm whales exhibited a startle response to 10 kilohertz 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 kilohertz 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 a the mass stranding of a large group of melon-headed whales (*Peponocephala electra*) (Southall 2013). Although pathological data suggesting a direct physical effect are lacking and the authors acknowledge that while the use of this type of sonar is widespread and common place 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 sub-bottom profiler, multi-beam echosounder, and acoustic Doppler current profiler, and pinger. Although effects such as this have not been documented for ESA-listed species, the combination of exposure of 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 will 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 non-ESA-listed marine mammals (e.g., beaked whales). The sonars proposed for use by the R/V *Marcus G. Langseth* differs from sonars used during naval operations, which generally have a longer pulse duration and more horizontal orientation than the more downward-directed sub-bottom profiler, multi-beam echosounder, and acoustic Doppler current profiler, and pinger. The sound energy received by any individuals exposed to the sub-bottom profiler, multi-beam echosounder, and acoustic Doppler current profiler, and pinger 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 sub-bottom profiler, multi-beam echosounder, acoustic Doppler current profiler, and pinger 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.

The sub-bottom profiler, multi-beam echosounder, acoustic Doppler current profiler, and pinger have the potential to expose ESA-listed sea turtles to sound levels above 175 dB re: 1 μPa (rms) threshold. However, as described previously, current data indicates sea turtles hear in the low-frequency range. The sub-bottom profiler operates at frequencies of 3.5 kilohertz, the multi-beam echosounder operates at frequencies of 10 to 13 (usually 12) kilohertz, the acoustic Doppler current profiler operates at frequencies of 75 kilohertz, the pinger operates at frequencies of 19 to 34 kilohertz, all which emit sounds outside the hearing frequency of sea turtles (typically 30 Hertz to 2 kilohertz), with a range of maximum sensitivity between 100 to 800 Hertz). Sea turtles are not expected to detect and therefore not respond to sounds emitted by the sub-bottom profiler, multi-beach echosounder, acoustic Doppler current profiler, and pinger.

6.5 Gear Entanglement and Interaction

There is a variety of gear that would be used during the proposed actions that might entangle, strike, or otherwise interact with ESA-listed species in the action area. The towed seismic equipment (e.g., airgun array and towed hydrophone streamer) and wire cables used during heat flow measurements associated with 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 recovery, resulting in injury. This is a possibility for the measurements using the heat flow probe in particular, as they will be lowered into the water from the research vessel, weighted down, and would penetrate the seafloor. Entanglement can result in death or injury of marine mammals, sea turtles, and fishes (Deakos and H. 2011; Duncan et al. 2017; Moore et al. 2009b; Moore et al. 2009a; Van Der Hoop et al. 2013b; Van der Hoop et al. 2013a). 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, death is usually quick, due to drowning. However, large whales, like North Pacific right whales (*Eubalaena japonica*), 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 (Lysiak et al. 2018; Van der Hoop et al. 2017).

Towed gear from the seismic survey activities poses a risk of entanglement to ESA-listed marine mammals, sea turtles, and fishes. The towed hydrophone streamer could come in direct contact with ESA-listed species and sea turtle entanglement have occurred in towed gear from seismic survey vessels. For example, a NSF-funded seismic survey off the coast of Costa Rica during 2011 recovered a dead olive ridley turtle in the deflector foil of towed seismic equipment; it is unclear whether the sea turtle became lodged in the deflector 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 (Hauser 2008; Holst and Smultea 2008a; Holst et al. 2005a; Holst et al. 2005b). To the best of our knowledge, sea turtles do not occur in high densities in the action area. The towed hydrophone streamer is rigid and as such will not encircle, wrap around, or in any other way entangle any of the large whales considered during this consultation. We expect the taut cables will prevent entanglement. The portable towed hydrophone streamer does not include any floatation that contains subsurface crossbars or frames that would entrap sea turtles; therefore, no sea turtle "guards" are necessary. Furthermore, mysticetes (baleen whales) and pinnipeds (Guadalupe fur seals) are expected to avoid areas where the airgun array is actively being used, meaning they will also avoid towed gear. Instances of such entanglement events with ESA-listed marine mammals are unknown to us.

In addition to marine mammals and sea turtles, some of the ESA-listed fish species (e.g., eulachon, green sturgeon, salmon, and steelhead) could be entangled or stuck by equipment during the seismic survey activities. ESA-listed eulachon, salmon, and steelhead are distributed throughout the water column, while green sturgeon occur at the ocean bottom (typically in depths less than 110 meters [360.9 feet]). The heat flow measurement probe will operate at or near the seafloor. The towed hydrophone array and towed airgun array pose similar risk to ESA-listed fish. 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. The shape of the streamlined bodies of ESA-listed fish and the ability to avoid materials that could entangle, strike, or interact with them in the water column make it extremely unlikely.

The probe used for heat flow measurements will result in very minor, temporary disturbances to seafloor sediments. The heat flow measurements are not expected to significantly impact geologic resources or ESA-listed species.

7 SPECIES AND CRITICAL HABITAT NOT LIKELY TO BE ADVERSELY AFFECTED

This section identifies the ESA-listed species and designated critical habitat under NMFS jurisdiction that may occur within the action area (as described in Table 7) that are not likely to be adversely affected by the proposed actions. This section also identifies potential stressors associated with the proposed actions that are not likely to adversely affect ESA-listed species and designated critical habitat that may occur within the action area.

NMFS uses two criteria to identify the ESA-listed or critical habitat that are not likely to be adversely affected by the proposed actions, 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. An ESA-listed species or designated critical habitat that co-occurs with a stressor of the action but is not likely to respond to the stressor is also not likely to be adversely affected by the proposed actions. We applied these criteria to the ESA-listed species and designated critical habitats in Table 7 and we summarize our results below.

An action warrants a "may affect, not likely to be adversely affected" finding when its effects are wholly *beneficial, insignificant*, or *discountable*. *Beneficial* effects have an immediate positive effect without any adverse effects to the species or habitat. *Beneficial* effects are usually discussed when the project has a clear link to the ESA-listed species or its specific habitat needs and consultation is required because the species may be affected.

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 likely 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 an ESA-listed species), but it is very unlikely to occur.

If the effects of an action are determined to be wholly beneficial, insignificant, or discountable, we conclude that the action is not likely to adversely affect ESA-listed species or designated critical habitat. This same decision model applies to individual stressors associated with the proposed actions, such that some stressors may be determined to be not likely to adversely affect ESA-listed species or critical habitat because any effects associated with the stressors will not rise to the level of take under the ESA.

In this section, we evaluate effects to ESA-listed species that may be affected, but are not likely to be adversely affected, by the proposed actions. For these ESA-listed species and critical habitat, we focus specifically on stressors associated with the NSF and L-DEO's seismic survey activities and their effects on these ESA-listed species. The effects of other stressors associated with the proposed actions, which are not likely to adversely affect ESA-listed species and proposed critical habitat, are evaluated in Section 7.1. The species and designated critical habitat (along with their regulatory status and recovery plan) potentially occurring within the action area that may be affected, but are not likely to be adversely affected, are listed in Table 7 (overall determination shown as 'NLAA'), except for the blue whale, fin whale, Central America DPS of humpback whale, Mexico DPS of humpback whale, sei whale, sperm whale, and Guadalupe fur seal.

7.1 Potential Stressors to Endangered Species Act-Listed Marine Mammals, Sea Turtles, and Fishes

Potential stressors that may affect, but are not likely to adversely affect the ESA-listed marine mammals (cetaceans and pinnipeds), sea turtles, fishes, and designated critical habitat considered in this opinion (see Table 7) include pollution, vessel strike, vessel noise and visual disturbance, acoustic noise from the airgun array (for fish), acoustic noise from sub-bottom profiler, multi-beam echosounder, acoustic Doppler current profiler, pinger, and gear entanglement and interaction. The following sections describe how we reached this effects determination for these potential stressors.

7.1.1 Pollution

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

Exhaust (i.e., air pollution) from the research vessel would occur during the entirety of the proposed actions, during all transit and operations, and could affect air-breathing ESA-listed species such as marine mammals and sea turtles. It is unlikely that 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 actions (approximately 23 days), the brief amount of time that marine mammals and sea turtles spend at the water's surface, and the various regulations to minimize air pollution from exhaust, such as NSF and L-DEO's compliance with the Act to Prevent Pollution from Ships. For these reasons, the effects that may result from exhaust on ESA-listed marine mammals and sea turtles are considered insignificant.

Discharges into the water from the research vessel 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 consultation will be minimal, if they occur at all. Wastewater from the research vessel would be treated in accordance with U.S. Coast Guard standards. The potential

for fuel or oil leakages is extremely unlikely. As stated in Section 6.1, the NSF proposes to include guidance on the handling and disposal of marine trash and debris during the low-energy seismic survey. The research vessel used during the NSF-funded low-energy seismic survey has spill-prevention plans, which will allow a rapid response to a spill in the event one occurs. In addition to this, the potential for an oil or fuel spill to emanate from the R/V *Marcus G. Langseth* during the proposed seismic survey activities is extremely small. An oil or fuel leak will likely pose a significant risk to the research vessel and its crew and actions to correct a leak should occur immediately to the fullest extent possible. In the event that a leak should occur, the amount of fuel or oil onboard the R/V *Marcus G. Langseth* is unlikely to cause widespread, high-dose contamination (excluding the remote possibility of severe damage to the research vessel) that will impact ESA-listed species directly or pose hazards to their food sources that may be part of 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 actions 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 and L-DEO follows standard, established guidance on the handling and disposal of marine trash and debris during the low-energy seismic survey. The gear used in the proposed actions may also result in marine debris. 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.

Therefore, we conclude that pollution by vessel exhaust, wastewater, fuel or spills or leaks, and trash or other debris may affect, but is not likely to adversely affect ESA-listed species.

7.1.2 Vessel Strike

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 seismic surveys. The R/V *Marcus G. Langseth* will be traveling at generally low speeds, reducing the amount of noise produced by the propulsion system and the probability of a vessel strike (Kite-Powell et al. 2007; Vanderlaan and Taggart 2007). The risk of a vessel strike resulting from the proposed actions is considered extremely low, and are rare events offshore. Our expectation of vessel strike for a marine mammal, sea turtle, and fish is extremely small due to the hundreds of thousands of kilometers the R/V *Marcus G. Langseth* has traveled without a vessel strike, the general expected movement of marine mammals, sea turtles, and fish 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 (Hauser and Holst 2009; Holst 2010; Holst and Smultea 2008b). The R/V *Marcus G. Langseth* will have an operating speed of typically 8.3 kilometers per hour (4.5 knots) during seismic data acquisition. When not towing seismic survey gear, the R/V *Marcus G. Langseth* typically transits

at 18.5 kilometers per hour (10 knots). Vessel strike is a less pronounced threat for fishes, as fish are mostly expected to be able to sense and maneuver away from vessels. Sturgeon have been known to be struck and killed by vessels, but we are not aware of reports of vessel strike for Southern DPS of green sturgeon in the action area. Vessel strike was identified as a low-risk threat to Southern DPS Of green sturgeon (NMFS 2018), as they generally are not at the water's surface and are often associated with the hard bottom. 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 the potential for vessel strike of ESA-listed species from the research vessel is extremely unlikely to occur. As a result, we find that the risk from this potential stressor on ESA-listed marine mammals, sea turtles, and fishes in the action area is extremely unlikely to occur, and is therefore discountable. Therefore, we conclude that vessel strike may affect, but is not likely to adversely affect ESA-listed species.

7.1.3 Vessel Noise and Visual Disturbance

Numerous studies of interactions between surface vessels and cetaceans have demonstrated that free-ranging cetaceans engage in avoidance behavior when surface vessels move toward them. It is not clear whether these responses are caused by the physical presence of a surface vessel, the underwater noise generated by the vessel or an interaction between the two (Amaral and Carlson 2005; Au and Green 2000; Bain et al. 2006; Bauer 1986; Bejder et al. 1999; Bejder and Lusseau. 2008; Bejder et al. 2009; Bryant et al. 1984; Corkeron 1995; Erbe 2002b; Félix 2001; Goodwin and Cotton 2004; Lemon et al. 2006; Lusseau 2003; Lusseau 2006; Magalhaes et al. 2002; Nowacek et al. 2001; Richter et al. 2003; Scheidat et al. 2004; Simmonds 2005a; Watkins 1986b; Williams et al. 2002; Wursig et al. 1998). However, several authors suggest that the noise generated during motion is probably an important factor (Blane and Jaakson 1994b; Evans et al. 1992; Evans et al. 1994). These studies suggest that the behavioral responses of cetaceans to surface vessels are similar to their behavioral responses to predators. With this said, the overall contribution of vessel noise by the R/V *Marcus G. Langseth* is likely small in the overall regional sound field of the action area. The R/V *Marcus G. Langseth*'s passage past ESA-listed marine mammals, sea turtles, or fish would be brief, at a distance of at least 100 meters (328.1 feet), and not likely to be significant in impacting any individual's ability to feed, reproduce, or avoid predators. Brief interruptions in communication via masking are possible, but unlikely given the habits of marine mammals to move away from vessels, either as a result of engine noise, the physical presence of the vessel, or both (Lusseau 2006; Mitson and Knudsen 2003). In addition, the R/V *Marcus G. Langseth* will travel at slow speeds, reducing the amount of noise produced by the propulsion system (Kite-Powell et al. 2007; Vanderlaan and Taggart 2007). The distance between the research vessel and observed marine mammals, per vessel avoidance measures, will also minimize the potential for acoustic disturbance from engine noise. Because the potential acoustic interference from engine noise is expected to be nearly undetectable or so minor that it cannot be meaningfully evaluated, we find that the risk from this potential stressor on ESA-listed marine mammals is insignificant. Therefore, we conclude that vessel noise may affect, but is not likely to adversely affect ESA-listed species.

7.1.4 Acoustic Noise from the Airgun Array

ESA-listed sea turtles and fishes may be exposed to and detect noise generated by the low-energy seismic survey. Effects to sea turtles from acoustic noise from the airgun array may include temporary behavioral responses (e.g., temporary displacement and stress) with some potential for TTS, with individuals returning to normal shortly after the exposure has ended. The predicted 175 dB re: 1 µPa (rms) isopleth, which represents our best understanding to the threshold at which sea turtles exhibit behavioral responses to airgun arrays, is 98 meters (321.5 feet). The modeled SELcum threshold for PTS for sea turtles is 0.3 meters (1 feet). Southern DPS of eulachon, multiple DPS/ESUs of salmonids (Chinook salmon, Coho salmon, chum salmon, Sockeye salmon, and steelhead trout) and Southern DPS of green sturgeon range is generally limited to shallow (0 to 100 meters [0 to 328.1 feet]) and intermediate (100 to 1,000 meters [328.1 to 3,280.8 feet]) water depths and the tracklines of the seismic survey activities are in deep water depths, we expect effects from the noise from the airgun array operations to be insignificant. The predicted 150 dB re: 1 µPa (rms) isopleth for behavioral responses of fishes from acoustic stimuli that occur within that isopleth is 1,608 meters (5,275.6 feet). The modeled SEL_{cum} isopleth for the onset of TTS for fishes with swim bladders not involved in hearing that occur within that isopleth is 39.5 meters (129.6 feet). The modeled SEL_{cum} threshold isopleth for PTS for fishes with swim bladders that occur within that isopleth is 0.4 meters (1.3 feet), fishes with swim bladders not involved in hearing that occur within that isopleth is 0.1 meters (0.3 feet), and fishes 2 grams or larger that occur within that isopleth is 39.5 meters (129.6 feet). The modeled SEL_{cum} isopleth for the onset of injury/mortality for fishes with swim bladders not involved in hearing that occur within that isopleth is 21.6 meters (70.9 feet). The modeled SEL_{cum} isopleth for the onset of mortality for fishes with swim bladders not involved in hearing that occur within that isopleth is 0.1 meters (0.3 feet). Also, ESA-listed fishes are mobile and expected to move away from an active sound source as they would move out of the area as intensity increases before levels of ESA harm and harassment are reached. We find the exposure impacts to ESA-listed fish from this potential stressor to be insignificant or discountable. Therefore, we conclude that the noise from the airgun array may affect, but is not likely to adversely affect ESA-listed fish.

The effects of acoustic noise from the airgun array on ESA-listed marine mammals in the action area discussed below in Section 10.

7.1.5 Acoustic Noise from Sub-Bottom Profiler, Multi-Beam Echosounder, and Acoustic Doppler Current Profiler, and Pinger

We do not expect masking of communication will occur to an appreciable extent in marine mammals, sea turtles, and fish due to the sub-bottom profiler, multi-beam echosounder, and acoustic Doppler current profiler, and pinger'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 sub-bottom profiler, multi-beam

echosounder, acoustic Doppler current profiler, and pinger are likely to be similar to the other pulsed sources discussed earlier if received at the same levels. Boebel et al. (2006) and Lurton and DeRuiter (2011) concluded that sub-bottom profilers, multi-beam echosounders, and acoustic Doppler current profilers similar to those to be used during the proposed seismic survey activities presented a low risk for auditory damage or any other injury. Also, we do not expect hearing impairment such as TTS and other physical effects if the animal is in the area, as it will have to pass the transducers at close range and match the research vessel's speed and direction in order to be subjected to sound levels that can cause these effects. Sea turtles generally do not possess a hearing range that includes frequencies emitted by the sub-bottom profiler, multi-beam echosounder, acoustic Doppler current profiler, and pinger; 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. We find the probability of adverse impacts to ESA-listed marine mammals, sea turtles, and fish from this potential stressor to be extremely unlikely to occur. We are unable to quantify the level of exposure from secondary sound sources, but do not expect any exposure at levels sufficient to cause more than behavioral responses (e.g., avoidance of the sound source) in some species capable of hearing frequencies produced by the sub-bottom profiler, multi-beam echosounder, acoustic Doppler current profiler, and pinger. As discussed earlier, the sound levels produced by the airgun array are of primary concern in terms of exposure, due to their greater energy power, and the potential to cause injury or disrupt essential behavioral patterns. We find that the risk from this potential stressor on ESA-listed marine mammals, sea turtles, and fish is insignificant. Therefore, we conclude that the sub-bottom profiler, multi-beam echosounder, acoustic Doppler current profiler, and pinger may affect, but are not likely to adversely affect ESA-listed species.

7.1.6 Gear Entanglement and Interaction

There is a variety of gear proposed for use during the proposed actions that might entangle, strike, or otherwise interact with ESA-listed species in the action area. Towed seismic equipment (airgun array and towed hydrophone streamer) associated with the proposed seismic survey activities as well as the probe for heat flow measurements may pose a risk of entanglement to ESA-listed species. Although the airgun array, towed hydrophone streamer, and heat flow measurement probe could come in direct contact with an ESA-listed species, entanglements and interactions are highly unlikely. The airgun array, towed hydrophone streamer, and heat flow measurement probe is rigid and as such is not expected to encircle, wrap around, or in any other way entangle any of the ESA-listed marine mammals, sea turtles, and fishes considered during this consultation. The weight of the towed heat flow measurement probe will keep the wire taught as well as the slow speed of the research vessel will prevent gear entanglement and interactions with ESA-listed species. For these reasons, we expect the taut cables will prevent entanglement of ESA-listed species. Furthermore, mysticetes and possibly sperm whales and pinnipeds are expected to avoid areas where the airgun array is actively being used, meaning they will also likely avoid towed seismic equipment. Instances of such entanglement and interaction events in the towed hydrophone streamer, heat flow measurement probe, and other

seismic survey equipment with ESA-listed species are unknown to us. Based upon extensive deployments of this type of equipment and gear, with no reported entanglement or interaction and the nature of the gear that is likely to prevent it from occurring, we find the probability of adverse impacts to ESA-listed marine mammals, sea turtles, and fish from this stressor to be extremely unlikely to occur, and any effects are discountable. Therefore, we conclude that gear entanglement and interaction may affect, but is not likely to adversely affect ESA-listed species.

7.1.7 Potential Stressors Considered Further

The only potential stressor that is likely to adversely affect ESA-listed species within the action area are sound fields produced by the seismic airgun array. This stressor and the sound sources associated with the low-energy seismic survey effects may adversely affect the ESA-listed marine mammals and are further analyzed and evaluated in detail in Section 10.

7.2 Marine Mammals – Cetaceans

The Western North Pacific DPS of gray whale, Southern Resident DPS of killer whale, and North Pacific right whale may occur in the action area and may be affected by the proposed actions. In addition to the potential stressors that are not likely to adversely affect ESA-listed cetaceans discussed above in Section 7.1, other stressors resulting from the proposed actions may affect, but are not likely to adversely affect specific species and designated critical habitat as discussed in the following subsections.

7.2.1 Gray Whale – Western North Pacific Distinct Population Segment

The ESA-listed Western North Pacific DPS of gray whale may occur in the action area and may be affected by the stressors associated with the NSF and L-DEO's proposed low-energy seismic survey (see Section 6). While the Western North Pacific DPS of gray whale can be found in coastal and pelagic habitats within the action area, it is unlikely that Western North Pacific DPS of gray whales will be adversely affected by stressors associated with the proposed actions as they are not expected to occur in the portion of the action area where airgun array operations are expected to occur. Each of the stressors associated with the proposed actions, along with our determination on their impacts to ESA-listed marine mammals (particularly cetaceans) within the action area, are discussed above.

Gray whales mostly inhabit shallow coastal waters in the North Pacific Ocean. The Western North Pacific DPS of gray whales exhibits extensive plasticity in the occurrence of animals, shifting use of areas within and between years, as well as over longer time frames such as in response to oceanic climate cycles (e.g., El Niño-Southern Oscillation, Pacific Decadal Oscillation, and Arctic Oscillation) (Gardner and Chávez-Rosales 2000; Weller et al. 2012). Some Western North Pacific DPS of gray whales winter on the west coast of North America while other migrate south to winter in waters off Japan and China, and summer in the Okhotsk Sea off northeast Sakhalin Island, Russia, and off southeastern Kamchatka in the Bering Sea (Burdin et al. 2013).

The Western North Pacific DPS of gray whales feeds during the summer and fall in the Okhotsk and Bering Seas off northeastern Japan and eastern Russia, respectively. Prey availability and, to a lesser extent, sea ice extent, are probably strong influences on the habitats used by the Western North Pacific DPS of gray whales (Clarke and Moore 2002; Moore 2000). The non-ESA-listed Eastern North Pacific DPS of gray whales also feeds in the Bering Sea, in addition to the Beaufort Sea and Chukchi Seas and the coastal waters of western North America. This population is estimated to comprised of approximately 26,290 individuals, while the Western North Pacific DPS is comprised of approximately 290 individuals (reviewed in (Carretta et al. 2019).

Previous studies have observed approximately 30 gray whales from the Western North Pacific DPS in the Western and Eastern North Pacific Ocean (including coastal waters of Canada, U.S., and Mexico), as some gray whales from the Western North Pacific DPS are thought to migrate to the eastern North Pacific Ocean in winter, while others from this population migrate south to waters of Japan and China (reviewed in (Carretta et al. 2019)). Genetic structure analysis of gray whales feeding off Russia show most animals are recent descendants of Eastern North Pacific population of gray whales, with estimates that 20 to 55 percent now using wintering grounds off Mexico. A small proportion of animals from the Western North Pacific DPS of gray whales remain in the Western North Pacific Ocean year-round (Lang et al. 2020).

Most gray whales travel within 10 kilometers (5.4 nautical miles) from shore. The northbound phases of gray whale migration occurs approximately 8 kilometers (4.3 nautical miles) from shore during January through July and 5 kilometers (2.7 nautical miles) from shore during March through July. The southbound phase of gray whale migration occurs during October through March.

From this overview, the Western North Pacific DPS of gray whales may be found within the action area. However, the Western North Pacific DPS of gray whale is not expected to occur in the area of the proposed seismic survey activities as the tracklines to the proposed low-energy seismic survey are far south of the summer feeding area as well as further offshore than in the nearshore and shallow waters which they normally occur. Most animals that occur in the Northeast Pacific Ocean likely belong to the delisted Eastern North Pacific population of gray whales. Since the proposed seismic survey activities will take place in a location where we do not expect Western North Pacific DPS of gray whales to be present, we do not expect the animals to be exposed to the potential stressors of acoustic noise from the airgun array. The potential for exposure to the potential stressors of acoustic noise from the airgun array or gear entanglement and interaction is extremely unlikely to occur. Western North Pacific DPS of gray whales may be exposed to the potential stressors of pollution, vessel strike, vessel noise, acoustic noise from the airgun array, acoustic noise from the sub-bottom profiler, multi-beam echosounder, acoustic Doppler current profiler, and pinger or gear entanglement and interaction; however, we determined any effects associated with these potential stressors are insignificant or discountable (discussed further in Section 7.1). Due to the rare nature of Western North Pacific

DPS of gray whales in the action area, the potential adverse impacts from the acoustic noise from the airgun array is discountable. Therefore, we conclude that the NSF and L-DEO's proposed low-energy seismic survey may affect, but is not likely to adversely affect ESA-listed Western North Pacific DPS of gray whales.

7.2.2 Killer Whale – Southern Resident Distinct Population Segment

The ESA-listed Southern Resident DPS of killer whale may occur in the action area and may be affected by the stressors associated with the NSF and L-DEO's proposed low-energy seismic survey (see Section 6). While the Southern Resident DPS of killer whale can be found in coastal and pelagic habitats within the action area, it is unlikely that Southern Resident DPS of killer whales will be adversely affected by stressors associated with the proposed actions as they are not expected to occur in the portion of the action area where airgun array operations are expected to occur. Each of the stressors associated with the proposed actions, along with our determination on their impacts to ESA-listed marine mammals (particularly cetaceans) within the action area, are discussed below.

Killer whales are distributed worldwide, but populations are isolated by region and ecotype. Killer whales have been divided into DPSs on the basis of differences in genetics, ecology, morphology, and behavior. The Southern Resident DPS of killer whales includes three large, stable pods (J, K, and L), which occasionally interact (Parsons et al. 2009b). The Southern Resident DPS of killer whale can be found along the Canada and U.S. West Coast in the Pacific Ocean, and in the Salish Sea, Strait of Juan de Fuca, and Puget Sound.

Southern Resident DPS of killer whales occur for part of the year in the inland waterways of Puget Sound, Strait of Juan de Fuca, and Southern Georgia Strait mostly during the spring, summer, and fall. They also move to coastal waters off Washington and British Columbia, and have been sighted as far as central California and southeast Alaska (NMFS 2019). The summer range (i.e., May through September) of the Southern Resident DPS of killer whale is near Haro Strait, Boundary Pass, San Juan Island, and the Strait of Juan de Fuca, Washington and British Columbia. Southern Resident DPS of killer whales do occur off the Oregon and Washington coasts (e.g., around the Columbia River), but in winter, during the months of February and March. Their movement patterns appear related to the seasonal availability of prey, especially Chinook salmon. There is evidence to show that the different pods spend time in different locations while in coastal waters. Results from satellite tagging, acoustic recording data, and opportunistic sightings indicate that Southern Resident DPS of killer whales spend the majority of their time on the continental shelf, within 34 kilometers (18.4 nautical miles) of shore (NMFS 2019).

Southern Resident DPS of killer whales do not generally occur offshore in the Northeast Pacific Ocean. Southern Resident DPS of killer whales have rarely been observed as far west in the Northeast Pacific Ocean as the location of the seismic survey activities. For coastal waters along the U.S. West Coast, critical habitat includes marine waters between the 6.1 meter (20 feet) depth contour from the U.S. international border with Canada south to Point Sur, California. The

action area, particularly where airgun array operations are planned, is considered to be outside (west) of their typical migratory patterns. In 2012, NSF-funded seismic surveys occurred in the Pacific Ocean off the coast of Washington in June and July, and reported no killer whales during those seismic surveys. In 2021, NSF-funded seismic surveys occurred in the Northeast Pacific Ocean off Oregon, Washington, and British Columbia, and reported one sighting of a mixed pod of killer whales and northern right whale dolphins.

From this overview, the Southern Resident DPS of killer whales may be found within the action area. However, the Southern Resident DPS of killer whale are not expected to occur in the area of the proposed seismic survey activities as the tracklines to the proposed low-energy seismic survey are further west than their range; however, they may occur in the action area of the port stops and transit. Since the proposed seismic survey activities will take place in a location where we do not expect Southern Resident DPS of killer whales to be present, we do not expect the animals to be exposed to the potential stressors of acoustic noise from the airgun array. The potential for exposure to the potential stressors of acoustic noise from the airgun array or gear entanglement is extremely unlikely to occur. Southern Resident DPS of killer whales may be exposed to the potential stressors of pollution, vessel strike, and vessel noise, acoustic noise from the airgun array, acoustic noise from the sub-bottom profiler, multi-beam echosounder, acoustic Doppler current profiler, pinger, or gear entanglement and interaction; however, we determined any effects associated with these potential stressors are insignificant or discountable (discussed further in Section 7.1). Due to the rare nature of Southern Resident DPS of killer whales in the action area, the potential adverse impacts from the acoustic noise from the airgun array is discountable. Therefore, we conclude that the NSF and L-DEO's proposed low-energy seismic survey may affect, but is not likely to adversely affect ESA-listed Southern Resident DPS of killer whales

7.2.3 North Pacific Right Whale

The ESA-listed North Pacific right whale may occur in the action area and may be affected by the stressors associated with the NSF and L-DEO's proposed low-energy seismic survey (see Section 6). Each of the stressors associated with the proposed actions, along with our determination on their impacts to ESA-listed marine mammals (particularly cetaceans) within the action area, are discussed below.

North Pacific right whales are found in temperate and subpolar waters of the North Pacific Ocean. North Pacific right whales mostly inhabit coastal and continental shelf waters. Little is known about their migration patterns, but they have been observed in lower latitudes during winter (Japan, California, and Mexico) where they likely calve and nurse and they have been observed in higher latitudes during summer where they likely feed (Clapham et al. 2004a; Kraus et al. 1986). They have been documented feeding on large concentrations of copepods in Alaska waters in the summer. At least a portion of the population migrates to reproduce, and have been sighted as far south as Hawaii and Baja California (Clapham et al. 2004a; Kraus et al. 1986).There are two currently recognized stocks of North Pacific right whales, a Western North

Pacific stock that feeds primarily in the Sea of Okhotsk, and an Eastern North Pacific stock that feeds in eastern North Pacific Ocean waters off Alaska, Canada, and Russia.

The North Pacific right whale inhabits the Pacific Ocean, particularly between 20 and 60 degrees North latitude. There are sporadic records from below 20 degrees North latitude, but the bulk of the data show animals concentrated north of 35 degrees North latitude. Prior to exploitation by commercial whalers, concentrations of North Pacific right whales were found in the Gulf of Alaska, Aleutian Islands, south-central Bering Sea, Okhotsk Sea, and Sea of Japan (Clapham et al. 2004a; Gregr 2011; Ivashchenko et al. 2013; Omura et al. 1969; Scarff 1986a; Shelden et al. 2005). North Pacific right whales were probably never common along the west coast of North America (Brownell Jr. et al. 2001; Scarff 1986a), although historically, animals were sighted in waters off the coast of British Columbia and Washington, Oregon, and California (Clapham et al. 2004b; Scarff 1986b). The rarity of reports for North Pacific right whales in more southern coastal areas in winter in either historical or recent times suggests that their breeding grounds may have been offshore (Clapham et al. 2004a). There has been little recent sighting data of North Pacific right whales occurring in the central North Pacific Ocean and Bering Sea. However, since 1996, North Pacific right whales have been consistently observed in Bristol Bay and the southeastern Bering Sea during summer months. Presently, sightings are extremely rare, occurring primarily in the Okhotsk Sea and the eastern Bering Sea (Brownell Jr. et al. 2001; Shelden et al. 2005; Wade et al. 2006; Zerbini et al. 2010).

In October 2013, a North Pacific right whale sighting was made off the Strait of Juan de Fuca, with a group of humpback whales moving south in the offshore area of the U.S. Navy's Northwest Training and Testing action area (Navy 2015). There have also been four sightings, each of a single North Pacific right whale, in California waters within approximately the last 30 years (in 1988, 1990, 1992, and 2017) (Brownell et al. 2001; Carretta et al. 1994; Price 2017). Various sightings of North Pacific right whales in the general vicinity of the action area have occurred on an irregular basis. Two North Pacific right whales were sighted in 1983 on Swifsure Bank at the entrance of the Strait of Juan de Fuca (Osborne et al. 1988). There were no sightings of North Pacific right whales during six vessel surveys conducted in summer and fall off California, Oregon, and Washington from 1991 through 2008 (Barlow 2010). Two North Pacific right whale calls were detected on a bottom-mounted hydrophone (located in water depths of 1,390 meters [4,560.4 feet]) off the coast of Washington on June 29, 2013 (Sirovic et al. 2014). During NSF and L-DEO's high-energy seismic survey in the Northeast Pacific Ocean during summer 2021, a sighting of two individuals was made northwest of the seismic survey area in British Columbia, west of Haida Gwaii on July 27, 2021.

From this overview, the North Pacific right whales may be found within the action area. In addition to the low population numbers (likely less than 1,000 individuals) in the North Pacific Ocean, because only a few individuals have been observed (Brownell Jr. et al. 2001; Wade et al. 2006) even given more recent sightings and detections this species is considered extremely rare in the action area. The seismic survey activities will take place during the summer when we

expect that North Pacific right whales to be on their summer feeding grounds outside of the action area in the Bering Sea, Gulf of Alaska, Okhotsk Sea, and the Northwestern Pacific Ocean (Muto et al. 2019). Based on this information, there is a very low probability of encountering this species anywhere in the coastal and offshore waters in the action area during the seismic survey activities. Since the proposed seismic survey activities will take place in a location where we do not expect North Pacific right whales to be present, we do not expect the animals to be exposed to the potential stressors of acoustic noise from the airgun array. The potential for exposure to the potential stressors of acoustic noise from the airgun array or gear entanglement and interaction is extremely unlikely to occur. North Pacific right whales may be exposed to the potential stressors of pollution, vessel strike, vessel noise during the transit and port stops of the R/V *Marcus G. Langseth*, acoustic noise from the sub-bottom profiler, multi-beam echosounder, acoustic Doppler current profiler, pinger, and gear entanglement and interaction. However, we determined any effects associated with these potential stressors are insignificant or discountable (discussed further in Section 7.1). Due to the rare nature of North Pacific right whales in the action area, the potential adverse impacts from the acoustic noise from the airgun array is discountable. Therefore, we conclude that the NSF and L-DEO's proposed low-energy seismic survey may affect, but is not likely to adversely affect ESA-listed North Pacific right whales.

7.3 Marine Reptiles

ESA-listed sea turtles (i.e., Eastern DPS of green turtle, leatherback turtle, North Pacific Ocean DPS of loggerhead turtle, and Mexico's Pacific coast breeding colonies population of olive ridley turtles) may occur in the action area and may be affected by stressors associated with the NSF and L-DEO's proposed low-energy seismic survey (see Section 6). While sea turtles can be found in coastal and pelagic habitats within the action area, it is unlikely that sea turtles will be adversely affected by stressors associated with the proposed actions as they are not expected to occur in the portion of the action area where airgun array operations are expected to occur. Each of the stressors associated with the proposed actions, along with our determination on their impacts to ESA-listed sea turtles within the action area, are discussed above.

East Pacific DPS of green turtle, North Pacific Ocean DPS of loggerhead turtle, and Mexico's Pacific coast breeding colonies population of olive ridley turtles have been documented off the coast of Oregon, Washington, and/or British Columbia, but these occurrences are considered extralimital as they are generally warm-water species (Halpin et al. 2018; Mcalpine et al. 2004; WDFW 2012). Strandings of sea turtles have increased in recent years, particularly for olive ridley turtles, possibly due to warmer ocean conditions or El Niño (Boyer 2017). Each of these stressors associated with the proposed actions, along with our determinations on their impacts to ESA-listed sea turtles within the action area, are discussed above.

In U.S. waters of the Pacific Ocean, leatherback turtles forage in continental shelf waters between 200 and 2,000 meters (656.2 to 6,561.7 feet) isobaths (77 FR 4169). Depth is considered a factor in leatherback turtle occurrence, as there is evidence that indicates they preferentially forage in areas on the continental shelf; sea surface temperature is also an important factor in

predicting occurrence (with a potential thermal limit of 13 degrees Celsius [55.4 degrees Fahrenheit]) (Benson et al. 2011; Gregr 2015). Leatherback turtles arrive on foraging grounds off the U.S. West Coast primarily in April through July (Benson et al. 2011).

No leatherback turtles are expected to be exposed to airgun array operations due to the very low density of animals available (0.00014 turtles per square kilometer) and the small distances of the ESA (behavioral) harassment threshold of 98 meters (321.5 feet). Also, the NSF and L-DEO will use a 100 meter (328.1 feet) exclusion zone for the two GI airgun array as the shut-down distance for sea turtles. If a sea turtle is detected in or about to enter the exclusion zone, the airgun array will be shut-down (i.e., shut off) immediately.

From this overview, East Pacific DPS of green turtle, leatherback turtle, North Pacific Ocean DPS of loggerhead turtle, and olive ridley turtle may be found within the action area. However, these species are considered rare in the action area. We consider the risk of overlap of these species with the low-energy seismic survey to be extremely unlikely to occur. East Pacific DPS of green turtle, leatherback turtle, North Pacific Ocean DPS of loggerhead turtle, and Mexico's Pacific coast breeding colonies population of olive ridley turtle may be exposed to potential stressors of pollution, vessel strike, vessel noise, acoustic noise from the sub-bottom profiler, multi-beam echosounder, acoustic Doppler current profiler, and pinger, acoustic noise from the airgun array, or gear entanglement and interaction; however, we determined any effects associated with these potential stressors are insignificant or discountable (discussed further in Section 7.1). Due to the rarity of reports from the waters of the Northeast Pacific Ocean and extralimital portion of their range suggests that the East Pacific DPS of green turtle, leatherback turtle, North Pacific Ocean DPS of loggerhead turtle, and Mexico's Pacific coast breeding colonies population of olive ridley turtle are rare in the action area, the potential adverse impacts from acoustic noise from the airgun array is discountable. Therefore, we conclude that the NSF and L-DEO's proposed low-energy seismic survey may affect, but is not likely to adversely affect ESA-listed sea turtles.

7.4 Fishes

ESA-listed fish (i.e., Southern DPS of eulachon, Southern DPS of green sturgeon, California Coastal ESU of Chinook salmon, Central Valley Spring-Run ESU of Chinook salmon, Lower Columbia River ESU of Chinook salmon, Puget Sound ESU of chinook salmon, Sacramento River Winter-Run ESU of Chinook salmon, Snake River Fall-Run ESU of Chinook salmon, Snake River Spring/Summer-Run ESU of Chinook salmon, Upper Columbia River Spring-Run ESU of Chinook salmon, Upper Willamette River ESU of Chinook salmon, Columbia River ESU of chum salmon, Hood Canal Summer-Run ESU of chum salmon, Central California Coast ESU of Coho salmon, Lower Columbia River ESU of Coho salmon, Oregon Coast ESU of Coho salmon, Southern Oregon and Northern California Coasts ESU of Coho salmon, Ozette Lake ESU of Sockeye salmon, Snake River ESU of Sockeye salmon, California Central Valley DPS of steelhead trout, Central California Coast DPS of steelhead trout, Lower Columbia River DPS of steelhead trout, Middle Columbia River DPS of steelhead trout, Northern California DPS of

steelhead trout, Puget Sound DPS of steelhead trout, Snake River Basin DPS of steelhead trout, South-Central California Coast DPS of steelhead trout, Southern California DPS of steelhead trout, Upper Columbia River DPS of steelhead trout, and Upper Willamette River DPS of steelhead trout) may occur in the action area and may be affected by the stressors associated with the NSF and L-DEO's proposed low-energy seismic survey (see Section 6). Numerous ESA-listed DPSs or ESUs of salmonids in the Pacific Ocean could occur in the action area during their oceanic life phase. There is some uncertainty about precisely where in the Pacific Ocean these (or any) salmonids go (Meyers 1998); based on what we do understand, however, the DPSs or ESUs may be present, because salmon form mixed stock aggregations during their time in the ocean (Bellinger et al. 2015). While the ESA-listed fish can be found in the coastal and pelagic habitats within the action area, it is unlikely that ESA-listed fish will be adversely affected by stressors associated with the proposed actions. Each of the stressors associated with the proposed actions, along with our determinations on their impacts on ESA-listed fish within the action area, are discussed above.

7.4.1 Eulachon – Southern Distinct Population Segment

The eulachon occupies nearshore waters to depths of about 300 meters (984.3 feet) in the Northeast Pacific Ocean from California to the Bering Sea. Adults and juveniles are generally found along the continental shelf, in coastal and offshore marine habitats, in waters from 50 to 200 meters (164 to 656.2 feet) deep (Gustafson 2016). Although eulachon have been documented to occur in deeper water depths (maximum of 625 meters [2,050.5 feet]), these instances are rare and have only been observed from trawl data in Alaska which may greatly overestimate eulachon's true maximum depth as fish may become entrained into the nets, either on deployment or recovery (Hay and McCarter 2000).

The Southern DPS of eulachon are those fish that spawn in their natal rivers south of the Nass River in British Columbia to the Mad River in California. Adults are most frequently found in the Columbia River and its tributaries (e.g., Cowlitz River, Sandy River), and sometimes in the Klamath River, California. Spawning eulachon enter the Lower Columbia River estuary from late December through March, while larvae drift downstream into the ocean from February through March (Gustafson 2016). In research trawl surveys, most juvenile eulachon are taken between 137 to 147 meters (449.5 to 482.3 feet) off the U.S. West Coast (defined as Washington, Oregon, and California) (Gustafson et al. 2012). This species typically spends three to five years in saltwater before returning to fresh water to spawn.

There will be no tracklines for airgun array operations that will take place in water depths less than 1,600 meters (5,240.3 feet). Because of the small size of the ensonified area, acoustic noise created by the airgun array are not expected to extend into places where Southern DPS of eulachon occur and expose them to the seismic survey activities.

7.4.2 Green Sturgeon – Southern Distinct Population Segment

The North American green sturgeon is an anadromous fish that occurs in the nearshore Eastern Pacific Ocean from Alaska to Mexico (Moyle 2002). Green sturgeon are long-lived, late-maturing iteroparous, anadromous species that spawn infrequently in natal streams, and spend substantial portions of their lives in marine waters. NMFS has identified two DPSs of green sturgeon; Northern and Southern (Israel et al. 2009). The Northern DPS of green sturgeon spawns primarily in the Klamath and Rogue rivers, and occasionally in the Columbia River, while the Southern DPS spawns exclusively in the Sacramento Basin (Schreier and Stevens 2020). The Southern DPS of green sturgeon includes individuals which spawn in the Sacramento, Feather, and Yuba rivers.

Green sturgeon from both the Northern DPS and Southern DPS range along the U.S. West Coast of the Pacific Ocean (Moyle 2002), with green sturgeon tagged and released in the Sacramento River later detected in Willapa Bay, Washington (Hansel et al. 2017). Large concentrations of fish congregate in coastal bays and estuaries along the West Coast of the U.S. in Washington, Oregon, and California (including the Columbia River estuary, Willapa Bay, Grays Harbor, San Francisco, and Monterey Bay) during summer and fall. In winter and spring, similar aggregations can be found from Vancouver Island to Hecate Strait, British Columba, Canada (Lindley et al. 2008). Green sturgeon are found in Willapa Bay, Washington, from May through September, but acoustically-tagged individuals occur there over shorter time periods (Borin et al. 2017). Hansel et al. (2017) detected acoustically-tagged green sturgeon in the Columbia River estuary from May through October.

In preparation for spawning, adult Southern DPS of green sturgeon enter San Francisco Bay between mid-February and early-May, then migrate rapidly (on the order of a few weeks) up the Sacramento River (Heublein et al. 2009). Spawning occurs from April through early July, with peaks of activity that depend on a variety of factors including water temperature and water flow rates (Poytress et al. 2009; Poytress et al. 2010). Post-spawn fish typically congregate and hold for several months in a few deep pools in the upper main stem Sacramento River near spawning sites and migrate back downstream when river flows increase in fall. They re-enter the ocean during the winter months (November through January) and begin their marine migration north along the coast (Erickson and Hightower 2007).

Green sturgeon have a swim bladder, but no known structures in the auditory system that would enhance hearing, and sensitivity (lowest sound detectable at any frequency) is not very great. Sounds would have to be more intense to be detected compared to fishes with swim bladders that enhance hearing.

Subadult and adult green sturgeon spend most of their lives in the marine environment, at water depths between 20 to 70 meters (66 to 230 feet) (up to 110 meters [360.9 feet] (Erickson and Hightower 2007; Huff et al. 2011), from southern California and Mexico to the Bering Sea in Alaska (NMFS 2015b). Information regarding their preference for areas of high seafloor complexity and prey selection in coastal waters (benthic prey) indicate green sturgeon reside and

migrate along the seafloor while in coastal waters. There will be no tracklines for airgun array operations that will take place in water depths less than 1,600 meters (5,240.3 feet). Because of the small size of ensonified area, acoustic noise created by the airgun array are not expected to extend into places where they occur and expose them to the seismic survey activities.

The timing of the proposed actions is significant in terms of likelihood of green sturgeon exposure to potential stressors. In July and August, tagged green sturgeon moved into shallower waters (20 meters [65.6 feet] deep or less) (Huff et al. 2011). Satellite tagging data from 2019 indicate that up until mid-July, tagged green sturgeon are using the coastal waters of Washington, moving into the shallow coastal waters near the Columbia River by late July (J. Smith, personal communication). Due to the timing of the proposed actions and the overall low amount of overlap that will take place in waters less than 100 meters (328.1 feet) deep, and that we expect green sturgeon to spend a portion of the time of the proposed actions in shallow waters outside of the action area, we expect exposure to the potential stressors to be highly unlikely.

We were unable to determine the density of Southern DPS of green sturgeon in the action area, but we do not expect them to be exposed to the sound field produced by the airgun array.

7.4.3 Salmonids – Chinook Salmon, Chum Salmon, Coho Salmon, Sockeye Salmon, and Steelhead Trout

Salmonids are anadromous (i.e., adults migrate from marine to fresh water streams and rivers to spawn) and some species are semelparous (i.e., they spawn once and then die) fish species. Some sockeye salmon spend their entire lives in fresh water. Unlike salmon, steelhead trout are capable of spawning more than once before they die; however, it is rare for steelhead trout to spawn more than twice before dying, and most that do so are females (Moyle 2002). We expect both juvenile and adult Chinook, chum, Coho, and Sockeye salmon and steelhead trout may occur in the action area. The marine environment represents very important habitat for salmon and steelhead trout during critical phases of their life cycle. This includes:

- Juveniles when they are entering the marine environment from their natal rivers;
- Juveniles already in the marine environment for their growth phase; and
- Pre-spawning adults that are returning to their natal rivers to spawn.

While not every population of salmonids in the Pacific Ocean may be exposed during their entry into the ocean or during their spawning run due to the location and timing of the proposed actions, we still expect that they may be exposed to potential stressors in the marine environment. Salmonids in the Pacific Ocean spend a few years in the ocean during their growth phase. Upon reaching the ocean, juveniles feed voraciously and grow rapidly in the marine environment, with growth rates dependent on water temperatures and food availability.

Estuaries represent important habitat for both juvenile and adult salmon. Adults use coastal areas near their natal rivers as staging areas before moving into fresh water to spawn. Residence times for adults in staging areas can vary from one to six weeks. Juveniles can remain in the estuaries

for four days (chum salmon) and up to six months (Chinook salmon) before entering the marine environment (Simenstad et al. 1982), likely using the areas to adjust to higher salinity water.

The specific spawning migration and entry timing to the ocean from rivers varies by species and DPS or ESU. See Table 8, Table 9, Table 10, Table 11, and Table 12 below for information on migration timing by species. Here, we refer to adult salmonids present in their natal rivers and moving upriver to spawn as "adult spawning migration timing" and juveniles leaving their natal rivers to enter the ocean for their growth phase as "juvenile entry into marine environment."

Salmonids in the Pacific Ocean form mixed stock aggregations in the marine environment. In the case of Chinook salmon, individuals from a broad area are found in the coastal waters of the action area.

In a fishery-dependent study from May through September in coastal water of Oregon and northern California, Bellinger et al. (2015) identified Chinook salmon from numerous river systems from Alaska to the Central Valley, California. Stock richness was highest in the northern part of the sampling area than in the south. In a study of killer whale prey collection from off the coasts of Oregon and Washington, Chinook salmon from a broad area were found in fecal samples, including fish from the Middle Fraser River, Canada, Puget Sound, Washington, and the Columbia River, Oregon and Washington, the Snake River, Washington and Idaho, the Klamath River, California, the Central Valley (Sacramento and San Joaquin Rivers), California, and the Taku River in southeast Alaska (NMFS 2019). Spawning migration times and marine entry times for Chinook salmon are shown in Table 8.

Table 8. Spawning Migration and Entry Timing for Distinct Population Segments/Evolutionarily Significant Units of Chinook Salmon.

Chinook Salmon DPS/ESU	Chinook Salmon Adult Spawning Migration Timing	Chinook Salmon Juvenile Entry into Marine Environment
Puget Sound	April through May: Spring-run June through July: Summer-run August through September: Fall-run	May through June: Spring-run April through July: Summer and fall-run
Upper Columbia River Spring-Run	Late March through May, peak in mid-May	April through June, peaks in May. All enter Canadian waters by end of June.
Lower Columbia River	March through June: Spring-run August through October: Fall-run	March through September, peaks in April through June: Spring-run March through September, peaks in September: Fall-run
Upper Willamette River	February through August, peak from April through late May	March through September, peaks in June

Snake River Spring-Summer	March through May, spawning adults present along the coast of Washington and Columbia River plume, peaks in May	April through June, peaks in May. All entering Canadian waters by June.
Snake River Fall-Run	August through October, spawning adults present along the coast of Washington and Columbia River plume, peaks in September	June through November, no significant peak. All entering Canadian waters by end of November.
California Coastal	September through early November	February through June
Central Valley Spring-Run	March through July	February through June, peaks April through May
Sacramento River Winter-Run	November through June	January through May, peaking in mid-March

DPS=distinct population segment, ESU=evolutionarily significant unit

Coho salmon enter the ocean in spring of their second year, and spend the next few years in the ocean, as they grow from smolts to adults, before the adults return to fresh water to spawn, usually in fall or early winter of their third year (Cole 2000). Spawning migration times and marine entry times for Coho salmon are shown in Table 9.

Table 9. Spawning Migration and Entry Timing for Distinct Population Segments/Evolutionarily Significant Units of Coho Salmon.

Coho Salmon DPS/ESU	Coho Salmon Adult Spawning Migration Timing	Coho Salmon Juvenile Entry into Marine Environment
Lower Columbia River	Mid-September through mid-November	March through July
Oregon Coast	October through December	March through July
Southern Oregon/Northern California	September through October	March through May
Central California Coast	November through January	March through May

DPS=distinct population segment, ESU=evolutionarily significant unit

Upstream spawning migration times and marine entry times for chum salmon are shown in Table 10.

Table 10. Spawning Migration and Entry Timing for Distinct Population Segments/Evolutionarily Significant Units of Chum Salmon.

Chum Salmon DPS/ESU	Chum Salmon Adult Spawning Migration Timing	Chum Salmon Juvenile Entry into Marine Environment
Hood Canal Summer-Run	Mid-August through mid-October, peak in September	February through early April
Columbia River	Early-October through mid-November	March through May

DPS=distinct population segment, ESU=evolutionarily significant unit

Spawning migration times and marine entry times for sockeye salmon are shows in Table 11.

Table 11. Spawning Migration and Entry Timing for Distinct Population Segments/Evolutionarily Significant Units of Sockeye Salmon.

Sockeye Salmon DPS/ESU	Sockeye Salmon Adult Spawning Migration Timing	Sockeye Salmon Juvenile Entry into Marine Environment
Ozette Lake	Mid-April through mid-August, peak in May through June	March through June, peak in April through May
Snake River	June through July	May through mid-June

DPS=distinct population segment, ESU=evolutionarily significant unit

Spawning migration times and marine entry times for steelhead trout are shown in Table 12.

Table 12. Spawning Migration and Entry Timing for Distinct Population Segments/Evolutionarily Significant Units of Steelhead Trout.

Steelhead Trout DPS/ESU	Steelhead Trout Adult Spawning Migration Timing	Steelhead Trout Juvenile Entry into Marine Environment
Puget Sound	November through mid-June: Winter-run April through November: Summer-run	March through June
Upper Columbia River	November through May June to early August: “A-run”	Mid-April through early June
Middle Columbia River	November through May June through early August: “A-run”	Mid-April through early June
Lower Columbia River	Late February through early June: Spring-run November through May: Winter-run	Mid-April through early June

Upper Willamette River	February through March: Late winter-run	Mid-April through early June
Snake River Basin	June through early August: "A-run" August through October: "B-run"	Mid-April through early June
Northern California Coast	March through August: Summer-run September through November: Winter-run	March through June
California Central Valley	August through October	March through May
Central California Coast	October through November	January through June
South-Central California	January through May	January through May

DPS=distinct population segment, ESU=evolutionarily significant unit

Chinook salmon are commonly found in the California Current, in nearshore environments. Thermal conditions are likely an important factor in their habitat use. In late summer and fall (late July through November), tagged Chinook salmon occupied cool areas (9 to 12 degrees Celsius [48.2 to 53.6 degrees Fahrenheit]) (Hinke et al. 2005). It is thought that the cool, upwelled water in the coastal shelf serves as a migratory corridor and feeding ground for Chinook and Coho (Bellinger et al. 2015).

Adult Coho salmon are found on the continental shelf from southeast Alaska to Monterey Bay, California (Beacham et al. 2016; Weitkamp and Neely 2002). Some adults migrate to the offshore waters of the North Pacific Ocean (Quinn et al. 2005). Juveniles are initially found in the nearshore environment before moving to the continental shelf areas with the adults (Beacham et al. 2016).

In June, in the continental shelf and oceanic waters off the coast of Washington, the average depth at capture for Coho salmon was 85.6 meters (280.8 feet), and 55 meters (180.4 feet) for Chinook salmon, with Coho salmon ranging further offshore. In June, 80 percent of yearling Chinook and Coho salmon were found in the nearshore zone (about 30 meters [98.4 feet] deep) to water depths of 83 to 124 meters (272.3 to 406.8 feet), respectively (Peterson et al. 2010). In another study, juvenile Chinook salmon were most frequency captured in waters less than 37 meters (121.4 feet) deep near the Columbia River off Oregon and Washington between May and September (Fisher 1995).

Immature and maturing chum salmon are distributed widely throughout the offshore waters of the Gulf of Alaska, outside the action area (Salo 1991). After entering the ocean, juvenile chum salmon migrate northward from the Columbia River and Hood Canal along the coast until reaching Alaska (Johnson et al. 1997).

Juvenile sockeye salmon use a narrow band along the coast to rapidly move northward from their natal river, leaving it in mid-May through mid-June, and arriving in the Gulf of Alaska by mid-

June through mid-July. Adult sockeye salmon distribute widely in the offshore waters of the Gulf of Alaska (Gustafson et al. 1997; Tucker et al. 2015).

Adult steelhead trout occur in the North Pacific Ocean in the oceanic waters off the continental shelf. When they reach maturity, they migrate east back over the continental shelf to their natal rivers (Quinn 2005). In contrast to other juvenile salmon that use a north-south coastal migration route, juvenile steelhead trout quickly migrate west after leaving their natal rivers to the oceanic waters past the continental shelf. These movements can take as little as one to three days, with an average of ten days (Daly et al. 2014).

In a study conducted in fall (September through October) and winter (January through February) in the eastern Bering Sea, salmon most often occupy the upper level of the water column, with some variation by species and life stage (Walker et al. 2007). Some immature Chinook, chum, and sockeye salmon were captured at depths between 30 to 60 meters (98.4 to 196.6 feet), in addition to being caught in waters above 30 meters (98.4 feet) deep. Chinook and chum salmon have the deepest vertical distributions, with Chinook salmon having an average depth of 42 meters (137.8 feet) (average daily maximum of 130 meters [426.5 feet] deep), and chum salmon occupying an average depth of 16 meters (52.5 feet) (average daily maximum of 58 meters [190.3 feet]) (Walker et al. 2007). Coho salmon were found at an average depth of 11 meters (36.1 feet), with an average daily maximum of 46 meters (150.9 feet), and sockeye salmon found at average depth of 3 meters (9.8 feet) (average daily maximum of 19 meters [62.3 feet]) (Walker et al. 2007).

Both juvenile and adult steelhead trout are regarded as being surface-oriented, occupying the upper 10 meters (32.8 feet) of the water column (Light et al. 1989). Adult sockeye salmon occupy the upper 30 meters (98.4 feet) of the water column, with most occupying the upper 10 meters (32.8 feet) (Ogura and Ishida 1995; Quinn et al. 1989). Juvenile sockeye salmon are mostly found in the upper 15 meters (49.2 feet) of the water column (Beamish et al. 2007).

Most Chinook, chum, and sockeye salmon spend two to four years foraging and maturing in the ocean environment before returning to natal rivers to spawn. Coho salmon typically return to spawn at age three and thus spend approximately two years at sea. Eulachon typically spend three to five years at sea before returning to fresh water to spawn.

Since Chinook and Coho salmon primarily reside on the continental shelf, NMFS (2015a) used the continental shelf break as the westward boundary of these species' distribution (the shelf break was defined as the 200 meter (656.2 feet) depth contour (Landry and Hickey 1989)). Similar studies were not available for chum and sockeye salmon, and steelhead trout. Chum salmon geographic distribution was based on the ocean migration of the species from British Columbia, Washington, and Oregon, as determined from tagging data and presented in Neave et al. (1976). The migration pattern described in Neave et al. (1976) did not include information on individuals found immediately offshore of their river of origin in Oregon and Washington. Chum salmon migrate north and west once they leave their river of origin (Byron and Burke 2014; Quinn 2005) and generally found on the continental shelf, inshore of 37 kilometers (20 nautical

miles) from the coast (Pearcy and Fisher 1990). Therefore, NMFS (2015a) added the area of the continental shelf from each ESU's river of origin north to the mouth of Puget Sound (the area southernmost point where Neave et al. (1976) presented tagging data). NMFS (2015a) used the same geographic distribution for sockeye salmon as it did for chum salmon because in general, it is thought that sockeye salmon follow a similar migration pattern once they enter the ocean, moving north and west along the coast, and having moved offshore by the end of their first year in the ocean (Byron and Burke 2014; Quinn 2005). For steelhead trout, NMFS (2015a) relied on the geographic ocean distribution of the species during summer described in Light et al. (1989)

The continental shelf (waters less than 200 meters [656.2 feet] deep represents important habitat for ESA-listed fishes. Although steelhead trout can exhibit a more offshore distribution, the 200 meter (656.2 feet) depth line is used as a conservative measure to illustrate where ESA-listed fish are mainly located.

There will be no tracklines for airgun array operations that will take place in water depths less than 1,600 meters (5,240.3 feet). Because of the small size of the ensonified area, acoustic noise created by the airgun array are not expected to extend into places where salmonids occur and expose them to the seismic survey activities.

Limited information exists on Southern California DPS of steelhead trout runs. Based on combined estimates from the Santa Ynez, Ventura, and Santa Clara rivers, and Malibu Creek, an estimated 32,000 to 46,000 adult steelhead occupied this DPS historically. In contrast, less than 500 adults are estimated to occupy the same four waterways presently. The last estimated run size for steelhead in the Ventura River, which has its headwaters in Los Padres National Forest, is 200 adults (Busby et al. 1996). Given the extremely low abundance of ESA-listed Southern California DPS of steelhead trout in general and within the action area and the limited co-occurrence with the proposed action's potential stressors, the likelihood of the proposed actions adversely affecting Southern California DPS of steelhead trout is so low as to be discountable.

From this overview, ESA-listed fish (i.e., Southern DPS of eulachon, Southern DPS of green sturgeon, California Coastal ESU of Chinook salmon, Central Valley Spring-Run ESU of Chinook salmon, Lower Columbia River ESU of Chinook salmon, Puget Sound ESU of chinook salmon, Sacramento River Winter-Run ESU of Chinook salmon, Snake River Fall-Run ESU of Chinook salmon, Snake River Spring/Summer-Run ESU of Chinook salmon, Upper Columbia River Spring-Run ESU of Chinook salmon, Upper Willamette River ESU of Chinook salmon, Columbia River ESU of chum salmon, Hood Canal Summer-Run ESU of chum salmon, Central California Coast ESU of Coho salmon, Lower Columbia River ESU of Coho salmon, Oregon Coast ESU of Coho salmon, Southern Oregon and Northern California Coasts ESU of Coho salmon, Ozette Lake ESU of Sockeye salmon, Snake River ESU of Sockeye salmon, California Central Valley DPS of steelhead trout, Central California Coast DPS of steelhead trout, Lower Columbia River DPS of steelhead trout, Middle Columbia River DPS of steelhead trout, Northern California DPS of steelhead trout, Puget Sound DPS of steelhead trout, Snake River Basin DPS of steelhead trout, South-Central California Coast DPS of steelhead trout, Southern

California DPS of steelhead trout, Upper Columbia River DPS of steelhead trout, and Upper Willamette River DPS of steelhead trout) may be found within the action area. We consider these species to be rare or at low densities in the action area, overlap with this species with the low-energy seismic survey is extremely unlikely to occur. ESA-listed fish may be exposed to the potential stressors of pollution, vessel strike, vessel noise, acoustic noise from the airgun array, sub-bottom profiler, multi-beam echosounder, acoustic Doppler current profiler, pinger or gear entanglement and interactions; however, we determined any effects associated with these potential stressors are insignificant or discountable (discussed further in Section 7.1). Therefore, we conclude that the NSF and L-DEO's proposed low-energy seismic survey may affect, but is not likely to adversely affect ESA-listed fish.

7.5 Designated Critical Habitat

The designated critical habitat of leatherback turtle occur in the action area and may be affected by the proposed actions.

7.5.1 Humpback Whale – Central America and Mexico Distinct Population Segment Critical Habitat

In 2021, NMFS designated critical habitat for the Central America DPS, Mexico DPS, and Western North Pacific DPS of humpback whales (86 FR 21082). Areas designated as critical habitat include specific marine areas located off the coasts of California, Oregon, Washington, and Alaska. Specific areas designated as critical habitat for the Central America DPS of humpback whales contain approximately 166,422.4 square kilometers (48,521 square nautical miles) of marine habitat in the North Pacific Ocean within the portions of the California Current Ecosystem off the coasts of Washing, Oregon, and California. Specific areas designated as critical habitat for the Mexico DPS of humpback whales contain approximately 569,700.2 square kilometers (116,098 square nautical miles) of marine habitat in the North Pacific Ocean, including areas within portions of the eastern Bering Sea, Gulf of Alaska, and California Current Ecosystem. Specific areas designated as critical habitat for the Western North Pacific DPS of humpback whales contain approximately 203,774 square kilometers (59,411 square nautical miles) of marine habitat in the North Pacific Ocean, including areas within the eastern Bering Sea and Gulf of Alaska.

For the Central America DPS of humpback whale, the critical habitat includes all marine waters in Washington, Oregon, and California (Figure 4). In Washington, the nearshore boundary is defined by the 50 meter (164 feet) isobath, and the offshore boundary is defined by the 1,200 meter (3,937 feet) isobath relative to the mean lower low water. Critical habitat also includes waters within the U.S. portion of the Strait of Juan de Fuca to an eastern boundary line at Angeles Point at 123 degrees 33' West. In Oregon, the nearshore boundary is defined by the 50 meter (164 feet) isobath. The offshore boundary is defined by the 1,200 meter (3,937 feet) isobath relative to mean lower low water; except, in areas off Oregon south of 42 degrees 10' West, the offshore boundary is defined by the 2,000 meter (6,561.7 feet) isobath. In California, the nearshore boundary is defined by the 50 meter (164 feet) isobaths relative to mean lower low

water except from 38 degrees 40' North to 36 degrees 00' North, the nearshore boundary is defined by the 15 meter (49.2 feet) isobath relative to mean lower low water; and from 36 degrees 00' North to 34 degrees 30' North, the nearshore boundary is defined by the 30 meter (98.4 feet) isobath relative to mean lower low water. North of 40 degrees 20' North, the offshore boundary of the critical habitat is defined by a line corresponding to the 2,000 meter (6,561.7 feet) isobath, and from 40 degrees 20' North to 38 degrees 40' North, the offshore boundary is defined by the 3,000 meter (9,842.5 feet) isobath. From 38 degrees 40' North southward, the remaining areas have an offshore boundary defined by a line corresponding to the 3,700 meter (12,139.1 feet) isobath.

For the Mexico DPS of humpback whale, the critical habitat includes marine waters in Alaska, Washington, Oregon, and California (Figure 4). In Alaska, the nearshore boundaries is generally defined by the 1 meter (3.3 feet) isobath relative to mean lower low water. On the north side of the Aleutian Islands, the seaward boundary of the critical habitat is defined by a line extending from 55 degrees 41' North, 162 degrees 41'West to 55 degrees 41' North, 169 degrees 30' West, then southward through Samalaga Pass to a boundary drawn along the 2,000 meter (6,561.7 feet) isobath on the south side of the islands. This isobath forms the southern boundary of the critical habitat, eastward to 164 degrees 25' West. From this point, the 1,000 meter (3,280.8 feet) isobath forms the offshore boundary, which extends eastward to 158 degrees 39' West. Critical habitat also includes the waters around Kodiak Island and the Barren Islands. The western boundary for this area runs southward along 154 degrees 54' West to the 1,000 meter (3,280.8 feet) depth contour, and then extends eastward to a boundary at 150 degrees 40' West. The area also extends northward to the mouth of Cook Inlet where it is bounded by a line that extends from Cape Douglas across the inlet to Cape Adam. Critical habitat also includes the Prince William Sound area and associated waters defined by an eastern boundary at 148 degrees 31' West, a western boundary at 145 degrees 27' West, and a seaward boundary drawn along the 1,000 meter (3,280.8 feet) isobaths. In Washington, the nearshore boundary is defined by the 50 meter (164 feet) isobath, and the offshore boundary is defined by the 1,200 meter (3,937 feet) isobath relative to the mean lower low water. Critical habitat also includes waters within the U.S. portion of the Strait of Juan de Fuca to an eastern boundary line at Angeles Point at 123 degrees 33' West. In Oregon, the nearshore boundary is defined by the 50 meter (164 feet) isobath. The offshore boundary is defined by the 1,200 meter (3,937 feet) isobath relative to mean lower low water; except, in areas off Oregon south of 42 degrees 10' West, the offshore boundary is defined by the 2,000 meter (6,561.7 feet) isobath. In California, the nearshore boundary is defined by the 50 meter (164 feet) isobath relative to mean lower low water except from 38 degrees 40' North to 36 degrees 00' North, the nearshore boundary is defined by the 15 meter (49.2 feet) isobath relative to mean lower low water; and from 36 degrees 00' North to 34 degrees 30' North, the nearshore boundary is defined by the 30 meter (98.4 feet) isobath relative to mean lower low water. North of 40 degrees 20' North, the offshore boundary of the critical habitat is defined by a line corresponding to the 2,000 meter (6,561.7 feet) isobath, and from 40 degrees 20' North to 38 degrees 40' North, the offshore boundary is defined by the 3,000 meter

(9,842.5 feet) isobath. From 38 degrees 40' North southward, the remaining areas have an offshore boundary defined by a line corresponding to the 3,700 meter (12,139.1 feet) isobath.

The Western North Pacific DPS of humpback whale does not occur in the action area and is not be considered further in this consultation.

The physical and biological features essential to the conservation of Central America DPS of humpback whales includes prey species, primarily euphausiids (*Thysanoessa*, *Euphausia*, *Nyctiphanes*, and *Nematoscelis*) and small pelagic schooling fishes, such as Pacific sardine (*Sardinops sagax*), northern anchovy (*Engraulis mordax*), and Pacific herring (*Clupea pallasii*), of sufficient quality, abundance, and accessibility within humpback whale feeding areas to support feeding and population growth.

The physical and biological features essential to the conservation of Mexico DPS of humpback whales includes prey species, primarily euphausiids (*Thysanoessa*, *Euphausia*, *Nyctiphanes*, and *Nematoscelis*) and small pelagic schooling fishes, such as Pacific sardine (*Sardinops sagax*), northern anchovy (*Engraulis mordax*), Pacific herring (*Clupea pallasii*), capelin (*Mallotus villosus*), juvenile walleye pollock (*Gadus chalcogrammus*), and Pacific sand lance (*Ammondytes personatus*) of sufficient quality, abundance, and accessibility within humpback whale feeding areas to support feeding and population growth.

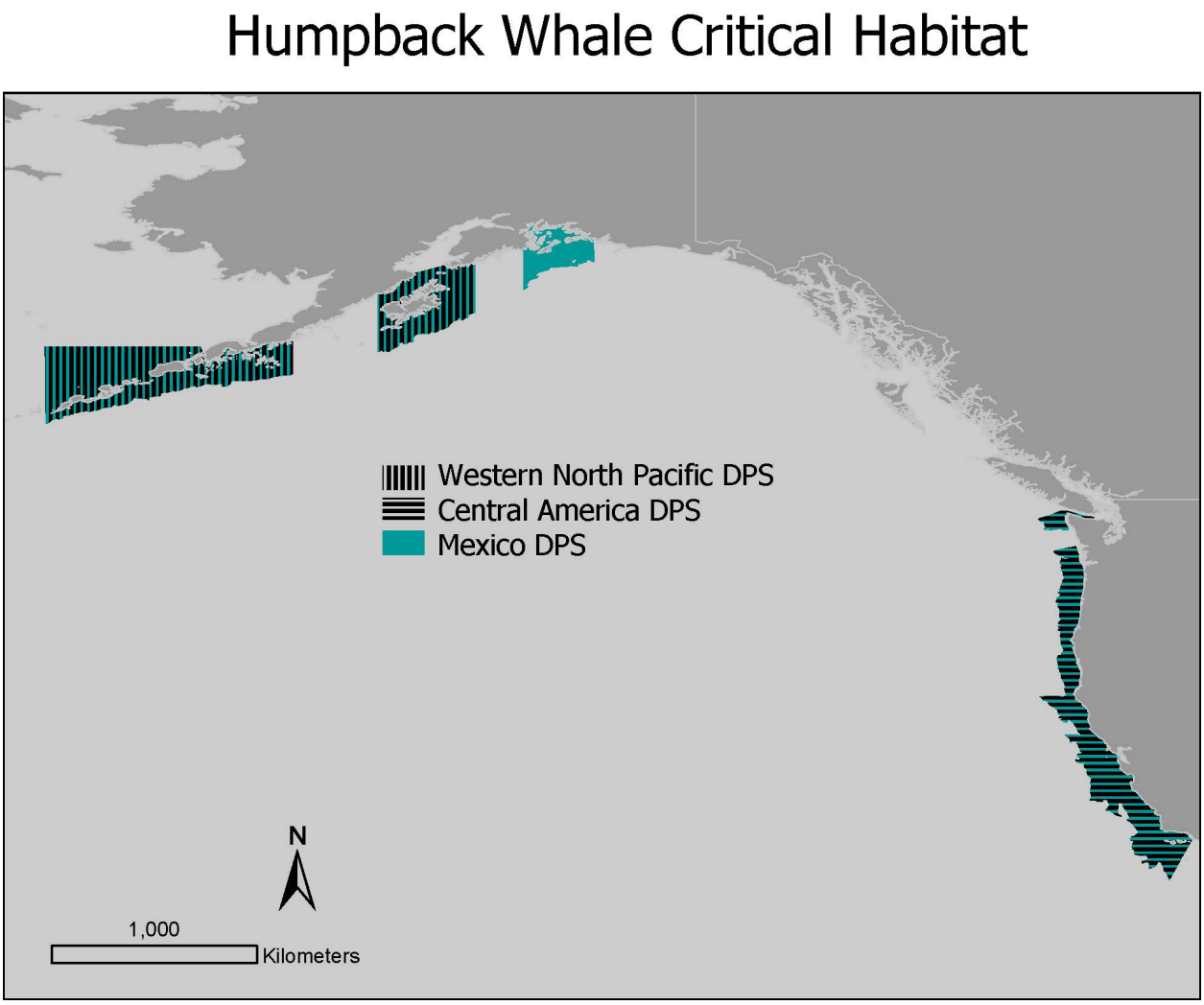

Figure 4. Overview map of critical habitat for the endangered Central America distinct population segment, threatened Mexico distinct population segment, and endangered Western North Pacific distinct population segment of humpback whales.

7.5.2 Killer Whale – Southern Resident Distinct Population Segment Critical Habitat

In 2006, NMFS designated critical habitat for the Southern Resident DPS of killer whale (71 FR 69054). The three specific areas in Washington: (1) the Summer Core Area in Haro Strait and waters around the San Juan Islands; (2) Puget Sound; and (3) the Strait of Juan de Fuca (Figure 5), which comprise approximately 6,630 square kilometers (1,933 square nautical miles) of marine habitat (Figure 5).

The physical and biological features essential to the conservation of Southern Resident DPS of killer whales includes: (1) water quality to support growth and development; (2) prey species of sufficient quantity, quality, and availability to support individual growth, reproduction and development, as well as overall population growth; and (3) inter-area passage conditions to allow for migration, resting, and foraging.

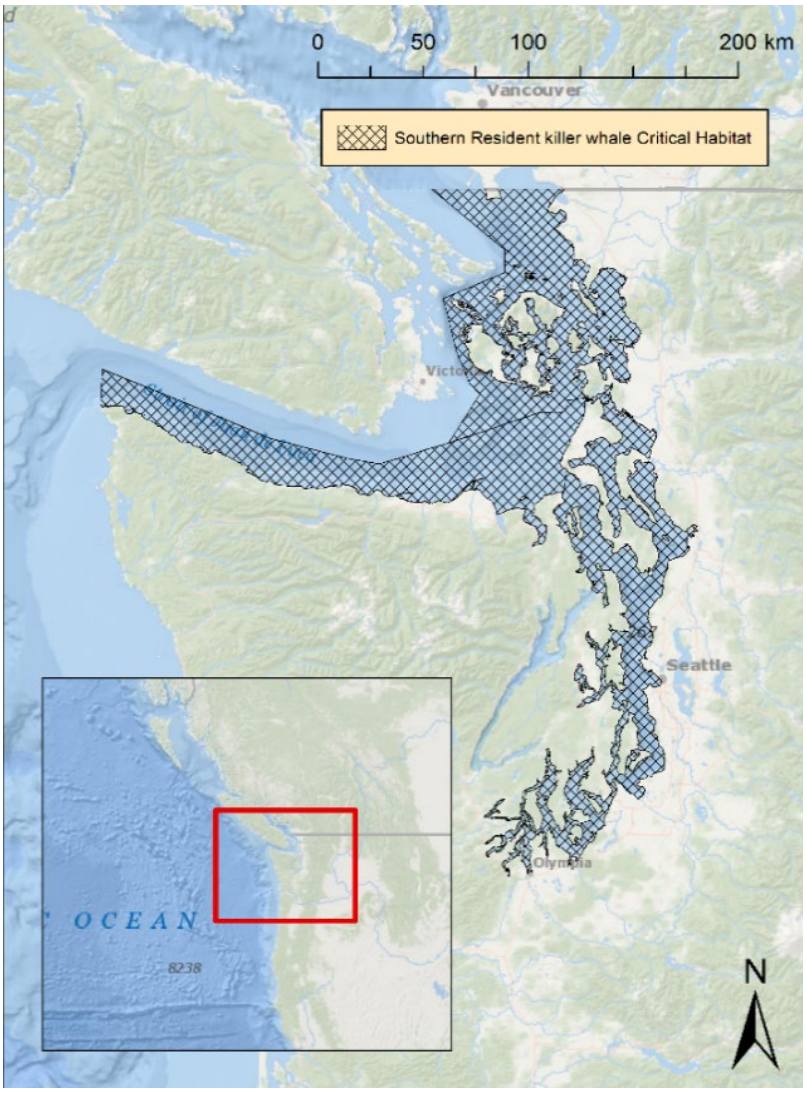

Figure 5. Map identifying designated critical habitat for the endangered Southern Resident distinct population segment of killer whale.

In 2021, NMFS revised designated critical habitat for the Southern Resident DPS of killer whale by expanding it to include six additional coastal critical habitat areas along the U.S. West Coast, while keeping the designated critical habitat area in Washington (Figure 6) (86 FR 41668). Specific newly designated areas along the U.S. West Coast include 41,207 square kilometers (12,014 square nautical miles) of marine waters between the 6.1 meter (20 feet) depth contour and the 200 meter (656.2 feet) depth contour from the U.S. international border with Canada south to Point Sur, California.

For the inland waters of Washington State, critical habitat includes three specific marine areas of Puget Sound, Washington, within the following counties: Clallam, Jefferson, King, Kitsap, Island, Mason, Pierce, San Juan, Skagit, Snohomish, Thurston, and Whatcom. Critical habitat includes all waters relative to a contiguous shoreline delimited by the line at a depth of 6.1 meters (20 feet) relative to extreme high water in each of the following areas:

- Summer Core Area – All U.S. marine waters in Whatcom and San Juan counties; and all marine waters in Skagit County west and north of the Deception Pass Bridge (Highway 20) (48 degrees 24' 25" North, 122 degrees 38' 35" West).
- Puget Sound Area – All marine waters in Island County east and south of the Deception Pass Bridge (Highway 20) (48 degrees 24' 25" North, 122 degrees 38' 35" West), and east of a line connecting the Point Wilson Lighthouse (48 degrees 8' 39" North, 122 degrees 44' 26" West) and a point on Whidbey Island located at 48 degrees 12' 30" North, 122 degrees 44' 26" West; all marine waters in Skagit County east of the Deception Pass Bridge (Highway 20) (48 degrees 24' 25" North, 122 degrees 38' 35" West); all marine waters of Jefferson County east of a line connecting the Point Wilson Lighthouse (48 degrees 8' 39" North, 122 degrees 44' 26" West) and a point on Whidbey Island located at latitude 48 degrees 12' 30" North, 122 degrees 44' 26" West, and north of the Hood Canal Bridge (Highway 104) (47 degrees 51' 36" North, 122 degrees 37' 23" West); all marine waters in eastern Kitsap County east of the Hood Canal Bridge (Highway 104) (47 degrees 51' 36" North, 122 degrees 7' 23" West); all marine waters (excluding Hood Canal) in Mason County; and all marine waters in King, Pierce, Snohomish, and Thurston counties.
- Strait of Juan de Fuca Area – All U.S. marine waters in Clallam County east of a line connecting Cape Flattery, Washington (48 degrees 23' 10" North, 124 degrees 43' 32" West), Tatoosh Island, Washington (48 degrees 23' 30" North, 124 degrees 44' 12" West), and Bonilla Point, British Columbia (48 degrees 35' 30" North, 124 degrees 43' 00" West); all marine waters in Jefferson and Island counties west of the Deception Pass Bridge (Highway 20) (48 degrees 24' 25" North, 122 degrees 38' 35" West), and west of a line connecting the Point Wilson Lighthouse (48 degrees 8' 39" North, 122 degrees 45' 12" West) and a point on Whidbey Island located at 48 degrees 12' 30" North, 122 degrees 44' 26" West.

For coastal marine waters along the U.S. West Coast, critical habitat includes six specific marine areas along the coasts of Washington, Oregon, and California. Critical habitat includes all waters relative to a contiguous shoreline delimited by the line at a depth of 6.1 meters (20 feet) relative to mean high water in each of the following areas:

- Coastal Washington/Northern Oregon Inshore Area – U.S. marine waters west of a line connecting Cape Flattery, Washington (48 degrees 23' 10" North, 124 degrees 44' 12" West), Tatoosh Island, Washington (48 degrees 23' 30" North, 124 degrees 44' 12" West), and Bonilla Point, British Columbia (48 degrees 35' 30" North, 124 degrees 43' 00" West), from the U.S. international border with Canada south to Cape Meares, Oregon (45 degrees 29' 12" North), between the 6.1 meter (20 feet) and 50 meters (164 feet) isobaths contours. This includes waters off Clallam, Jefferson, Grays Harbour, and Pacific counties in Washington and Clatsop and Tillamook counties in Oregon.

- Coastal Washington/Northern Oregon Offshore Area – U.S. marine waters west of a line connecting Cape Flattery, Washington (48 degrees 23' 10" North, 124 degrees 43' 32" West), Tatoosh Island, Washington (48 degrees 23' 30" North, 124 degrees 44' 12" West), and Bonilla Point, British Columbia (48 degrees 35' 30" North, 124 degrees 43' 00" West) south to Cape Meares, Oregon (45 degrees 29' 12" North), between the 50 meter (164 feet) and 200 meter (656.2 feet) isobaths contours. This includes water off Clallam, Jefferson, Grays Harbor, and Pacific counties in Washington and Clatsop and Tillamook counties in Oregon.
- Central/Southern Oregon Coast Area – U.S. marine waters from Cape Meares, Oregon (45 degrees 29' 12" North) south to the border between Oregon and California (42 degrees 00' 00" North), between the 6.1 meter (20 feet) and 200 meter (656.2 feet) isobaths contours. This includes waters off Tillamook, Lincoln, Lane, Douglas, Coos, and Curry counties in Oregon.
- Northern California Coast Area – U.S. marine waters from the border between Oregon and California (42 degrees 00' 00" North) south to Cape Mendocino, California (40 degrees 26' 19" North), between the 6.1 meter (20 feet) and 200 meter (656.2 feet) isobaths contours. This includes waters off Del Norte and Humboldt counties in California.
- North Central California Coast Area – U.S. marine waters from Cape Mendocino, California (40 degrees 26' 19" North) south to Pigeon Point, California (37 degrees 11' 00" North), between the 6.1 meter (20 feet) and 200 meter (656.2 feet) isobaths contours. This includes waters off Humboldt, Mendocino, Sonoma, Marin, San Francisco, and San Mateo counties in California.
- Monterey Bay Area – U.S. marine waters from Pigeon Point, California (37 degrees 11' 00" North) south to Point Sur, California (36 degrees 18' 00" North), between the 6.1 meter (20 feet) and 200 meter (656.2 feet) isobaths contours. This includes water off San Mateo, Santa Cruz, and Monterey counties in California.

The physical and biological features essential to the conservation of Southern Resident DPS of killer whales includes: (1) water quality to support growth and development; (2) prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth; and (3) passage conditions to allow for migration, resting, and foraging.

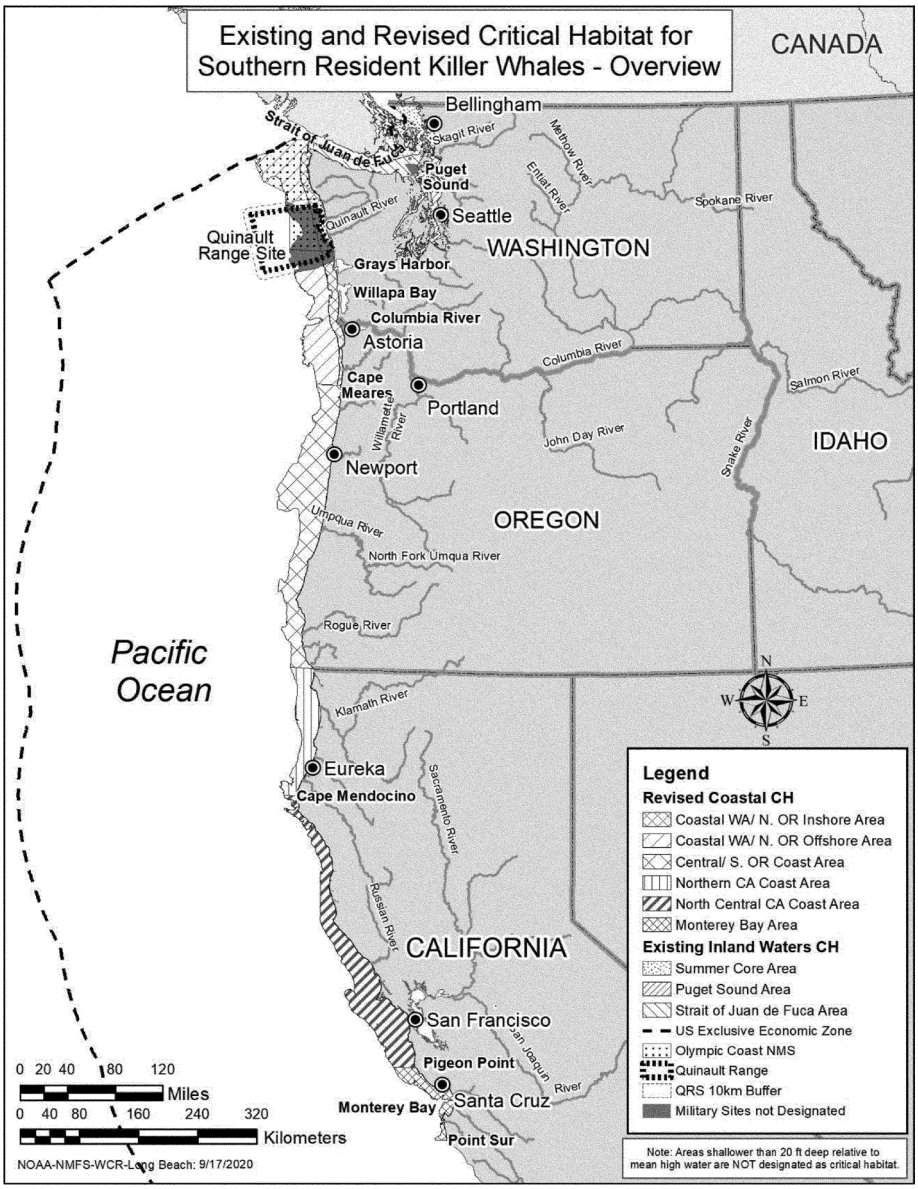

Figure 6. Existing and revised designated critical habitat for endangered Southern Resident distinct population segment of killer whales.

7.5.3 Leatherback Turtle Critical Habitat

In 1979, leatherback turtle critical habitat was identified adjacent to Sandy Point, St. Croix, Virgin Islands; however, this designated critical habitat does not occur in the action area of the low-energy seismic survey.

In 2012, NMFS revised designated critical habitat for the leatherback turtle by designating additional areas within the Pacific Ocean. This designation includes approximately 43,798 square kilometers (16,910 square miles) stretching along the California coast from Point Arena to Point Arguello east of the 3,000 meter (9,842.4 feet) depth contour; and 64,760 square kilometers (25,004 square miles) stretching from Cape Flattery, Washington to Cape Blanco,

Oregon east of the 2,000 meter (6,561.7 feet) depth contour. The designated areas comprise approximately 108,558 square kilometers (41,914 square miles) of marine habitat and include waters from the ocean surface down to a maximum depth of 80 meters (262 feet) (Figure 7).

NMFS has identified one physical and biological feature for the conservation of leatherback turtles in marine waters off the U.S. West Coast that includes the occurrence of prey species, primarily scyphomedusae (i.e., jellyfish) of the order Semaeostomeae (e.g., *Chrysaora*, *Aurelia*, *Phacellophora*, and *Cyanea*), of sufficient condition, distribution, diversity, abundance, and density necessary to support individual as well as population growth, reproduction, and development of leatherback turtles (77 FR 4170).

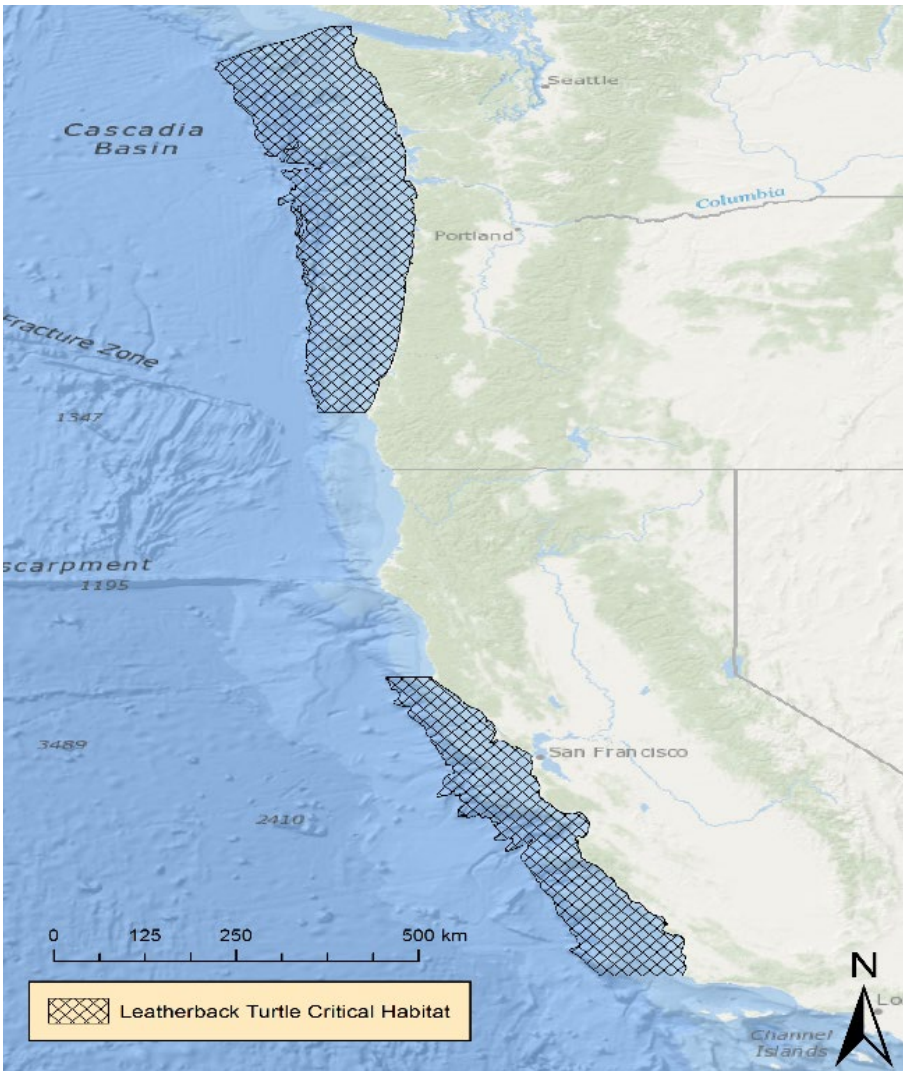

Figure 7. Map identifying designated critical habitat for the endangered leatherback turtle along the United States Pacific Coast.

7.5.4 Green Sturgeon – Southern Distinct Population Segment Critical Habitat

In 2009, NMFS designated critical habitat for the Southern DPS of green sturgeon. Specific areas include coastal U.S. marine waters within 109.7 meters (359.9 feet) depth from Monterey Bay,

California (including Monterey Bay), north to Cape Flattery, Washington, including the Strait of Juan de Fuca, Washington, to its U.S. boundary; the Sacramento River, lower Feather River, and lower Yuba River in California; the Sacramento-San Joaquin Delta and Suisun, San Pablo, and San Francisco bays in California; the lower Columbia River estuary; and certain coastal bays and estuaries in California (Humboldt Bay), Oregon (Coos Bay, Winchester Bay, Yaquina Bay, and Nehalem Bay), and Washington (Willapa Bay and Grays Harbor). NMFS designated approximately 515 kilometers (320 miles) of freshwater river habitat, 2,323 square kilometers (11,421 square miles) of marine habitat, 784 kilometers (487 miles) of habitat within the Yolo and Sutter bypasses (Sacramento River, California) as critical habitat for Southern DPS of green sturgeon (Figure 8).

The physical and biological features essential for Southern DPS of green sturgeon include freshwater riverine systems, estuarine habitats, and nearshore coastal marine areas that provide sufficient food resources, substrate type suitable for egg deposition, and development, water flow, water quality, migratory corridors, depth (greater than or equal to 5 meters [16.4 feet]), and sediment quality.

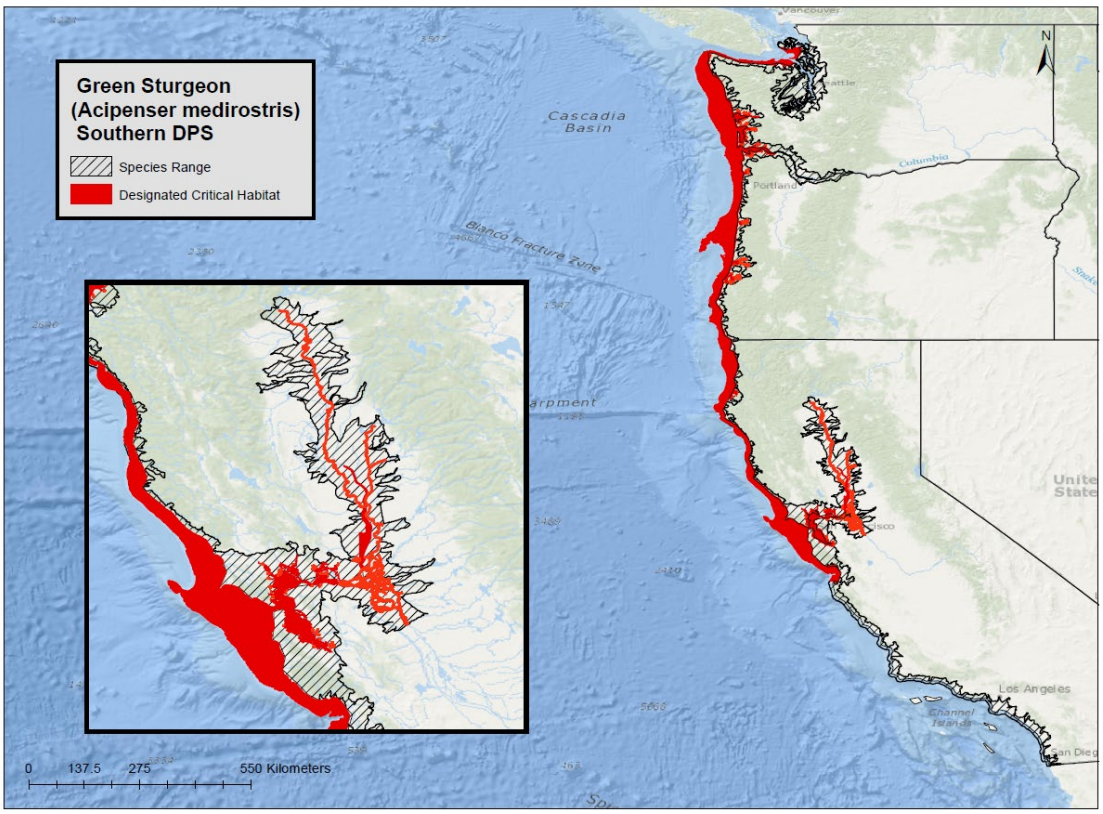

Figure 8. Map of geographic range (within the contiguous United States) and designated critical habitat for the threatened Southern distinct population segment of green sturgeon.

7.5.5 Effects to Designated Critical Habitat

The proposed seismic survey activities overlap with portions of the designated critical habitat for the Central America DPS and Mexico DPS of humpback whale, Southern Resident DPS of killer

whale, leatherback turtle, and Southern DPS of green sturgeon. The seismic survey area east of the 2,000 meter contour is located within the designated critical habitat of leatherback turtles, but the research vessel will transit through the Northeast Pacific Ocean. The research vessel's transit to and from the port of Newport, Oregon and overlaps with the designated critical habitat of the Central America DPS and Mexico DPS of humpback whale, Southern Resident DPS of killer whale, leatherback turtle, and Southern DPS of green sturgeon. Very few effects to this habitat are expected for the reasons detailed below.

Given the nature of the proposed seismic survey activities, none of the physical and biological features essential to the conservation of Central America DPS and Mexico DPS of humpback whale, Southern Resident DPS of killer whale, leatherback turtle, and Southern DPS of green sturgeon will be significantly altered. We do not expect there to be substantial effects to water quality as a result of the proposed actions. Vessel transit will not significantly alter large scale physical or oceanographic conditions or processes, nutrients, bathymetry, inter-area passage conditions, migratory corridors, or prey resources and availability. We expect Southern Resident DPS of killer whales will be more likely to occur closer to shore, in areas that are not near the seismic survey activities and/or heat flow measurements. While the presence of the research vessel and the seismic survey activities may impact Southern Resident DPS of killer whales, we are expecting an overall low amount of exposure for Southern Resident DPS of killer whales. Based on the size of the action area relative to the designated critical habitat, Southern Resident DPS of killer whales should be able to maneuver away from the research vessel. Furthermore, the proposed actions are an overall short duration in areas where we expect Southern Resident DPS of killer whales most likely to occur (e.g., off the coasts of Washington and Vancouver Island). No impediment of migration corridors would be expected to occur for Southern DPS of green sturgeon as the amount of time that the proposed actions will overlap with designated critical habitat during transits is a few days (approximately three days), and most of that transit time will be further offshore. The research vessel can come into close proximity with, or even in contact with, prey species found within these designated critical habitats. We expect that any such interactions will only result in a temporary, slight displacement of prey. If larger prey were to come into contact with the research vessel's propellers, it is possible that individual prey can be killed. However, even if this unlikely event were to occur, the removal of several individual prey will have a limited impact on the overall abundance of prey resources in the area of the designated critical habitat. Given the short-term nature of vessel transit, it will not significantly alter ambient noise levels. Any effects from vessel transit will be short-term and minimal, and will not have any measurable impact on the physical and biological features. Because the operations of the research vessel are temporary (i.e., not a permanent structure), the seismic survey activities will not prevent animals from accessing critical habitats in the water. Also, the equipment will not alter, damage, or destroy physical habitat.

The proposed acoustic sound sources from the seismic survey activities will not significantly alter the primary prey or food resources available given the short duration of the low-energy seismic survey within the designated critical habitat for the Central America DPS and Mexico

DPS of humpback whale, Southern Resident DPS of killer whale. We expect impacts to fish to be in the form of behavioral disturbance, TTS, and injury, but no mortality. After the research vessel has moved away from their prey species may occur, we expect prey species to return to normal behavior in the action area. If prey fish (e.g., small pelagic schooling fish), euphausiids, shrimp, amphipods, jellyfish (if at all), and benthic organisms avoid the area of the active airgun array operations due to aversions from the sound source, it is expected to be temporary with no long-term significant effects. Prey species are mobile and are broadly distributed throughout the action area; therefore, marine mammals, sea turtles, and fish that may be temporarily displaced during seismic survey activities are expected to be able to resume foraging once they have moved away from areas with disturbing levels of underwater noise. Conditions are expected to return to normal within a few days at the most after the seismic survey activities have ceased in the action area. Because the seismic survey activities are relatively short in duration (approximately six days of airgun array operations, approximately 14 days of heat flow measurements, and approximately three days of transit), the disturbance will be temporary in nature, and similar habitat and prey resources are available in the surrounding area, the impacts to marine mammals, sea turtles, and fish and their prey resources that they utilize for food are not expected to cause significant or long-term consequences for individuals or their populations. The heat flow measurement probe may also temporarily disperse fish and other prey.

The use of active acoustics during the seismic survey activities will be temporary and relatively short in duration, and are not expected to significantly impair acoustic conditions that allow for effective communication for feeding areas that support feeding and population growth. The research vessel will be continuously moving during the entire low-energy seismic survey. No tracklines enter the designated critical habitat of Central America DPS of humpback whales, Mexico DPS of humpback whales, and Southern Resident DPS of killer whales.

When considering the limit of potential exposure, we conclude that any disturbance to the physical and biological features will be insignificant. Therefore, the proposed seismic survey activities may affect, but are not likely to adversely affect any of the physical and biological features of the designated critical habitat for the Central America DPS and Mexico DPS of humpback whale, Southern Resident DPS of killer whale, leatherback turtle, and Southern DPS of green sturgeon.

7.6 Summary of Effects Determinations for Potential Stressors Associated with the Proposed Actions

Table 13 depicts our effects analysis by potential stressor for each ESA-listed species and designated critical habitat considered in this consultation.

Table 13. Summary of Endangered Species Act-listed species effects determination by potential stressor associated with the proposed actions.

ESA-listed Species in the Action Area	Overall Determination	Potential Stressors					
		Pollution	Vessel Strike	Vessel Noise, Visual Disturbance	Acoustic Sources		Gear Entanglement Interaction
					SBP MBES ADCP Pinger	Seismic Airgun Array	
Marine Mammals – Cetaceans							
Blue Whale	LAA	NLAA	NLAA	NLAA	NLAA	LAA	NLAA
Fin Whale	LAA	NLAA	NLAA	NLAA	NLAA	LAA	NLAA
Gray Whale – Western North Pacific DPS	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Humpback Whale – Central America DPS	LAA	NLAA	NLAA	NLAA	NLAA	LAA	NLAA
Humpback Whale – Mexico DPS	LAA	NLAA	NLAA	NLAA	NLAA	LAA	NLAA
North Pacific Right Whale	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Sei Whale	LAA	NLAA	NLAA	NLAA	NLAA	LAA	NLAA
Sperm Whale	LAA	NLAA	NLAA	NLAA	NLAA	LAA	NLAA
Marine Mammals – Pinnipeds							
Guadalupe Fur Seal	LAA	NLAA	NLAA	NLAA	NLAA	LAA	NLAA

ESA-listed Species in the Action Area	Overall Determination	Potential Stressors					
		Pollution	Vessel Strike	Vessel Noise, Visual Disturbance	Acoustic Sources		Gear Entanglement Interaction
					SBP MBES ADCP Pinger	Seismic Airgun Array	
Marine Reptiles							
Green Turtle – East Pacific DPS	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Leatherback Turtle	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Loggerhead Turtle – North Pacific Ocean DPS	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Fish							
Chinook Salmon – California Coastal ESU	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Chinook Salmon – Central Valley Spring-Run ESU	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Chinook Salmon – Lower Columbia River ESU	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Chinook Salmon – Puget Sound ESU	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA

ESA-listed Species in the Action Area	Overall Determination	Potential Stressors					
		Pollution	Vessel Strike	Vessel Noise, Visual Disturbance	Acoustic Sources		Gear Entanglement Interaction
					SBP MBES ADCP Pinger	Seismic Airgun Array	
Chinook Salmon – Sacramento River ESU	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Chinook Salmon – Snake River Fall-Run ESU	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Chinook Salmon – Snake River Spring/Summer-Run ESU	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Chinook Salmon – Upper Columbia River Spring-Run ESU	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Chinook Salmon – Upper Willamette River ESU	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Chum Salmon – Columbia River ESU	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Chum Salmon – Hood Canal Summer-Run ESU	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA

ESA-listed Species in the Action Area	Overall Determination	Potential Stressors					
		Pollution	Vessel Strike	Vessel Noise, Visual Disturbance	Acoustic Sources		Gear Entanglement Interaction
					SBP MBES ADCP Pinger	Seismic Airgun Array	
Coho Salmon – Central California Coast ESU	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Coho Salmon – Lower Columbia River ESU	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Coho Salmon – Oregon Coast ESU	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Coho Salmon – Southern Oregon and Northern California Coasts ESU	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Eulachon – Southern DPS	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Green Sturgeon – Southern DPS	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Sockeye Salmon – Ozette Lake ESU	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Sockeye Salmon – Snake River ESU	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA

ESA-listed Species in the Action Area	Overall Determination	Potential Stressors					
		Pollution	Vessel Strike	Vessel Noise, Visual Disturbance	Acoustic Sources		Gear Entanglement Interaction
					SBP MBES ADCP Pinger	Seismic Airgun Array	
Steelhead Trout – California Central Valley DPS	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Steelhead Trout – Central California Coast DPS	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Steelhead Trout – Lower Columbia River DPS	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Steelhead Trout – Middle Columbia River DPS	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Steelhead Trout – Northern California DPS	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Steelhead Trout – Puget Sound DPS	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Steelhead Trout – Snake River Basin DPS	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Steelhead Trout – South-Central	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA

ESA-listed Species in the Action Area	Overall Determination	Potential Stressors					
		Pollution	Vessel Strike	Vessel Noise, Visual Disturbance	Acoustic Sources		Gear Entanglement Interaction
					SBP MBES ADCP Pinger	Seismic Airgun Array	
California Coast DPS							
Steelhead Trout – Southern California DPS	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Steelhead Trout – Upper Columbia River DPS	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Steelhead Trout – Upper Willamette River DPS	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Critical Habitat							
Humpback Whale – Central America DPS and Mexico DPS	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Killer Whale – Southern Resident DPS	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Leatherback Turtle	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA

ESA-listed Species in the Action Area	Overall Determination	Potential Stressors					
		Pollution	Vessel Strike	Vessel Noise, Visual Disturbance	Acoustic Sources		Gear Entanglement Interaction
					SBP MBES ADCP Pinger	Seismic Airgun Array	
Green Sturgeon – Southern DPS	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA

ESA=Endangered Species Act, SBP=sub-bottom profiler, MBES=multi-beam echosounder, ADCP=acoustic Doppler current profiler, DPS=distinct population segment, ESU=evolutionarily significant unit, NLAA=not likely to adversely affect, LAA=- likely to adversely affect

8 SPECIES LIKELY TO BE ADVERSELY AFFECTED

This section identifies the ESA-listed species that occur within the action area (Figure 3) that may be affected by the proposed actions. The only ESA-listed marine mammal species that are likely to be adversely affected by the proposed actions are blue whales, fin whales, Central America DPS of humpback whales, Mexico DPS of humpback whales, sei whales, sperm whales, and Guadalupe fur seals. The determinations for the effects of stressors that are not likely to adversely affect these same ESA-listed marine mammals, sea turtles, and fishes during the proposed low-energy seismic survey are discussed in Section 7.1. Other potential stressors (i.e., acoustic noise from the airgun array) are discussed in more detail in Section 10.

8.1 Status of Species Likely to be Adversely Affected

This section identifies and examines the status of each species that is expected to be adversely affected by the proposed actions. The status includes the existing level of risk that the ESA-listed species face, based on parameters considered in documents such as recovery plans, status reviews, and ESA-listing decisions. The species status section helps to inform the description of the species' current "reproduction, numbers, or distribution," which is part of the jeopardy determination as described in 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 these NMFS websites: https://www.fisheries.noaa.gov/species-directory/threatened-endangered. Because there are not likely to be adverse affects to designated critical habitat (see Section 7.4.3), only the status of the species likely to be adversely affected will be discussed in this section. One factor affecting the rangewide status of marine mammals, and aquatic habitat at large is climate change. Climate change will be discussed in the Environmental Baseline section (Section 9).

8.2 Blue Whale

The blue whale is a widely distributed baleen whale found in all major oceans (Figure 9).

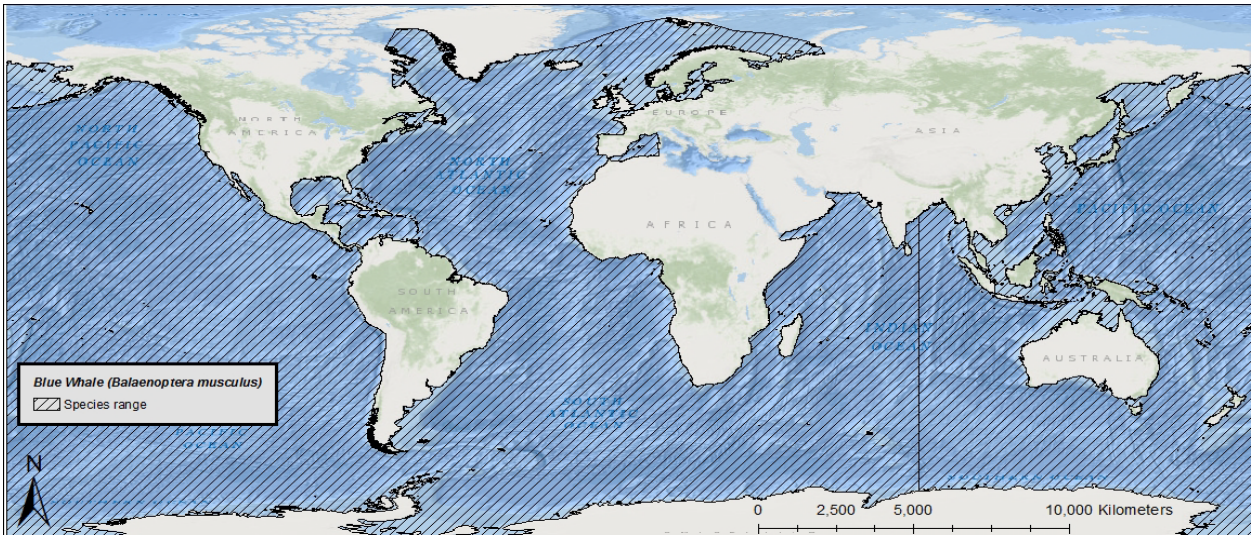

Figure 9. Map identifying the range of the endangered blue whale.

Blue whales are the largest animal on earth and distinguishable from other whales by a long-body and comparatively slender shape, a broad, flat "rostrum" when viewed from above, proportionally smaller dorsal fin, and are a mottled gray color that appears light blue when seen through the water. Most experts recognize at least three subspecies of blue whale, *B. m. musculus*, which occurs in the Northern Hemisphere, *B. m. intermedia*, which occurs in the Southern Ocean, and *B. m. brevicauda*, a pygmy species found in the Indian Ocean and South Pacific. The blue whale was originally listed as endangered on December 2, 1970.

Information available from the recovery plan (NMFS 1998), recent stock assessment reports (Carretta 2019a; Carretta 2019b; Carretta et al. 2018; Hayes et al. 2018; Muto et al. 2018), and status review (COSEWIC 2002) were used to summarize the life history, population dynamics and status of the species as follows.

8.2.1 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 five 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 Ocean, blue whales overwinter along the Pacific Coast of Baja California, and the upwelling area known as the Costa Rica Thermal Dome, 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).

8.2.2 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 blue whale.

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 U.S. waters: the Eastern North Pacific Ocean (N=1,647; N_{min}=1,551), Central North Pacific Ocean (N=133; N_{min}=63), and Western North Atlantic Ocean (N=400 to 600; N_{min}=440). In the Southern Hemisphere, the latest abundance estimate for Antarctic blue whales is 2,280 individuals in 1997/1998 [95 percent confidence intervals 1,160 to 4,500 (Branch 2007)]. While no range-wide estimate for pygmy blue whales exists (Thomas et al. 2016), the latest estimate for pygmy blue whales off the west coast of Australia is 662 to 1,559 individuals based on passive acoustic monitoring (McCauley and Jenner 2010), or 712 to 1,754 individuals based on photographic mark-recapture (Jenner 2008). Due to the location of the action, the Eastern North Pacific stock of blue whales is most likely to be in the action area. The minimum population size for eastern North Pacific Ocean blue whales is 1,050; the more recent abundance estimate is 1,496 (Carretta 2019a).

Current estimates indicate the Eastern North Pacific stock shows no signs of population growth since the early 1990s, perhaps because the population is nearly at carrying capacity (Carretta et al. 2018). An overall population growth rate for the species or growth rates for the two other individual U.S. stocks are not available at this time. In the Southern Hemisphere, population growth estimates are available only for Antarctic blue whales, which estimate a population growth rate of 8.2 percent per year (95 percent confidence interval 1.6 to 14.8 percent, Branch 2007).

Little genetic data exist on blue whales globally. Data from Australia indicates that at least populations in this region experienced a recent genetic bottleneck, likely the result of commercial whaling, although genetic diversity levels appear to be similar to other, non-threatened mammal species (Attard et al. 2010). Consistent with this, data from Antarctica also demonstrate this bottleneck but high haplotype diversity, which may be a consequence of the recent timing of the bottleneck and blue whales long lifespan (Sremba et al. 2012). 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 500 individuals or less may be at a greater risk of extinction due to genetic risks resulting from inbreeding. Stock populations 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, blue whale 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. In the North Atlantic Ocean, the blue whale range extends from the subtropics to the Greenland Sea. They are most frequently sighted in waters off eastern Canada with a majority of sightings taking place in the Gulf of St. Lawrence. In the North Pacific Ocean, blue whales range from Kamchatka to southern Japan in the west and from the Gulf of Alaska and California to Costa Rica in the east. They primarily occur off the Aleutian Islands and the Bering Sea. In Canadian Pacific waters, blue whale habitat includes the continental shelf break, continental slope, and offshore waters beyond the continental shelf break (Canada 2017). 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. Exclusive Economic Zone, from November through March (Hazen et al. 2017). In the northern Indian Ocean, there is a "resident" population of blue whales with sightings being reported from the Gulf of Aden, Persian Gulf, Arabian Sea, and across the Bay of Bengal to Burma and the Strait of Malacca. In the Southern Hemisphere, distributions of subspecies (*B. m. intermedia* and *B. m. brevicauda*) seem to be segregated. The subspecies *B. m. intermedia* occurs in relatively high latitudes south of the "Antarctic Convergence" (located between 48 degrees South and 61degrees South latitude) and close to the ice edge. The subspecies *B. m. brevicauda* is typically distributed north of the Antarctic Convergence.

8.2.3 Vocalization and Hearing

Blue whale vocalizations tend to be long (greater than 20 seconds), low frequency (less than 100 Hertz) signals (Thomson and Richardson 1995), with a range of 12 to 400 Hertz and dominant energy in the infrasonic range of 12 to 25 Hertz (Ketten 1998; McDonald et al. 2001; McDonald et al. 1995b; 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 Hertz), 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 (Aburto et al. 1997; Berchok et al. 2006; Clark and Gagnon 2004b; Cummings and Thompson 1971; Ketten 1998; McDonald et al. 2001; 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 whales (less than 30 meters [98.4 feet]), while deeper diving whales (greater than 50 meters [164 feet]) were likely feeding and calling less.

Although general characteristics of blue whale calls are shared in distinct regions (McDonald et al. 2001; Mellinger and Clark 2003; Rankin et al. 2005; Thompson et al. 1996), 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 (Berchok et al. 2006; Mellinger and Clark 2003; 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. 2006b) 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 Hertz); 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 (Hildebrand et al. 2011; Hildebrand et al. 2012; Oleson et al. 2007c).

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 (Mellinger and Clark 2003; Payne and McVay 1971b). 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 Hertz compared to approximately 22.5 Hertz in 1964 and 1965, illustrating a more than 30 percent shift in call frequency over four decades (McDonald et al. 2006b). 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, Indian, Pacific, and Southern 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) (Edds-Walton

1997; Oleson et al. 2007b; Payne and Webb 1971; Thompson et al. 1992b). 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 Hertz 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 (Edds-Walton 1997; Payne and Webb 1971). 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 (Ketten 1997b; Richardson et al. 1995c). Based on vocalizations and anatomy, blue whales are assumed to predominantly hear low-frequency sounds below 400 Hertz (Croll et al. 2001; Oleson et al. 2007c; Stafford and Moore 2005). In terms of functional hearing capability, blue whales belong to the low frequency group, which have a hearing range of 7 Hertz to 35 kilohertz (NOAA 2018).

8.2.4 Status

The blue whale is endangered as a result of past commercial whaling. In the North Atlantic Ocean, at least 11,000 blue whales were harvested from the late 19th to mid-20th centuries. In the North Pacific Ocean, at least 9,500 whales were killed between 1910 and 1965. In the eastern North Pacific Ocean, about 3,411 blue whales were killed between 1905 and 1971 (Monnahan et al. 2014). According to historical whaling records from five whaling stations in British Columbia, 1,398 blue whales were killed between 1908 and 1967 (Gregr et al. 2000). Commercial whaling no longer occurs, but blue whales are threatened by vessel strikes, entanglement in fishing gear, pollution, harassment due to whale watching, and reduced prey abundance and habitat degradation due to climate change. Because populations appear to be increasing in size, the species appears to be somewhat resilient to current threats; however, the species has not recovered to pre-exploitation levels.

8.2.5 Critical Habitat

No critical habitat has been designated for the blue whale.

8.2.6 Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover blue whale populations. These threats will be discussed in further detail in the Environmental Baseline section of this consultation. See the 2020 Recovery Plan for the blue whale for complete down listing/delisting criteria for each of the following recovery objectives:

1. Increase blue whale resiliency and ensure geographic and ecological representation by achieving sufficient and viable populations in all ocean basins and in each recognized subspecies.

2. Increase blue whale resiliency by managing or eliminating significant anthropogenic threats.

8.3 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. patachonica* (a pygmy form) in the Southern Hemisphere (Figure 10). Within the action area, fin whales occur year round off the coasts of Oregon and Washington (Carretta 2019b).

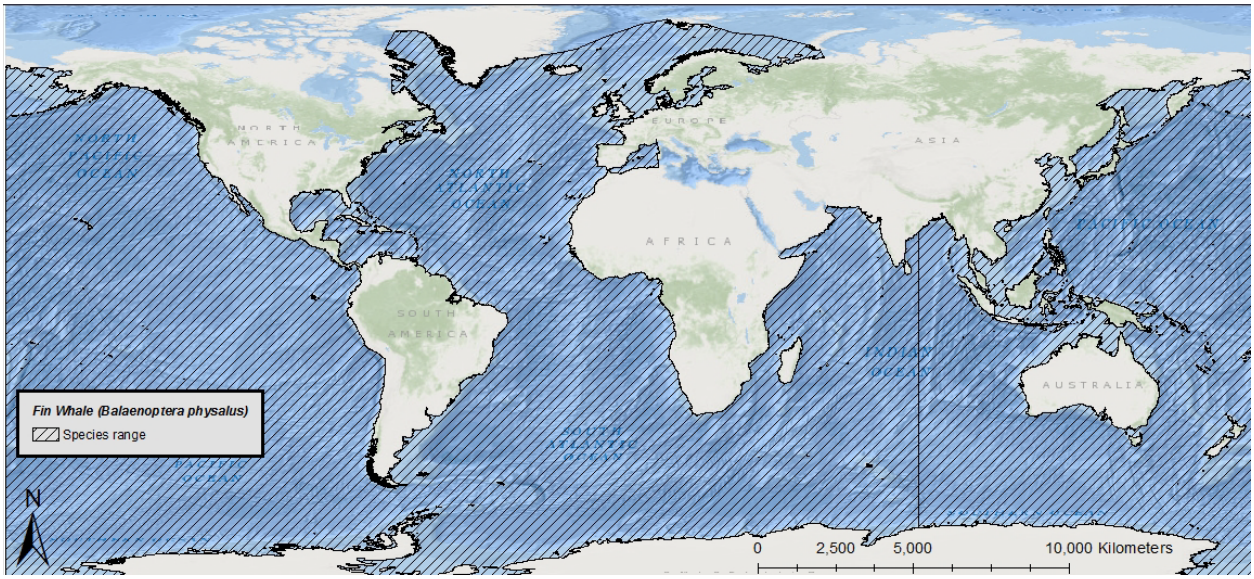

Figure 10. Map identifying the range of the endangered fin whale.

Fin whales are distinguishable from other whales by a sleek, streamlined body, with a V-shaped head, a tall falcate dorsal fin, and a distinctive color pattern of a black or dark brownish-gray body and sides with a white ventral surface. The lower jaw is gray or black on the left side and creamy white on the right side. 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 et al. 2018; Hayes et al. 2018; Muto et al. 2018) and status review (NMFS 2011a) were used to summarize the life history, population dynamics and status of the species as follows.

8.3.1 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. There is a presumed feeding area along the Juan de

Fuca Ridge off northern Washington, based on rates of fin whale calls in the area from fall through February (Muto et al. 2019; Soule and Wilcock 2013).

8.3.2 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 (Ohsumi and Wada 1974). In the North Atlantic Ocean, at least 55,000 fin whales were killed between 1910 and 1989. Approximately 704,000 fin whales were killed in the Southern Hemisphere from 1904 through 1975. Of the three to seven stocks thought to occur in the North Atlantic Ocean (approximately 50,000 individuals), one occurs in U.S. waters, where NMFS' best estimate of abundance is 1,618 individuals (N_{min}=1,234); however, this may be an underrepresentation as the entire range of the stock was not surveyed (Palka 2012). There are three stocks in U.S. Pacific Ocean waters: Northeast Pacific (N=3,168; N_{min}=2,554), Hawaii (approximately 154 individuals, N_{min}=75) and California/Oregon/Washington (approximately 9,029 individuals, N_{min}=8,127) (Nadeem et al. 2016b). The International Whaling Commission (IWC) also recognizes the China Sea stock of fin whales, found in the Northwest Pacific Ocean, which currently lacks an abundance estimate (Reilly et al. 2013). Abundance data for the Southern Hemisphere stock are limited; however, there were assumed to be somewhat more than 15,000 in 1983 (Thomas et al. 2016).

Current estimates indicate approximately 10,000 fin whales in U.S. Pacific Ocean waters, with an annual growth rate of 4.8 percent in the Northeast Pacific stock and a stable population abundance in the California/Oregon/Washington stock (Nadeem et al. 2016b). The best current abundance estimate for fin whales in California, Oregon, and Washington waters out to 555.6 kilometers (300 nautical miles) is 9,029 (CV=0.12) (Nadeem et al. 2016a); the minimum population estimate is 8,127 individuals (Carretta 2019b). An overall population trend in U.S. Pacific Ocean waters 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 through 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 2019b). Overall population growth rates and total abundance estimates for the Hawaii stock, China Sea stock, western North Atlantic stock, and Southern Hemisphere fin whales are not available at this time.

Archer et al. (2013) recently 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 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. Generally speaking, haplotype diversity was found to be high both within ocean basins, and across. 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 are over 100,000 fin whales worldwide, occurring primarily in the North Atlantic Ocean, North Pacific Ocean, and Southern Hemisphere where they appear to be reproductively isolated. The availability of prey, sand lice in particular, is thought to have had a strong influence on the distribution and movements of fin whales.

8.3.3 Vocalization and Hearing

Fin whales produce a variety of low frequency sounds in the 10 to 200 Hertz range (Edds 1988; Thompson et al. 1992a; Thompson et al. 1992b; Watkins 1981; Watkins et al. 1987b; Watkins et al. 1987a). Typical vocalizations are long, patterned pulses of short duration (0.5 to two seconds) in the 18 to 35 Hertz range, but only males are known to produce these (Clark et al. 2002a; Clark et al. 2002b; Patterson and Hamilton 1964b; Patterson and Hamilton 1964a). The most typically recorded call is a 20 Hertz pulse lasting about one second, and reaching source levels of 189 ± 4 dB re: 1 µPa at 1 meter (Charif et al. 2002a; Charif et al. 2002b; Clark et al. 2002a; Clark et al. 2002b; Edds 1988; Garcia et al. 2018; Richardson et al. 1995c; Richardson et al. 1995b; Sirovic et al. 2007b; Sirovic et al. 2007a; Watkins 1981; Watkins et al. 1987b; Watkins et al. 1987a). These pulses frequently occur in long sequenced patterns, are down swept (e.g., 23 to 18 Hertz), and can be repeated over the course of many hours (Watkins et al. 1987a). In temperate waters, intense bouts of these patterned sounds are very common from fall through spring, but also occur to a lesser extent during the summer in high latitude feeding areas (Clark and Charif 1998). Richardson et al. (1995b) reported this call occurring in short series during spring, summer, and fall, and in repeated stereotyped patterns in winter. The seasonality and stereotype nature of these vocal sequences suggest that they are male reproductive displays (Watkins 1981; Watkins et al. 1987a); a notion further supported by data linking these vocalizations to male fin whales only (Croll et al. 2002). In Southern California, the 20 Hertz pulses are the dominant fin whale call type associated both with call-counter-call between multiple animals and with singing (U.S. Navy 2010; U.S. Navy 2012). An additional fin whale sound, the 40 Hertz call described by Watkins (1981), was also frequently recorded, although these calls are not as common as the 20 Hertz fin whale pulses. Seasonality of the 40 Hertz calls differed from the 20 Hertz calls, since 40 Hertz 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 Hertz 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 Hertz, with a dominant frequency of 20 Hertz, tonal and upsweep vocalizations of 34 to 150 Hertz, and songs of 17 to 25 Hertz (Cummings and Thompson 1994; Edds 1988; Garcia et al. 2018; Watkins 1981). In general, source levels for fin whale vocalizations are 140 to 200 dB re: 1 µPa at 1 meter (see also Clark and Gagnon 2004b;

see also Clark and Gagnon 2004a; as compiled by Erbe 2002b; as compiled by Erbe 2002c). The source depth of calling fin whales has been reported to be about 50 meters (164 feet) (Watkins et al. 1987a). Although acoustic recordings of fin whales from many diverse regions show close adherence to the typical 20-Hertz bandwidth and sequencing when performing these vocalizations, there have been slight differences in the pulse patterns, indicative of some geographic variation (Thompson et al. 1992a; Thompson et al. 1992b; Watkins et al. 1987b; Watkins et al. 1987a).

Although their function is still in doubt, low frequency fin whale vocalizations travel over long distances and may aid in long distance communication (Edds-Walton 1997; Payne and Webb 1971; Payne and Webb. 1971). 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 (Ketten 1997a; Ketten 1997b; Richardson et al. 1995c; Richardson et al. 1995b). 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 1997b). 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 Hertz and 12 kilohertz and a maximum sensitivity to sounds in the 1 to 2 kilohertz range. In terms of functional hearing capability, fin whales belong to the low-frequency group, which have a hearing range of 7 Hertz to 35 kilohertz (NOAA 2018).

8.3.4 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 commercial whaling program, and Iceland's formal objection to the International Whaling Commission's ban on commercial whaling. Additional threats include vessel strikes, reduced prey availability due to overfishing or climate change, and sound. The species' overall large population size may provide some resilience to current threats, but trends are largely unknown.

8.3.5 Critical Habitat

No critical habitat has been designated for the fin whale.

8.3.6 Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover fin whale populations. These threats will be discussed in further detail in the Environmental Baseline section of this consultation. 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.

8.4 Humpback Whale – Central America Distinct Population Segment

The humpback whale is a widely distributed baleen whale found in all major oceans (Figure 11).

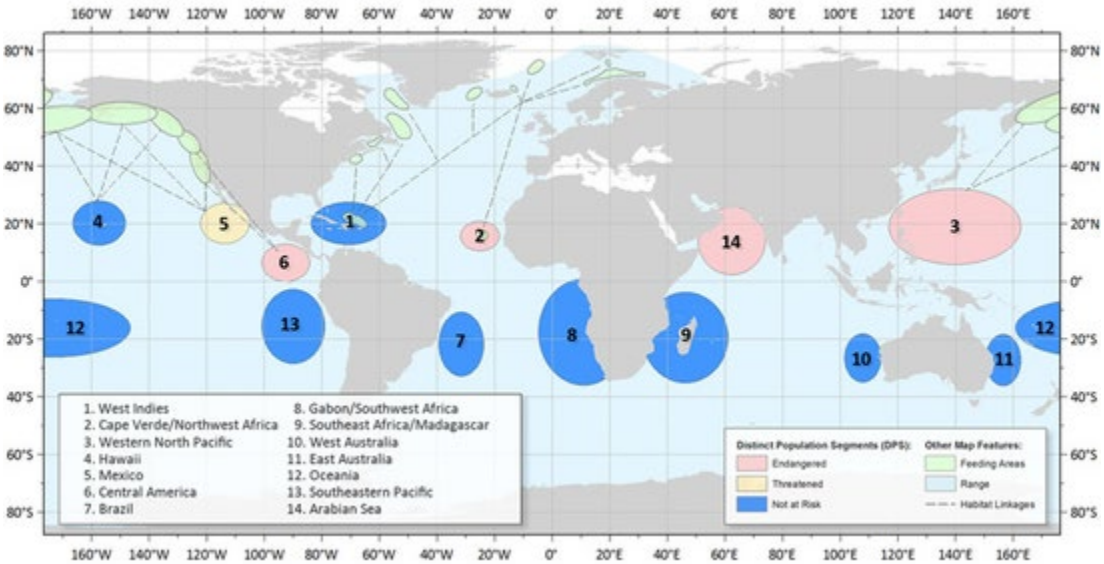

Figure 11. Map identifying 14 distinct population segments with one threatened and four endangered, based on primarily breeding location of the humpback whale, their range, and feeding areas (Bettridge et al. 2015a).

Humpback whales are distinguishable from other whales by long pectoral fins and are typically dark grey with some areas of white. They 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), recent stock assessment reports (Carretta et al. 2016; Muto et al. 2016; Waring et al. 2016), the status review (Bettridge et al. 2015a), and the final listing were used to summarize the life history, population dynamics and status of the species as follows.

8.4.1 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. 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. 2015a).

8.4.2 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 Central America DPS of humpback whales.

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 Ocean was 15,000 individuals. By 1966, whaling had reduced the North Pacific Ocean population to about 1,200 individuals. In the 2015 status review of humpback whales, the abundance of the Central America DPS was 431 (CV=0.3) and 783 (CV=0.17) individuals (Bettridge et al. 2015b); however this estimate is based on data from 2004 through 2006, and is not considered a reliable estimate of current abundance (Carretta 2019a). The current abundance of the Central America DPS of humpback whales is 1,496 with an estimated annual population growth rate is 1.6 percent (Curtis et al. 2022).

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. Population 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. 2015a).

The Central America DPS is composed of humpback whales that breed along the Pacific coast of Costa Rica, Panama, Guatemala, El Salvador, Honduras, and Nicaragua. 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 (Figure 4).

8.4.3 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 Hertz to 4 kilohertz with estimated source levels from 144 to 174 dB (Au and Green 2000; Au et al. 2006c; Au et al. 2000; Frazer and Mercado 2000b; Frazer and Mercado Iii 2000; Richardson et al. 1995c; Richardson et al. 1995d; Winn et al. 1970b). Males also produce sounds associated with aggression, which are generally characterized by frequencies between 50 Hertz to 10 kilohertz with most energy below 3 kilohertz (Silber 1986b; Tyack 1983b). Such sounds can be heard up to 9 kilometers (4.9 nautical miles) away (Tyack 1983b). Other social sounds from 50 Hertz to 10 kilohertz (most energy below 3 kilohertz) are also produced in breeding areas (Richardson et al. 1995c; Silber 1986b; Tyack 1983b). While in northern feeding areas, both sexes vocalize in grunts (25 Hertz to 1.9 kilohertz), pulses (25 to 89 Hertz) and songs (ranging from 30 Hertz to 8 kilohertz but dominant frequencies of 120 Hertz to 4 kilohertz), which can be very loud (175 to 192 dB re: 1 µPa at 1 meter) (Au and Green 2000; Au et al. 2000; Erbe 2002d; Payne 1985; Richardson et al. 1995c; Richardson et al. 1995d; Thompson et al. 1986b). However, humpback whales tend to be less vocal in northern feeding areas than in southern breeding areas (Richardson et al. 1995c).

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 1995). 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 (Clark and Clapham 2004; Gabriele and Frankel. 2002; Helweg et al. 1992; Schevill et al. 1964; 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 (Clark and Clapham 2004; Gabriele and Frankel. 2002; Mcsweeney et al. 1989). (Au et al. 2006b) 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 1971a). Components of the song range from below 20 Hertz up to 4 kilohertz, with source levels measured between 151 and 189 dB re: 1 µPa-meter and high frequency harmonics extending beyond 24 kilohertz (Au et al. 2006a; Au et al. 2006b; Winn et al. 1970b). Social calls range from 20 Hertz to 10 kilohertz, with dominant frequencies below 3 kilohertz (D'Vincent et al. 1985; Dunlop et al. 2008; Silber 1986b; Simao and Moreira 2005). 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 Hertz to 2 kilohertz, less than one second in duration, and have source levels of 162 to 192 dB re: 1 µPa-meter (D'Vincent et al. 1985; Thompson et al. 1986b). The fundamental frequency of feeding calls is approximately 500 Hertz (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 DTAGs (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 kilohertz.

NMFS categorizes humpback whales in the low-frequency cetacean functional hearing group, with an applied frequency range between 7 Hertz and 35 kilohertz (NMFS 2018). Humpback whale audiograms using a mathematical model based on the internal structure of the ear estimate sensitivity is from 700 Hertz to 10 kilohertz, with maximum relative sensitivity between 2 kilohertz and 6 kilohertz (Ketten and Mountain 2014). Research by Au et al. (2001) and Au et al. (2006b) off Hawaii indicated the presence of high frequency harmonics in vocalizations up to and beyond 24 kilohertz. 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 kilohertz may have been demonstrated in a playback study. Maybaum (1990) reported that humpback whales showed a mild response to a handheld sonar marine mammal detection and location device with frequency of 3.3 kilohertz at 219 dB re: 1 µPa-meter or frequency sweep of 3.1 to 3.6 kilohertz. In addition, the system had some low frequency components (below 1 kilohertz) 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.

8.4.4 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. 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). 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 DPS of humpback whales were taken, based on where the whalers were hunting (i.e., the purported feeding grounds for these DPSs). Humpback whales may be killed under the "aboriginal subsistence whaling" provision of the International Whaling Commission. Additional threats include vessel strikes, fisheries interactions (including entanglement), energy development,

harassment from whaling watching noise, harmful algal blooms, disease, parasites, and climate change. Along with sperm whales, humpback whales have been identified as the marine mammal species most affected by anthropogenic activities worldwide in terms of overall area of documented risk (Avila 2018). The species' large population size and increasing trends indicate that it is resilient to current threats, but the Central America DPS still faces a risk of extinction.

8.4.5 Critical Habitat

Critical habitat has been designated for Central America DPS of humpback whales (86 FR 21082) and occurs in the action area; see Section 7.5.1.

8.4.6 Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover humpback whale populations. These threats will be discussed in further detail in the Environmental Baseline section of this consultation. See the 2022 Recovery Outline for Central America DPS, Mexico DPS, and Western North Pacific DPS of humpback whales for interim guidance to direct recovery efforts. The interim recovery program will focus on:

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

8.5 Humpback Whale – Mexico Distinct Population Segment

The humpback whale is a widely distributed baleen whale found in all major oceans (Figure 11). Humpback whales are distinguishable from other whales by long pectoral fins and are typically dark grey with some areas of white. They 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), recent stock assessment reports (Carretta et al. 2016; Muto et al. 2016; Waring et al. 2016), the status review (Bettridge et al. 2015a), and the final listing were used to summarize the life history, population dynamics and status of the species as follows.

8.5.1 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 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. 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. 2015a).

8.5.2 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 Mexico DPS of humpback whales.

The global, pre-exploitation estimate for humpback whales is 1,000,000 (Roman and Palumbi 2003). The current abundance of the Mexico DPS is unavailable. A population growth rate is currently unavailable for the Mexico DPS of humpback whales. While the current trend is unknown, Calambokidis and Barlow (2020) reported an approximate 8.2 percent annual growth rate from 1989 through 2018 for humpback whales off California and Oregon, where animals from the Central America DPS and Mexico DPS of humpback whales overlap.

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. Population 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 Mexico DPS is estimated to have more than 2,000 individuals and thus, should have enough genetic diversity for long-term persistence and protection from substantial environmental variance and catastrophes (Bettridge et al. 2015a).

The Mexico DPS is composed of humpback whales that breed along the Pacific coast of mainland Mexico, and the Revillagigedos Islands, and transit through the Baja California Peninsula coast. This DPS feeds across a broad geographic range from California to the Aleutian Islands, with concentrations in California-Oregon, northern Washington-southern British Columbia, northern and western Gulf of Alaska, and Bering Sea feeding grounds (Figure 4) (81 FR 62259).

8.5.3 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 Hertz to 4 kilohertz with estimated source levels from 144 to 174 dB (Au and Green 2000; Frazer and Mercado 2000b; Richardson et al. 1995c; Winn et al. 1970b). Males also produce sounds associated with aggression, which are generally characterized by frequencies

between 50 Hertz to 10 kilohertz with most energy below 3 kilohertz (Silber 1986b; Tyack 1983b). Such sounds can be heard up to 9 kilometers (4.9 nautical miles) away (Tyack 1983b). Other social sounds from 50 Hertz to 10 kilohertz (most energy below 3 kilohertz) are also produced in breeding areas (Richardson et al. 1995c; Tyack 1983b). While in northern feeding areas, both sexes vocalize in grunts (25 Hertz to 1.9 kilohertz), pulses (25 to 89 Hertz) and songs (ranging from 30 Hertz to 8 kilohertz but dominant frequencies of 120 Hertz to 4 kilohertz), which can be very loud (175 to 192 dB re: 1 µPa at 1 meter) (Au and Green 2000; Erbe 2002d; Payne 1985; Richardson et al. 1995c; Thompson et al. 1986b). However, humpback whales tend to be less vocal in northern feeding areas than in southern breeding areas (Richardson et al. 1995c).

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 1995). 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 (Clark and Clapham 2004; Gabriele and Frankel. 2002; Helweg et al. 1992; Schevill et al. 1964; 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 (Clark and Clapham 2004; Gabriele and Frankel. 2002; Mcsweeney et al. 1989). (Au et al. 2006b) 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 1971a). Components of the song range from below 20 Hertz up to 4 kilohertz, with source levels measured between 151 and 189 dB re: 1 µPa-meter and high frequency harmonics extending beyond 24 kilohertz (Au et al. 2006b; Winn et al. 1970b).

Social calls range from 20 Hertz to 10 kilohertz, with dominant frequencies below 3 kilohertz (D'Vincent et al. 1985; Dunlop et al. 2008; Silber 1986b; Simao and Moreira 2005). 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 Hertz to 2 kilohertz, less than one second in duration, and have source levels of 162 to 192 dB re: 1 µPa-meter (D'Vincent et al. 1985; Thompson et al. 1986b). The fundamental frequency of feeding calls is approximately 500 Hertz (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 DTAGs (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 kilohertz.

NMFS categorizes humpback whales in the low-frequency cetacean functional hearing group, with an applied frequency range between 7 Hertz and 35 kilohertz (NMFS 2018). Humpback whale audiograms using a mathematical model based on the internal structure of the ear estimate sensitivity is from 700 Hertz to 10 kilohertz, with maximum relative sensitivity between 2 kilohertz and 6 kilohertz (Ketten and Mountain 2014). Research by Au et al. (2001) and Au et al. (2006b) off Hawaii indicated the presence of high frequency harmonics in vocalizations up to and beyond 24 kilohertz. 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 kilohertz may have been demonstrated in a playback study. Maybaum (1990) reported that humpback whales showed a mild response to a handheld sonar marine mammal detection and location device with frequency of 3.3 kilohertz at 219 dB re: 1 µPa-meter or frequency sweep of 3.1 to 3.6 kilohertz. In addition, the system had some low frequency components (below 1 kilohertz) 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.

8.5.4 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. 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. Additional threats include vessel strikes, fisheries interactions (including entanglement), energy development, harassment from whaling watching noise, harmful algal blooms, disease, parasites, and climate change. Along with sperm whales, humpback whales have been identified as the marine mammal species most affected by anthropogenic activities worldwide in terms of overall area of documented risk (Avila 2018). The species' large population size and increasing trends indicate that it is resilient to current threats, but the Mexico DPS still faces a risk of becoming endangered within the foreseeable future throughout all or a significant portion of its range.

8.5.5 Critical Habitat

Critical habitat has been designated for Mexico DPS of humpback whales (86 FR 21082) and occurs in the action area; see Section 7.5.1.

8.5.6 Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover humpback whale populations. These threats will be discussed in further detail in the Environmental Baseline section of this consultation. See the 2022 Recovery Outline for Central America DPS, Mexico DPS, and Western North Pacific DPS of humpback whales for interim guidance to direct recovery efforts. The interim recovery program will focus on:

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

8.6 Sei Whale

The sei whale is a widely distributed baleen whale found in all major oceans (Figure 12).

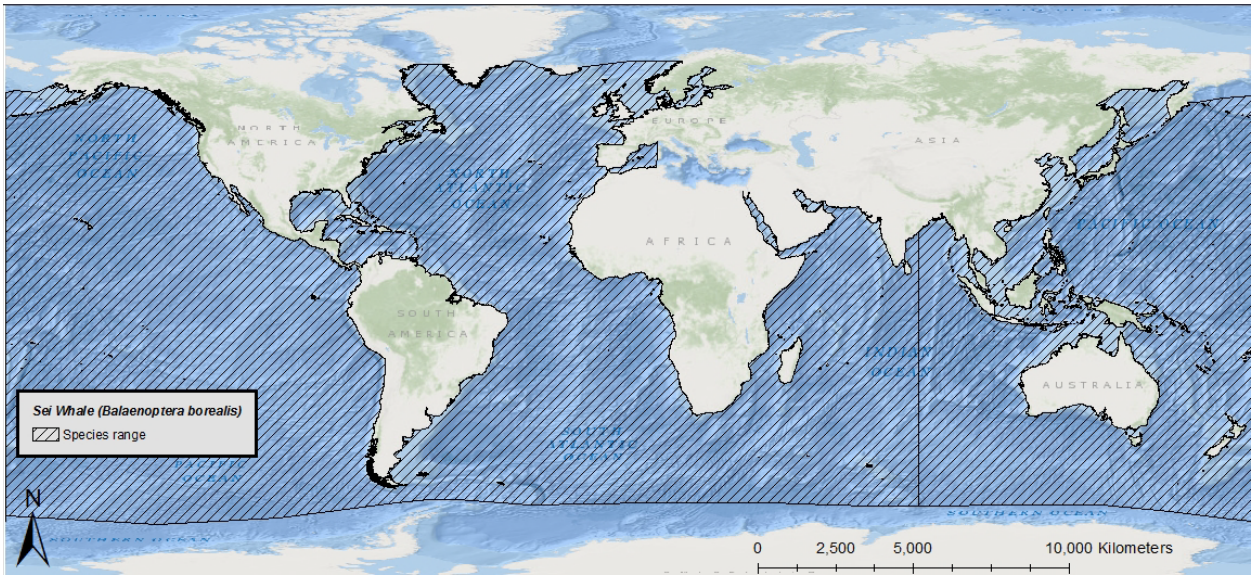

Figure 12. Map identifying the range of the endangered sei whale.

Sei whales are distinguishable from other whales by a long, sleek body that is dark bluish-gray to black in color and pale underneath, and a single ridge located on their rostrum. The sei whale was originally listed as endangered on December 2, 1970.

Information available from the recovery plan (NMFS 2011b), recent stock assessment reports (Carretta 2019b; Carretta et al. 2018; Hayes et al. 2018; Muto et al. 2018), and status review (NMFS 2012) were used to summarize the life history, population dynamics, and status of the species as follows.

8.6.1 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 six and 12 years of age with an average calving interval of two to three years. Sei whales mostly inhabit continental shelf and slope waters far from the coastline. 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.

8.6.2 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 sei whale.

Two sub-species of sei whale are recognized, *B. b. borealis* in the Northern Hemisphere and *B. b. schlegellii* in the Southern Hemisphere. There are no estimates of pre-exploitation abundance for the North Atlantic Ocean. 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 2016b; Thomas et al. 2016). In the Southern Hemisphere, pre-exploitation abundance is estimated at 65,000 whales, with recent abundance estimated at 9,800 to 12,000 whales. Three relatively small stocks occur in U.S. waters: Nova Scotia (N=357, N_{min}=236), Hawaii (N=391, N_{min}=204), and Eastern North Pacific (N=519, N_{min}=374). 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. The best abundance estimate for sei whales for the waters of the U.S. West Coast is 519 (CV=0.40) (Carretta 2019b). 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. 2018a). 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. 1991b; Danielsdottir et al. 1991a; Huijser et al. 2018b; Huijser et al. 2018a; Kanda et al. 2011; Kanda et al. 2006a; Kanda et al. 2006b; Kanda et al. 2015; Kanda et al. 2013).

Sei whales are distributed worldwide, occurring in the North Atlantic Ocean, North Pacific Ocean, and Southern Hemisphere. Very little is known about the distribution of sei whales in the

Northeast Pacific Ocean. Generally, the species occupies pelagic habitats, and is very rarely seen inshore.

8.6.3 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 Hertz range with 1.5 second duration and tonal and upsweep calls in the 200 to 600 Hertz 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 kilohertz (Thomson and Richardson 1995). (Tremblay et al. 2019) recorded 50 to 30 Hertz triplet and singlet downsweeps and 82 to 34 Hertz downsweeps from sei whales in the western North Atlantic, suggesting that sei whales may produce songs. 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 et al. 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 (Ketten 1997a; Ketten 1997b; Richardson et al. 1995c; Richardson et al. 1995b). 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 1997b). In terms of functional hearing capability, sei whales belong to the low-frequency group, which have a hearing range of 7 Hertz to 35 kilohertz (NOAA 2018).

8.6.4 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 2019b). Now, only a few individuals are taken each year by Japan; however, Iceland has expressed an interest in targeting sei whales. Current threats include vessel strikes, fisheries interactions (including entanglement), climate change (habitat loss and reduced prey availability), and anthropogenic noise. Given the species' overall abundance, they may be somewhat resilient to current threats. However, trends are largely unknown, especially for individual stocks, many of which have relatively low abundance estimates.

8.6.5 Critical Habitat

No critical habitat has been designated for the sei whale.

8.6.6 Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover sei whale populations. These threats will be discussed in further detail in the *Environmental Baseline* section of this consultation. 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.

8.7 Sperm Whale

The sperm whale is widely distributed and found in all major oceans (Figure 13).

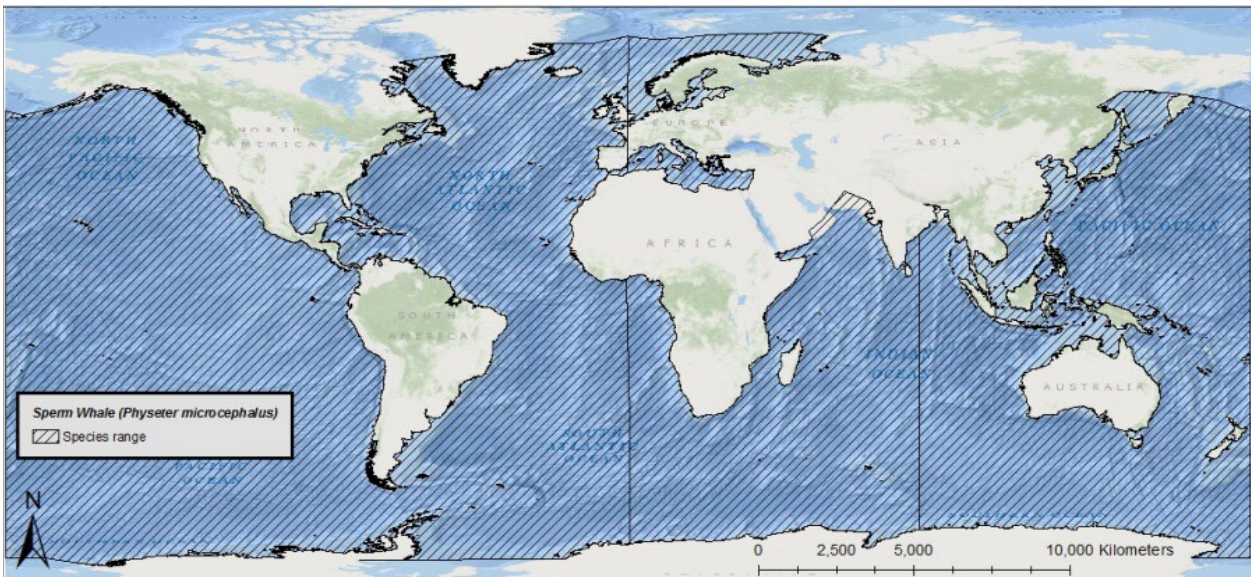

Figure 13. Map identifying the range of the endangered sperm whale.

The sperm whale is the largest toothed whale and distinguishable from other whales by its extremely large head, which takes up 25 to 35 percent of its total body length, and a single blowhole asymmetrically situated on the left side of the head near the tip. 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 et al. 2018; Hayes et al. 2018; Muto et al. 2018), and status review (NMFS 2015c) were used to summarize the life history, population dynamics and status of the species as follows.

8.7.1 Life History

The average lifespan of sperm whales is estimated to be at least 50 years (Whitehead 2009b). They have a gestation period of one to one and a half years, and calves nurse for approximately two years, though they may begin to forage for themselves within the first year of life (Tønnesen et al. 2018). Sexual maturity is reached between seven and 13 years of age for females with an average calving interval of 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 inhabit 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).

8.7.2 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 sperm whale.

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 2009b). The higher estimates may be approaching population sizes prior to commercial whaling, the reason for ESA-listing. There are no reliable estimates for sperm whale abundance across the entire Atlantic Ocean. However, estimates are available for two of three U.S. stocks in the Atlantic Ocean, the Northern Gulf of Mexico stock, estimated to consist of 763 individuals (N_{min}=560) and the North Atlantic stock, underestimated to consist of 2,288 individuals (N_{min}=1,815). There are insufficient data to estimate abundance for the Puerto Rico and U.S. Virgin Islands stock. In the Northeast Pacific Ocean, the abundance of sperm whales was estimated to be between 26,300 and 32,100 in 1997. In the eastern tropical Pacific Ocean, the abundance of sperm whales was estimated to be 22,700 (95 percent confidence intervals 14,800 to 34,600) in 1993. Population estimates are also available for two of three U.S. stocks that occur in the Pacific Ocean, the California/Oregon/ Washington stock, estimated to consist of 2,106 individuals (N_{min}=1,332), and the Hawaii stock, estimated to consist of 4,559 individuals (N_{min}=3,478). There are insufficient data to estimate the population abundance of the North Pacific stock. We are aware of no reliable abundance estimates specifically for sperm whales in the South Pacific Ocean, and there is insufficient data to evaluate trends in abundance and growth rates of sperm whale populations at this time.

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). Furthermore, sperm whales from the Gulf of Mexico, the western North Atlantic Ocean, the North Sea, and the Mediterranean Sea all have been shown to have low levels of genetic diversity (Engelhaupt et al. 2009). 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. Sperm whales have a global distribution and can be found in relatively deep waters in all ocean basins. While both males and females can be found in latitudes less than 40 degrees, only adult males venture into the higher latitudes near the poles. Sperm whales distribute widely throughout the North Pacific Ocean, with movements over 5,000 kilometers (2,699.8 nautical miles), likely driven by changes in prey abundance. Males appear to range more broadly than females (Mizroch and Rice 2013).

8.7.3 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 1999a). Sperm whales typically produce short duration repetitive broadband clicks with frequencies below 100 Hertz to greater than 30 kilohertz (Watkins 1977b) and dominant frequencies between 1 to 6 kilohertz and 10 to 16 kilohertz. Another class of sound, "squeals," are produced with frequencies of 100 Hertz to 20 kilohertz (e.g., Weir et al. 2007b). 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 (Goold and Jones 1995a; Goold and Jones 1995b; Mohl et al. 2003a; Mohl et al. 2003b; Weilgart and Whitehead 1993; Weilgart and Whitehead 1997b; Weilgart and Whitehead 1997a). Most of the energy in sperm whale clicks is concentrated at around 2 to 4 kilohertz and 10 to 16 kilohertz (Goold and Jones 1995a; Goold and Jones 1995b; Weilgart and Whitehead 1993). 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 Hertz and 1.7 kilohertz) 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 (Goold and Jones 1995a; Goold and Jones 1995b; Miller et al. 2004a; Miller et al. 2004b; Weilgart and Whitehead 1993; Weilgart and Whitehead 1997b; Weilgart and Whitehead 1997a; Whitehead and Weilgart 1991b; Whitehead and Weilgart 1991a). 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 (Laplanche et al. 2005a; Laplanche et al. 2005b; Miller et al. 2004a; Miller et al. 2004b). 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 (Rendell and Whitehead 2004b; Rendell and Whitehead 2004a; Weilgart and Whitehead 1997b; Weilgart and Whitehead 1997a). 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 (Pavan et al. 2000a; Pavan et al. 2000b; Weilgart and Whitehead 1997b; Weilgart and Whitehead 1997a). 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 1997a). 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 AEP tests were recorded (Carder and Ridgway 1990). From this whale, responses support a hearing range of 2.5 to 60 kilohertz and highest sensitivity to frequencies between 5 to 20 kilohertz. 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 et al. 1985a; Watkins et al. 1985b; Watkins and Schevill 1975a; Watkins and Schevill 1975c). In the Caribbean Sea, Watkins et al. (1985b) observed that sperm whales exposed to 3.25 to 8.4 kilohertz 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. 1985b). André et al. (1997) reported that foraging whales exposed to a 10 kilohertz 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 (André et al. 1997). Aaron et al. (2007); Thode et al. (2007)observed that the acoustic signal from the cavitation of a fishing vessel's propeller (110 dB re: 1 μPa^2-second between 250 Hertz and one kilohertz) 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 1995b). 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 Hertz and 160 kilohertz (NOAA 2018).

8.7.4 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. Commercial whaling is no longer allowed; however, illegal hunting may occur at biologically unsustainable levels. Continued threats to sperm whale populations include vessel strikes, entanglement in fishing gear, competition for resources due to overfishing, population, loss of prey and habitat due to climate change, and noise. The species' large population size shows that it is somewhat resilient to current threats.

8.7.5 Critical Habitat

No critical habitat has been designated for the sperm whale.

8.7.6 Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover sperm whale populations. These threats will be discussed in further detail in the *Environmental Baseline* section of this consultation. 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.

8.8 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) (Figure 14).

Figure 14. Map identifying the range of the threatened Guadalupe fur seal.

Guadalupe fur seals are medium sized, sexually dimorphic otariids (Belcher and T.E. Lee 2002; Reeves et al. 2002). Distinguishing characteristics of the Guadalupe fur seal include the digits on their hind flippers (all of similar length), large, long foreflippers, and unique vocalizations (Reeves et al. 2002). Guadalupe fur seals are dark brown to black, with the adult males having tan or yellow hairs at the back of their mane. Guadalupe fur seals were listed as threatened under the ESA on December 16, 1985 (50 FR 51252). Information available from recent stock assessment reports and available literature were used to summarize the life history, population dynamics and status of the species as follows.

8.8.1 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 parturition, 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 24 days (average of 14 days). Tracking data show that adult females spend 75 percent of their time sea, and 25 percent at rest (Gallo-Reynoso et al. 1995).

8.8.2 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 Guadalupe fur seal.

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 animals 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 2019a).

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 30 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; more recent evidence indicates that this trend is continuing (Aurioles-Gamboa et al. 2010; Esperon-Rodriguez and Gallo-Reynoso 2012). From 1984 through 2013 at Guadalupe Island, the Guadalupe fur seal population

increased at an average growth rate of 5.9 percent (range of 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 through 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 2019a). Based on direct counts of animals from 1955 and 1993, the estimated annual population growth rate is 13.7 percent (Carretta 2019a).

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 [*Neomonachus schauinslandi*]), that amount is much higher (0.14 versus 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 (*Mirounga angustirostris*) (which did experience a severe bottleneck), Guadalupe fur seals had more haplotypes and a higher number of variable sites. The authors hypothesized that the number 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 25 genotypes in pre-harvest fur seals, and seven present today (Weber et al. 2004).Guadalupe fur seals have been known to travel great distances, with sightings occurring thousands of kilometers away from the main breeding colonies (Aurioles-Gamboa et al. 1999). Guadalupe fur seals are infrequently observed in U.S. waters. They can be found on California's Channel Islands, with as many 15 individuals being sighted since 1997 on San Miguel Island, including three females and reared pups.

8.8.3 Vocalization and Hearing

Though there has been no auditory assessment of the Guadalupe fur seal, its hearing likely falls within similar range as that of the Northern fur seal 2 to 40 kilohertz (Moore and Schusterman 1987).

8.8.4 Status

A number of human activities may have contributed to the current status of this species, historic commercial hunting was likely the most devastating. Commercial sealers in the 19th century decimated the Guadalupe fur seal population, taking as many 8,300 Guadalupe fur seals from San Benito Island (Townsend 1924). Numbers on the total number of Guadalupe 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 that could be found. In 1928, the government of Mexico 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 has been increasing ever since.

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 as 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 that over the last 50 years the population has been increasing since being severely depleted, we believe that the Guadalupe fur seal population is resilient to future perturbations.

8.8.5 Critical Habitat

No critical habitat has been designated for the Guadalupe fur seal.

8.8.6 Recovery Goals

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

9 ENVIRONMENTAL BASELINE

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 (50 C.F.R. §402.02). In this section, we discuss the environmental baseline within the action area as it applies to species that are likely to be adversely affected by the proposed actions.

A number of human activities have contributed to the status of populations of ESA-listed marine mammals in the action area. Some human activities are ongoing and appear to continue to affect marine mammal 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 interactions (vessel strike and whale watching), fisheries (fisheries interactions), pollution (marine debris, pollutants and contaminants, and hydrocarbons), aquatic nuisance species, anthropogenic sound (vessel sound and commercial shipping, aircraft, seismic surveys, marine construction, active sonar, and military activities), and scientific research activities.

Focusing on the impacts of the activities in the action area specifically allows us to assess the prior experience and state (or condition) of the threatened and endangered individuals that occur in the action area that will be exposed to effects from the proposed actions under consultation. This is important because in some states or life history stages, or areas of their ranges, ESA-listed individuals will commonly exhibit, or be more susceptible to, adverse responses to stressors than they would be in other states, stages, or areas within their distributions. These localized stress responses or stressed baseline conditions may increase the severity of the adverse effects expected from the proposed actions.

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 are likely to impact ESA resources. NOAA's climate information portal provides basic background information on these and other measured or anticipated climate change effects (see https://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 ESA-listed species and continues to affect species, 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 for our cumulative effects analysis (Section 10), it is discussed here to provide a comprehensive analysis of the effects of climate change. While 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.

In order to evaluate the implications of different climate outcomes and associated impacts throughout the 21st century, many factors have to be considered. The amount of future greenhouse gas emissions is 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.

The globally-averaged combined land and ocean surface temperature data, as calculated by a linear trend, show a warming of approximately one degrees Celsius from 1901 through 2016 (Hayhoe et al. 2018). The *IPCC Special Report on the Impacts of Global Warming* (IPCC 2018) noted that human-induced warming reached temperatures between 0.8 and 1.2 degrees Celsius above pre-industrial levels in 2017, likely increasing between 0.1 and 0.3 degrees Celsius per decade. Warming greater than the global average has already been experienced in many regions and seasons, with most land regions experiencing greater warming than over the ocean (Allen et al. 2018).

Annual average temperatures have increased by 1.8 degrees Celsius across the contiguous United States since the beginning of the 20th century with Alaska warming faster than any other state and twice as fast as the global average since the mid-20th century (Jay et al. 2018). Global warming has led to more frequent heatwaves in most land regions and an increase in the frequency and duration of marine heatwaves (IPCC 2018). Average global warming up to 1.5 degrees Celsius as compared to pre-industrial levels is expected to lead to regional changes in extreme temperatures, and increases in the frequency and intensity of precipitation and drought (IPCC 2018).

Several of the most important threats contributing to the extinction risk of ESA-listed species, particularly those with calcium carbonate skeleton such as corals and mollusks as well as species for which these animals serve as prey or habitat, are related to global climate change. The main concerns regarding impacts of global climate change on coral reefs and other calcium carbonate habitats generally, and on ESA-listed corals and mollusks in particular, are 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.

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 in the atmosphere since the Industrial Revolution,

ocean acidification has already occurred throughout the world's oceans, and is predicted to increase considerably between now and 2100 (IPCC 2014a). These impacts are particularly concerning for those animals that serve as prey for ESA-listed species.

Ocean acidification negatively affects organisms such as crustaceans, crabs, mollusks, and other calcium carbonate-dependent organisms such as pteropods (free-swimming pelagic sea snails and sea slugs), the latter being important part of the food web in North Pacific Ocean waters. Some studies in the nutrient-rich regions have found that food supply may play a role in determining the resistance of some organisms to ocean acidification (Markon et al. 2018; Ramajo et al. 2016). Reduction in prey items can create a collapse of the zooplankton populations and thereby result in potential cascading reduction of prey at various levels of the food web, thereby reducing the availability of the larger prey items of marine mammals.

For 650,000 years or more, the average global atmospheric carbon dioxide concentration varied between 180 and 300 parts per million, but since the beginning of the Industrial Revolution in the late 1700s, atmospheric carbon dioxide concentrations have increased rapidly, primarily due to anthropogenic inputs (Fabry et al. 2008). The world's oceans have absorbed approximately one-third of anthropogenic carbon dioxide released, which has curtailed the increase in atmospheric carbon dioxide concentrations (Sabine et al. 2004). Despite the ocean's role as large carbon sinks, in 2016, the mean monthly average atmospheric carbon dioxide level exceeded 400 parts per million and continues to rise.

As the ocean absorbs more carbon dioxide, the pH of seawater is reduced. This process is commonly referred to as ocean acidification. Ocean acidification reduces the saturation states of certain biologically important calcium carbonate minerals like aragonite and calcite that many organisms use to form and maintain shells (Reisdorph and Mathis 2014). When seawater is supersaturated with these minerals, calcification (growth) of shells is favored. Likewise, when unsaturated, dissolution is favored (Feely et al. 2009).

Ocean acidification may cause a variety of species- and ecosystem-level effects in high latitude ecosystems. Species-level effects may include reductions in the calcification rates of numerous planktonic and benthic species, alteration of physiological processes such as pH buffering, hypercapnia, ion transport, acid-base regulation, mortality, metabolic suppression, inhibited blood-oxygen binding, and reduced fitness and growth (Fabry et al. 2008). Ecosystem effects could include altered species compositions and distributions, trophic dynamics, rates of primary productivity, and carbon and nutrient cycling (Fabry et al. 2008). Additionally, as the ocean becomes more acidic, low frequency sounds (1 to 3 kilohertz and below) travel farther because the concentrations of certain ions that absorb acoustic waves decrease with decreasing pH (Brewer and Hester 2009).

Additional consequences of climate change include increased ocean stratification, decreased sea-ice extent, altered patterns of ocean circulation, and decreased ocean oxygen levels (Doney et al. 2012). Climate change is also expected to increase the frequency of extreme weather and climate

events including, but not limited to, cyclones, tropical storms, heat waves, and droughts (IPCC 2014a).

Climate change has the potential to impact species abundance, geographic distribution, migration patterns, and susceptibility to disease and contaminants, as well as the timing of seasonal activities and community composition and structure (Evans and Bjørge 2013; IPCC 2014a; Kintisch 2006; Learmonth et al. 2006b; MacLeod et al. 2005; McMahon and Hays 2006; Robinson et al. 2005). Though predicting the precise consequences of climate change on highly mobile marine species is difficult (Simmonds and Isaac 2007a), recent research has indicated a range of consequences already occurring.

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 marine mammals, 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). 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. 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).

Similarly, 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. For example, blue whales, as predators that specialize in eating krill, are 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 similar to those observed in other krill predators, which would cause dramatic declines in their population sizes or would increase the year-to-year variation in population size; either of these outcomes would dramatically increase the extinction probabilities of these whales. 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 diets can be dominated by cephalopods. Sperm whales and Guadalupe fur seals, whose diets can be dominated by cephalopods, 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. For ESA-listed species that 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).

This review provides some examples of impacts to ESA-listed species and their habitats that may occur as the result of climate change. While 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, and may be exacerbated by additional threats in the action area.

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 led 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 area (Beamish 1993; Benson and Trites 2002; Hare and Mantua 2001; Mantua et al. 1997; Mundy and Cooney 2005; Stabeno et al. 2004).

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 while the central and western Pacific Ocean undergoes above average sea surface temperatures (Royer 2005). Warm Pacific decadal oscillation regimes, as occurs in El Niño events, tends to increase productivity along the U.S west coast, as upwelling typically diminishes (Childers et al. 2005; Hare et al. 1999). 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 0.85 degrees Celsius

from 1880 through 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. The warmest year on record for global sea surface temperature was also 2016, and 2020 as the eighth warmest.

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 (Kintisch 2006; Learmonth et al. 2006a; MacLeod et al. 2005; McMahon and Hays 2006; Robinson et al. 2005). Climate change can influence reproductive success by altering prey availability, as evidenced by the low success of northern elephant seals 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 2007b).

9.3 Unusual Mortality Events

Under the MMPA, an unusual mortality event (UME) is defined as "a stranding that is unexpected; involves a significant die-off of any marine mammal population; and demands immediate response." In the past, an UME was declared for fin and humpback whales in British Columbia (including Vancouver Island) and Gulf of Alaska, from April 23, 2015 through April 16, 2016, where 52 individuals were found dead (https://www.fisheries.noaa.gov/national/marine-life-distress/2015-2016-large-whale-unusual-mortality-event-western-gulf-alaska). The investigation did not determine a cause for the unusual mortality event, although ecological factors like the 2015 El Niño, the warm water blob, and the Pacific Coast Domoic Acid Bloom were contributing factors. Only one UME is active for ESA-listed marine mammals (i.e., Guadalupe fur seals) within the action area. An UME was declared for Guadalupe fur seals beginning January 1, 2015, and continuing through September 2, 2021. The UME was declared due to the increased stranding of Guadalupe fur seals in California, and was expanded to include Oregon and Washington due to the elevated number of strandings there (a total of 715 animals). Strandings in Oregon and Washington have been well above typical numbers since 2015 (Figure 15).

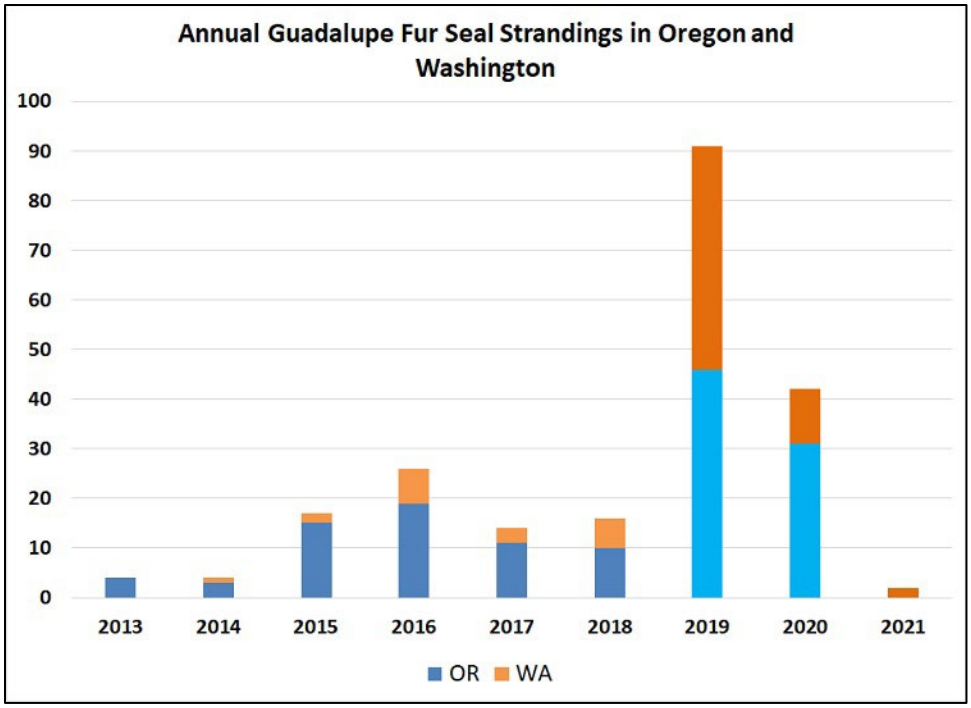

Figure 15. Guadalupe fur seal annual strandings in Oregon and Washington, 2013 through 2021.

Guadalupe fur seal stranding generally peak in April through June each year. Stranded individuals were mostly weaned pups and juveniles, aged one to two years old. Most stranded individuals showed signs of malnutrition and had secondary bacterial and parasitic infections. The malnutrition was attributed to ecological factors in the Pacific Ocean causing suboptimal prey conditions. Unprecedented ocean warming in the Northeast Pacific Ocean that resulted in reduced or changed prey availability most likely impacted the weaned pups' ability to feed.

9.4 Vessel Interactions

Within the action area, vessel interactions pose a threat to ESA-listed marine mammals. Overall, the action area sees a great deal of vessel activity, from cargo and commercial shipping, to recreational vessels, cruise ships, and whale watching vessels. Vessel interactions can come in the form of vessel strike and whale watching.

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 (Boren et al. 2001; Constantine 2001; Mann et al. 2000; Nowacek 2001; Samuels et al. 2000). A blue whale aborted its ascent when it was 57.5 meters (188.6 feet) from the vessel, and stayed underwater for three minutes beyond its projected surfacing time (Szesciorka et al. 2019). A study focusing on Southern Resident DPS of killer whales showed that individuals altered their foraging behavior when near vessels. When vessels were at an average distance of less than 366 meters (1,200.8 feet), individuals made fewer dives involving prey capture, and spent less time in these dives. The researchers found differences in response between the sexes, with females

making fewer fives than males when vessels were less than 366 meters (1,200.8 feet) (Holt et al. 2021).

9.4.1 Vessel Strike

Vessel strikes are considered a serious and widespread threat to ESA-listed marine mammals (especially large whales) and are the most well-documented "marine road" interaction 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). Blue whales are especially susceptible where shipping lanes overlap with common feeding areas, as they do in the Santa Barbara Channel (Redfern 2013). As vessels to become faster and more widespread, an increase in vessel interactions with cetaceans is to be expected. 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 as a result of vessel strike are detected, particularly in offshore waters, and 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, as most are likely never reported. 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 moralities associated with vessel strikes, especially for less buoyant species such as blue, humpback, and fin whales (Rockwood et al. 2017). Rockwood et al. (2017) modeled vessel strike mortalities of blue, humpback, and fin whales off California using carcass recovery rates of five and 17 percent and conservatively estimated that vessel strike mortality may be as high as 7.8, 2.0, and 2.7 times the recommended limit for blue, humpback, and fin whale stocks in this area, respectively.

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 some areas, one-third of all fin whale and North Atlantic right whale strandings appear to involve vessel strikes (Laist et al. 2001). 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. The latest five-year average mortalities and serious injuries related to vessel strikes for ESA-listed marine mammal stocks within U.S. waters likely to be found in the action area and experience adverse effects as a result

of the proposed action are given in Table 14 below (Carretta 2019b). These data represent only known mortalities and serious injuries. It is probably that more undocumented mortalities and serious injuries within the action area have likely occurred.

Table 14. Five-year annual average mortalities and serious injuries related to vessel strikes for Endangered Species Act-listed marine mammals for stocks in the Pacific Ocean within the action area.

Species	Observed	Estimated
Blue Whale	0.2	18
Fin Whale	1.6	43
Humpback Whale – Multiple DPSs	2.1	22
Sei Whale	0.2	NA
Sperm Whale	0	0
Guadalupe Fur Seal	0	0

DPS=distinct population segment, NA=not available

9.4.2 Whale Watching

Whale watching is a profitable and rapidly growing business with more than 3,300 operators worldwide, serving 13 million participants in 119 countries and territories, and may increase types of disturbance and negatively affect the species (Hoyt 2001; O'connor et al. 2009). As of 2010, commercial whale watching was a one billion dollar global industry per year (Lambert et al. 2010). Private vessels may partake in this activity as well. NMFS has issued regulations and guidelines relevant to whale watching. As noted previously, many of the cetaceans and pinnipeds considered in this consultation are highly migratory, so may also be exposed to whale watching activity occurring outside of the action area. Whale watching companies operate from the coast of Oregon, primarily seeing gray whales and humpback whales. Whale watching from the coast of Washington target killer whales and other species (e.g., humpback whales) in the Salish Sea and Puget Sound.

Although considered by many to be a non-consumptive use of marine mammals with economic, recreational, educational and scientific benefits, whale watching is not without potential negative impacts (reviewed in Parsons 2012). Whale watching has the potential to harass whales by altering feeding, breeding, and social behavior, or even injure them if the vessel gets too close or strikes the animal. Preferred habitats may be abandoned if disturbance levels are too high. Animals may also become more vulnerable to vessel strikes if they habituate to vessel traffic (Swingle et al. 1993; Wiley et al. 1995).

Several studies have examined the short-term effects of whale watching vessels on marine mammals (Au and Green 2000; Corkeron 1995; Erbe 2002b; Felix 2001; Magalhaes et al. 2002; Richter et al. 2003; Scheidat et al. 2004; Simmonds 2005b; Watkins 1986a; Williams et al.

2002). A whale's behavioral responses to whale watching vessels depended on the distance of the vessel from the whale, vessel speed, vessel direction, vessel sound, and the number of vessels. In some circumstances, whales do not appear to respond to vessels, but in other circumstances, whales change their vocalizations, surface time, swimming speed, swimming angle or direction, respiration rates, dive times, feeding behavior, and social interactions. Disturbance by whale watch vessels has also been noted to cause newborn calves to separate briefly from their mother's sides, which leads to greater energy expenditures by the calves (NMFS 2006b).

Although numerous short-term behavioral responses to whale watching vessels were documented, little information is available on whether long-term negative effects result from whale watching (NMFS 2006b). Christiansen et al. (2014) estimated the cumulative time minke whales spent with whale watching boats in Iceland to assess the biological significance of whale watching disturbances and found that, through some whales were repeatedly exposed to whale watching boats throughout the feeding season, the estimated cumulative time they spent with boats was very low. Christiansen et al. (2014) suggested that the whale watching industry, in its current state, is likely not having any long-term negative effects on vital rates.

It is difficult to precisely quantify or estimate the magnitude of the risks posed to marine mammals in general from vessel approaches associated with whale watching. The low-energy seismic survey will take place approximately 46.9 to 174.3 kilometers (25.3 to 94.1 nautical miles) from the coastline of Oregon and Washington in the Northeast Pacific Ocean (Figure 3). The Coast survey region is approximately 148.4 to 174.3 kilometers (80.1 to 94.1 nautical miles) from shore; the Nubbin survey region is approximately 165.1 to 171 kilometers (89.1 to 92.3 nautical miles) from shore; the Pseudofault survey region is approximately 149.2 to 164.7 kilometers (80.6 to 88.9 nautical miles) from shore; and the Oregon survey region is approximately 46.9 to 96.6 kilometers (25.3 to 52.1 nautical miles) from shore. Given the proposed seismic survey activities will occur in a remote area away from populated areas where whale watching may occur and not occur within approximately 46.9 to 174.3 kilometers (25.3 to 94.1 nautical miles) of land (coastline of Oregon and Washington), few (if any) whale watching vessels will be expected to co-occur with the proposed action's research vessel.

9.5 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 include entanglement and entrapment, which can lead to fitness consequences or mortality as a result 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. Use of mobile fishing gear, such as bottom trawls, disturbs the seafloor and reduces structural complexity. Indirect impacts of trawls include increased turbidity, alteration of surface sediment, removal of prey (leading to declines in

predator abundance), removal of predators, ghost fishing (i.e., lost fishing gear continuing to ensnare fish and other marine animals), and generation of marine debris. Lost gill nets, purse seines, and long-lines may foul and disrupt bottom habitats and have the potential to entangle or be ingested by marine mammals.

Fisheries can have a profound influence on fish populations. In a study of retrospective data, Jackson et al. (2001) concluded that ecological extinction caused by overfishing precedes all other pervasive human disturbance of coastal ecosystems, including pollution and anthropogenic climatic change. Marine mammals are known to feed on several species of fish that are harvested by humans (Waring et al. 2008). 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 several populations of marine mammals.

9.5.1 Fisheries Interactions

Globally, 6.4 million tons of fishing gear is lost in the oceans every year (Wilcox et al. 2015). Marine mammal entanglement (bycatch) is a global problem that every year results in the death of hundreds of thousands of animals worldwide. 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. In excess of 97 percent of entanglement is caused by derelict fishing gear (Baulch and Perry 2014b).

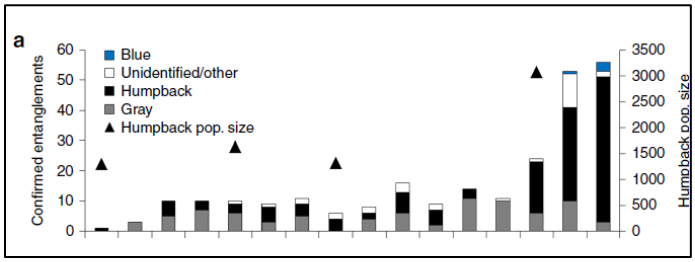

Figure 16. Trend in confirmed whale entanglements per year detected off the West Coast of the United States from 2001 through 2016, and estimated humpback whale population size (Santora et al. 2020).

Figure 16 shows the number of confirmed whale entanglements per year detected off the West Coast of the U.S. from 2001 through 2016 (Santora et al. 2020). The number of confirmed whale entanglements, most notably humpback whales, increased markedly throughout the 2014 through 2016 marine heat wave event in the Pacific Ocean. The latest five-year average mortalities and serious injuries related to fisheries interactions for the ESA-listed marine mammals likely to be found in the action area within U.S. waters are given in Table 15 below (Carretta 2019b). Data represent only known mortalities and serious injuries; more, undocumented mortalities and

serious injuries for these and other marine mammals found within the action area have likely occurred.

Table 15. Five-year average mortalities and serious injuries related to fisheries interactions for Endangered Species Act-listed marine mammals within the action area.

Species	Mortality
Blue Whale	0.9
Fin Whale	Greater than or equal to 0.5
Humpback Whale – Multiple ESA-listed DPSs	15.7
Sei Whale	0
Sperm Whale	NA
Guadalupe Fur Seal	Greater than or equal to 3.2

DPS=distinct population segment, NA=not available

There have been reports of Guadalupe fur seals stranding with evidence of entanglement in fishing gear or other marine debris (Hanni et al. 1997). Previous bycatch data do not report any Guadalupe fur seal bycatch in fisheries in the U.S., including observed fisheries such as the driftnet and gillnet fisheries in California, and the groundfish trawl fishery in California, Oregon, and Washington (NMFS 2000; NMFS 2013). From the period of 2009 through 2013, there were 20 Guadalupe fur seals reported as injured or killed as a result of human-related injury; 13 dead, three serious injured, and four non-seriously injured (Carretta et al. 2015). Several of these individuals were entanglement in pieces of gillnet, trawl nets, or gear from an unidentified net fishery.

Marine mammals are also known to ingest fishing gear, likely mistaking it for prey, which can lead to fitness consequences and mortality. Necropsies of stranded whales have found that ingestion of net pieces, ropes, and other fishing debris has resulted in gastric impaction and ultimately death (Jacobsen et al. 2010b). As with vessel strikes, entanglement or entrapment in fishing gear likely has the greatest impact on populations of ESA-listed species with the lowest abundance (e.g., Kraus et al. 2016). Nevertheless, all species of marine mammals may face threats from derelict fishing gear.

In addition to these direct impacts, cetaceans and pinnipeds may also be subject to indirect impacts from fisheries. Marine mammals probably consume at least as much fish as is harvested by humans (Kenney et al. 1985). Many cetacean and pinniped species (particularly fin whales 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.

Recreational fishing occurs throughout the action area. Commercial and recreational fisheries may impact marine mammals as they migrate through the action area through direct interactions (i.e., incidental take or bycatch) and indirectly through competition for prey resources and other impacts on prey populations.

9.6 Pollution

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

9.6.1 Marine Debris

Marine debris is an ecological threat that is introduced into the marine environment through ocean dumping, littering, or hydrologic transport of these materials from land-based sources (Gallo et al. 2018). Even natural phenomena, such as tsunamis and continental flooding, can cause large amounts of debris to enter the ocean environment (Watters et al. 2010). Marine debris has been discovered to be accumulating in gyres throughout the oceans. Marine mammals often become entangled in marine debris, including fishing gear (Baird et al. 2015). Despite debris removal and outreach to heighten public awareness, marine debris in the environment has not been reduced (NRC 2008) and continues to accumulate in the ocean and along shorelines within the action area.

Marine debris affects marine habitats and marine life worldwide, primarily by entangling or choking individuals that encounter it (Gall and Thompson 2015). Entanglement in marine debris can lead to injury, infection, reduced mobility, increased susceptibility to predation, decreased feeding ability, fitness consequences, and mortality for ESA-listed species in the action area. Entanglement can also result in drowning for air breathing marine species including marine mammals. The ingestion of marine debris has been documented to result in blockage or obstruction of the digestive tract, mouth, and stomach lining of various species and can lead to serious internal injury or mortality (Derraik 2002). In addition to interference with alimentary processes, plastics lodged in the alimentary tract could facilitate the transfer of pollutants into the bodies of whales and dolphins (Derraik 2002). 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 Northeast Pacific Ocean, but we assume similar effects from marine debris documented within other ocean basins could also occur to ESA-listed species from marine debris.

Cetaceans are also impacted by marine debris, which includes: plastics, glass, metal, polystyrene foam, rubber, and derelict fishing gear (Baulch and Perry 2014a; 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 2014b). A recent study showed that microplastics were present in nearly all fecal samples from Southern Resident DPS of killer whales (Harlacher 2020).

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 coast of California, with an assortment of fishing related debris (e.g., net scraps and rope) and other plastics inside their stomachs (Jacobsen et al. 2010a). One whale was emaciated, and the other had a ruptured stomach. It was suspected that gastric implications was the cause of both deaths. Jacobsen et al. (2010a) speculated the debris likely accumulated over many years, possibly in the North Pacific gyre that will carry derelict Asian fishing gear into the waters of the Eastern Pacific Ocean.

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). 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 in the ocean chemically attracts hydrocarbon pollutants such as polychlorinated biphenyl and dichlorodiphenyltrichloroethane. Marine mammals can mistakenly consume these wastes containing elevated levels of toxins instead of their prey. Once consumed, plastics can act as nutritional dilutants 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). It is expected that marine mammals may be exposed to marine debris over the course of the proposed actions 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 (Garrett 2004; Grant and Ross 2002; Hartwell 2004; Iwata 1993). 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 (Garrett 2004; Grant and Ross 2002; Hartwell 2004).

The accumulation of persistent organic pollutants, including polychlorinated-biphenyls, dibenzo-p-dioxins, dibenzofurans and related compounds, through trophic transfer may cause mortality and 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). Persistent organic pollutants may also facilitate disease emergence and lead to the creation of susceptible "reservoirs" for new pathogens in contaminated marine mammal populations (Ross 2002). Recent efforts have led to improvements in regional water quality and monitored pesticide levels have declined, although the more persistent chemicals are still detected and are expected to endure for years (Grant and Ross 2002; Mearns 2001).

In a small and imperiled population, these pollutants effects can be especially deleterious, as they could work in concert along with other stressors (e.g., reductions in prey), leading to reduced fitness for an individual. For example, in marine mammals like Southern Resident DPS of killer whales, contamination from pollutants could lead to endocrine disruption (delayed development, changes to metabolism, reduced perinatal survival), and compromised immune systems (Mongillo et al. 2016).

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). While exposure to pollutants and other contaminants is likely to continue and occur for marine mammals in the action area through the duration of the seismic survey activities, the level of risk and degree of impact is unknown.

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).

Because persistent organic pollutants are both ubiquitous and persistent in the environment, marine mammals and other forms of marine life will continue to be exposed to persistent organic pollutants for all of their lives. The effects of persistent organic pollutants to ESA-listed species are unknown and not directly studies, 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 persistent organic pollutants in ESA-listed species are not currently well known.

9.6.3 Hydrocarbons

Hydrocarbons that may pose a threat to ESA-listed marine mammals consist of natural seeps as well as oil spills. Hydrocarbons also have the potential to impact prey populations, and therefore may affect ESA-listed species indirectly by reducing food availability.

Oil spill are accidental and unpredictable events, but are a direct consequence of oil and gas development and production from oil and gas activities as well as from the use of vessels. Oil releases can occur at any number of points during the exploration, development, production, and transport of oil. Most instances of oil spill are generally small (less than 1,000 barrels), but larger spills occur as well.

There has never been a large-scale oil spill in the action area, but numerous small-scale vessel spills likely occur. A nationwide study examining vessel oil spills from 2002 through 2006 found that over 1.8 million gallons of oil were spilled from vessels in all U.S. waters (Dalton and Jin 2010). In this study, "vessel" included numerous types of vessels, including barges, tankers, tugboats, and recreational and commercial vessels, demonstrating that the threat of an oil spill can come from a variety of vessel types. In addition to vessels, oil spills can come from other sources like pipelines and rail cars, but in this discussion, we focus on spills to water. Below we review the effects of oil spills on marine mammals more generally. Much of what is known comes from studies of large oil spills such as the *Deepwater Horizon* oil spill since no information exists on the effects of small-scale oil spills within the action area.

Exposure to hydrocarbons released into the environment via oil spills and other discharges pose risks to marine species. Marine mammals are generally able to metabolize and excrete limited amounts of hydrocarbons, but exposure to large amounts of hydrocarbons and chronic exposure over time pose greater risks (Grant and Ross 2002). Acute exposure of marine mammals to petroleum products causes changes in behavior and may directly injure animals (Geraci 1990).

Perhaps one of the most famous oil spills in U.S. history occurred in the Gulf of Alaska when, in 1989 the *Exxon Valdez* released at least 11 million gallons of Alaska crude oil into one of the largest and most productive estuaries in North America. The Alaska Department of Environmental Conservation estimated that 149 kilometers (92.6 miles) of shoreline was heavily oiled and 459 kilometers (285.2 miles) were at least lightly oiled. Oil spills, both small and large, occur widely along U.S. shores at refining and transfer facilities and extraction sites. The *Exxon Valdez* oil spill was the worst in U.S. history until the 2010 *Deepwater Horizon* event.

The *Deepwater Horizon* oil spill in the Gulf of Mexico in 2010 led to the exposure of tens of thousands of marine mammals to oil, causing reproductive failure, adrenal disease, lung disease, and poor body condition.

Cetaceans have a thickened epidermis that greatly reduces the likelihood of petroleum toxicity from skin contact with oils (Geraci 1990), but they may inhale these compounds at the water's surface and ingest them while feeding (Matkin and Saulitis 1997). For example, as a result of the *Deepwater Horizon* oil spill, sperm whales could have been exposed to toxic oil components through inhalation, aspiration, ingestion, and dermal exposure. There were 19 observations of 33 sperm whales swimming in *Deepwater Horizon* surface oil or that had oil on their bodies (Diaz 2015 as cited in Deepwater Horizon NRDA Trustees 2016). The effects of oil exposure likely included physical and toxicological damage to organ systems and tissues, reproductive failure, and death. Large whales may have experienced multiple routes of exposure at the same time,

over intermittent timeframes and at varying rates, doses, and chemical compositions of oil. This estimation of effects to large whales is largely based on observed impacts to bottlenose dolphins resulting from exposure to oil from the *Deepwater Horizon* event. The oil spill from the *Deepwater Horizon* event occurred in deep water, which is sperm whale habitat. The same routes of internal oil exposure (ingestion, inhalation, and aspiration) would have occurred in sperm whales that have been shown to adversely affect bottlenose dolphins in coastal habitat. The surface oil and vapors at the water's surface were more concentrated offshore near the leaking well head that could have exposed sperm whales to high levels of contaminants between dives that were known to have occurred with bottlenose dolphins. Linnehan et al. (2021) concluded that bottlenose dolphins impacted by oil showed evidence of cardiac abnormalities (i.e., significantly thinner left ventricular walls, smaller left atria, and higher prevalence of valvular abnormalities) as well as pulmonary hypertension. Hydrocarbons also have the potential to impact prey populations, and therefore may affect ESA-listed species indirectly by reducing food availability.

As noted above, to our knowledge the past and present impacts of oil spills on ESA-listed species (blue whale, fin whale, Central America DPS and Mexico DPS of humpback whale, sei whale, sperm whale, and Guadalupe fur seal) within the action area are limited to those associated with small-scale vessel spills. Nevertheless, we consider the documented effects of oil spills outside the action area, such as the *Deepwater Horizon* oil spill, examples of the possible impacts that oil spill can have on ESA-listed species.

9.7 Aquatic Nuisance Species

Aquatic nuisance species are nonindigenous species that threaten the diversity or abundance of native species, the ecological stability of infested waters, or any commercial, agricultural or recreational activities dependent on such waters. Aquatic nuisance species include nonindigenous species that may occur within inland, estuarine, or marine waters and that presently or potentially threaten ecological processes and natural resources. Invasive species have been referred to as one of the top four threats to the world's oceans (Pughiuc 2010; Raaymakers 2003; Raaymakers and Hilliard 2002; Terdalkar et al. 2005). 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, 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. They have been implicated in the endangerment of 48 percent of ESA-listed species (Czech and Krausman 1997). Currently, there is little information on the level of aquatic nuisance species and the impacts of these invasive species may have on marine mammals in the

action area through the duration of the project. Therefore, the level of risk and degree of impact to ESA-listed marine mammals is unknown.

Gurevitch and Padilla (2004) note that of the 21 total marine species in the International Union for Conservation of Nature (IUCN) database listed to have gone extinct (four mammals, 11 birds, one fish, four molluscs, one alga), none are attributed to invasive alien species; most were extinct prior to 1900 and before many modern invasions.

Dueñas et al. (2018) conducted a systematic literature review of the available scientific evidence on invasive species' interactions with all threatened and endangered species protected under the ESA. Relevant to this consultation Dueñas et al. (2018) did not find any studies indicating that ESA-listed marine mammals negatively impacted by invasive species.

Many studies have demonstrated a close relationship between trade and aquatic nuisance species, with shipping being identified as the main vector of aquatic nuisance species in aquatic ecosystems (Nong 2018, Chan et al. 2019). Olson (2006) reviewed numerous studies of biological invasions and highlighted that international trade is an important vector that links to the existence and spread of invasive species internationally. Globally, shipping has been found to be responsible for 69 percent of marine invasive species (Molnar et al. 2008).

Risks associated with oceanic shipping come primarily from hitchhiking species on vessel hulls (fouling) and in ballast water (Drake and Lodge 2007; Keller and Perrings 2011). In general, the introduction of aquatic nuisance species is one of the primary causes decreased biodiversity in an ecosystem (Trombulak et al. 2004). The impact of aquatic nuisance species in marine systems ranges from extirpation of native species through competition or predation, shifts in ecosystem food webs, to changes to the physical structure of the habitat (Norse et al. 2005). Although it is not possible to predict which aquatic nuisance species will arrive and thrive in the Pacific Ocean (e.g., non-native species like striped bass [*Morone saxatillis*] and Japanese eelgrass [*Zostera japonica*]), it is reasonably certain that they will be yet another facet of change and potential stress to native biota which may affect either the health or prey base of native fauna.

9.8 Anthropogenic Sound

The ESA-listed species that occur in the action area are regularly exposed to several sources of anthropogenic sounds. These include, but are not limited to maritime activities (vessel sound and commercial shipping), aircraft, seismic surveys (exploration and research), marine construction, and military readiness activities. These activities occur to varying degrees throughout the year. Cetaceans and pinnipeds generate and rely on sound to navigate, hunt, avoid predators, and/or communicate with other individuals and anthropogenic sound can interfere with these important activities (Nowacek et al. 2007). The ESA-listed species have the potential to be impacted by either increased levels of anthropogenic-induced background sound or high intensity, short-term anthropogenic sounds.

The addition of anthropogenic sound to the marine environment is a known stressor that can possibly harm marine animals or significantly interfere with their normal activities (NRC 2005).

Within the action area, ESA-listed marine mammals may be impacted by anthropogenic sound in various ways. Responses to sound exposure may include lethal or nonlethal injury, temporary hearing impairment, behavioral harassment and stress, or no apparent response. For example, some sounds may produce a behavioral response, including but not limited to, avoidance of impacted habitat areas affected by irritating sounds, changes in diving behavior, or (for cetaceans) changes in vocalization patterns (MMC 2007).

Many researchers have described behavioral responses of marine mammals to sounds produced by boats and vessels, as well as other sound sources such as helicopters and fixed-wing aircraft, and dredging and construction (reviewed in Gomez et al. 2016; and Nowacek et al. 2007). Most observations have been limited to short-term behavioral responses, which included avoidance behavior and temporary cessation of feeding, resting, or social interactions; however, in terrestrial species habitat abandonment can lead to more long-term effects, which may have implications at the population level (Barber et al. 2010). Masking may also occur, in which an animal may not be able to detect, interpret, and/or respond to biologically relevant sounds. Masking can reduce the range of communication, particularly long-range communication, such as that for bowhead whales. This can have a variety of implications for an animal's fitness including, but not limited to, predator avoidance and the ability to reproduce successfully (MMC 2007). Recent scientific evidence suggests that marine mammals, including several baleen whales, compensate for masking by changing the frequency, source level, redundancy, or timing of their signals, but the long-term implications of these adjustments are currently unknown (Mcdonald et al. 2006a; Parks 2003; Parks 2009a). We assume similar impacts have occurred and will continue to affect marine species in the action area.

Despite the potential for these impacts to affect individual ESA-listed marine mammals, information is not currently available to determine the potential population level effects of anthropogenic sound levels in the marine environment (MMC 2007). For example, we currently lack empirical data on how sound impacts growth, survival, reproduction, and vital rates, nor do we understand the relative influence of such effects on the population being considered. As a result, the consequences of anthropogenic sound on ESA-listed marine mammals at the population or species scale remain uncertain, although recent efforts have made progress establishing frameworks to consider such effects (NAS 2017).

9.8.1 Vessel Sound and Commercial Shipping

Individual vessels produce unique acoustic signatures, although these signatures may change with vessel speed, vessel load, and activities that may be taking place on the vessel. Sound levels are typically higher for the larger and faster vessels. Peak spectral levels for individual commercial vessels are in the frequency band of 10 to 50 Hertz and range from 195 dB re: 1 μPa^2 second at 1 meter for fast-moving (greater than 37 kilometers per hour [20 knots]) supertankers to 140 dB re: 1 μPa^2 second at 1 meter for smaller vessels (NRC 2003c). Although large vessels emit predominantly low frequency sound, studies report broadband sound from large cargo vessels about 2 kilohertz, which may interfere with important biological functions of

cetaceans (Holt 2008a). At frequencies below 300 Hertz, 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 (Hildebrand 2009b; McKenna et al. 2012; NRC 2003c; NRC 2003b). Commercial shipping continues to be a major source of low-frequency sound in the ocean, particularly in the Northern Hemisphere where the majority of vessel traffic occurs (Hildebrand 2004). Although large vessels emit predominantly low frequency sound, studies report broadband sound from large cargo vessels above 2 kilohertz. The low frequency sounds from large vessels overlap with many mysticetes predicted hearing ranges (7 Hertz to 35 kilohertz) (NOAA 2018) and may mask their vocalizations and cause stress (Rolland et al. 2012a). The broadband sounds from large vessels may interfere with important biological functions of odontocetes, including foraging (Blair et al. 2016; Holt 2008b). At frequencies below 300 Hertz, ambient sound levels are elevated by 15 to 20 dB when exposed to sounds from vessels at a distance (McKenna et al. 2013b). Analysis of sound from vessels revealed that their propulsion systems are a dominant source of radiated underwater sound at frequencies less than 200 Hertz (Ross 1976). Additional sources of vessel sound include rotational and reciprocating machinery that produces tones and pulses at a constant rate. Other commercial and recreational vessels also operate within the action area and may produce similar sounds, although to a lesser extent given their much smaller size.

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. Peak spectral levels for individual commercial vessels are in the frequency band of 10 to 50 Hertz and range from 195 dB re: μPa^2-s at 1 meter for fast-moving (greater than 37 kilometers per hour [20 knots]) supertankers to 140 dB re: μPa^2-s at 1 meter for small fishing vessels (NRC 2003b). Small boats with outboard or inboard engines produce sound that is generally highest in the mid-frequency (1 to 5 kilohertz) range and at moderate (150 to 180 dB re: 1 μPa at 1 meter) sound source levels (Erbe 2002b; Gabriele et al. 2003; Kipple and Gabriele 2004). On average, sound levels are higher for the larger vessels, and increased vessel speeds result in higher sound levels. Measurements made over the period 1950 through 1970 indicated low frequency (50 Hertz) vessel traffic sound in the eastern North Pacific Ocean and western North Atlantic Ocean was increasing by 0.55 dB per year (Ross 1976; Ross 1993; Ross 2005). Whether or not such trends continue today is unclear. Most data indicate vessel sound is likely still increasing (Hildebrand 2009a). However, the rate of increase appears to have slowed in some areas (Chapman and Price 2011), and in some places, ambient sound including that produced by vessels appears to be decreasing (Miksis-Olds and Nichols 2016). Efforts are underway to better document changes in ambient sound (Haver et al. 2018), which will help provide a better understanding of current and future impacts of vessel sound on ESA-listed species. NOAA is working cooperatively with the ship building industry to find technologically-based solutions to reduce the amount of sound produced by commercial vessels.

Sonar systems are used on commercial, recreational, and military vessels and may also affect cetaceans (NRC 2003a). The action area may host many of these vessel types during any time of the year. Although little information is available on potential effects of multiple commercial and recreational sonars to ESA-listed marine mammals, the distribution of these sounds would be small because of their short durations and the fact that the high frequencies of the signals attenuate quickly in seawater (Nowacek et al. 2007). However, military sonar, particularly low frequency active sonar, often produces intense sounds at high source levels, and these may impact cetacean behavior (Southall et al. 2016). For further discussion on active sonar and anthropogenic sound from military activities on ESA-listed species located within the action area and considered in this consultation, see Sections 9.8.5 and 9.8.6.

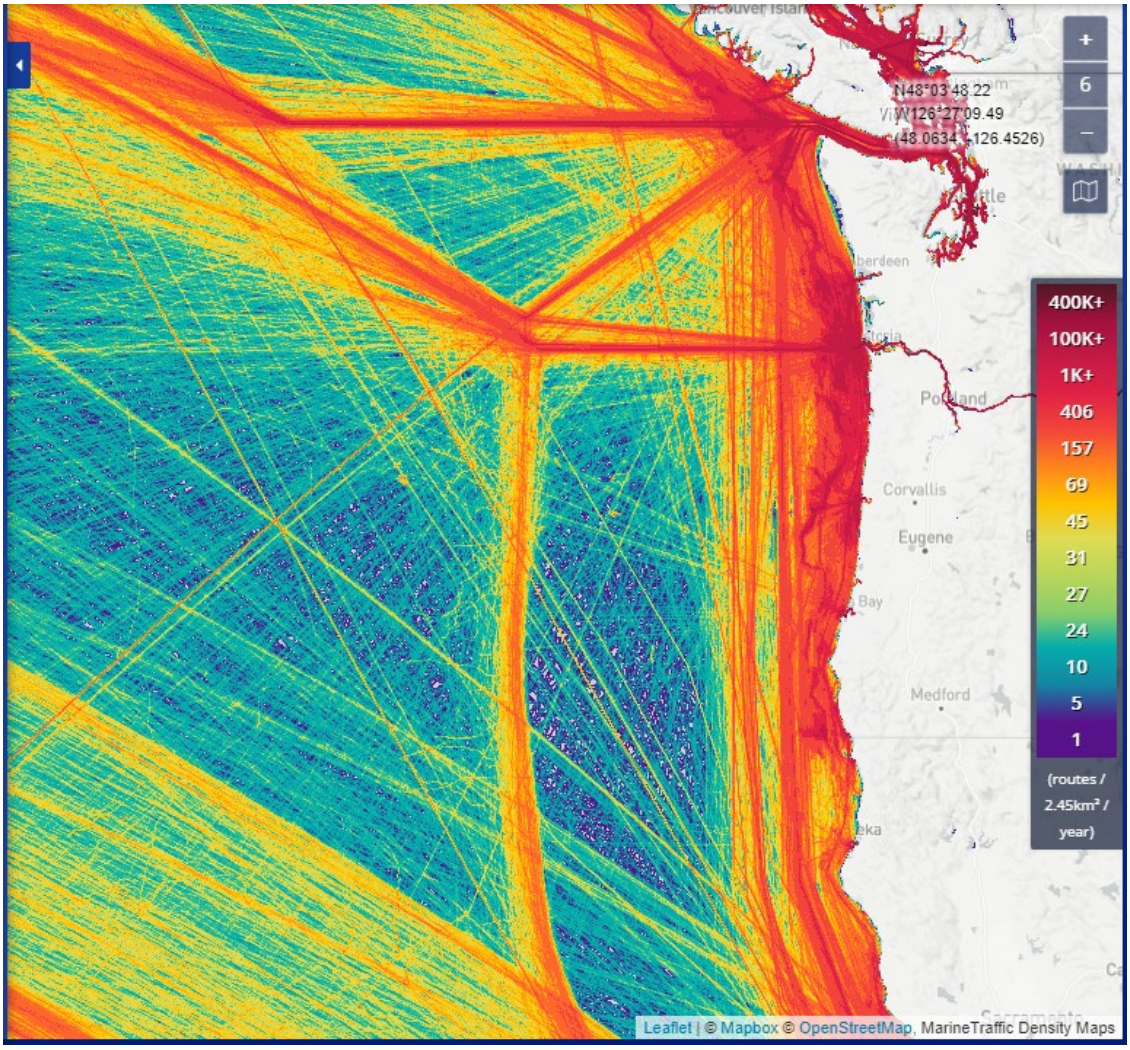

Figure 17. Map of vessel traffic density in the Northeast Pacific Ocean off Oregon and Washington. Image retrieved from Marine Traffic.

9.8.2 Aircraft

Aircraft within the action area may consist of small commercial or recreational airplanes or helicopters, to large commercial airliners. These aircraft produce a variety of sounds that can

potentially impact marine mammals. While it is difficult to assess these impacts, several studies have documented what appear to be minor behavioral disturbances in response to aircraft presence (Nowacek et al. 2007). Erbe et al. (2018) recorded underwater noise from commercial airplanes reaching as high as 36 dB above ambient noise. Sound pressure levels received at depth were comparable to cargo and container ships traveling at distances of 1 to 3 kilometers (0.5 to 1.6 nautical miles) away, although the airplane noises ceased as soon as the airplanes left the area, which was relatively quickly compared to a cargo vessel. While such noise levels are relatively low and brief, they still have the potential to be heard by cetaceans and pinnipeds at certain frequencies. Nevertheless, noise from aircraft is expected to be minimal due to the location of the action area, which is far from a populated area and has sparse aircraft traffic.

9.8.3 Seismic Surveys

There are seismic survey activities involving towed airgun arrays that may occur within the action area. They are the primary exploration techniques to locate hydrocarbon deposits, fault structure, and other geological hazards. Airguns contribute a massive amount of anthropogenic energy to the world's oceans (3.9×10^{13} Joules cumulatively), second only to nuclear explosions (Moore and Angliss 2006). Although most energy is in the low-frequency range, airguns emit a substantial amount of energy up to 150 kilohertz (Goold and Coates 2006). Seismic airgun noise can propagate substantial distances at low frequencies (e.g., Nieukirk et al. 2004). These activities may produce noise that could impact ESA-listed marine mammals within the action area.

These airgun arrays generate intense low-frequency sound pressure waves capable of penetrating the seafloor and are fired repetitively at intervals of ten to 20 seconds for extended periods (NRC 2003b). Most of the energy from the airguns is directed vertically downward, but significant sound emission also extends horizontally. Peak sound pressure levels from airguns usually reach 235 to 240 dB re: 1 µPa (rms) at dominant frequencies of five to 300 Hertz (NRC 2003a). Most of the sound energy is at frequencies below 500 Hertz, which is within the hearing range of baleen whales and sperm whales (Nowacek et al. 2007). In the U.S., seismic surveys involving the use of airguns with the potential to take marine mammals are generally covered by incidental take authorizations under the MMPA, and if they involve ESA-listed species, undergo formal ESA section 7 consultation. In addition, the Bureau of Ocean Energy Management authorizes oil and gas activities in domestic federal waters and the NSF and U.S. Geological Survey funds and/or conducts these seismic survey activities in domestic, international, and foreign waters, and in doing so, consults with NMFS to ensure their actions do not jeopardize the continued existence of ESA-listed species or adversely modify or destroy designated critical habitat. More information on the effects of these activities on ESA-listed species, including authorized takes, can be found in recent biological opinions.

The NSF funded and L-DEO conducted seismic surveys in the Northeast Pacific Ocean on the R/V *Maurice Ewing*, R/V *Wecoma*, R/V *Marcus G. Langseth*, or other research vessels in 2004, 2007, 2008, 2009, 2010, 2012, 2017, 2019, and 2021. Each of these seismic surveys include a

MMPA IHA and each are subject to a separate ESA section 7 consultation. The finalized consultations all resulted in a "no jeopardy" opinion.

9.8.4 Marine Construction

Marine construction activities in the action area that produces sound includes drilling, dredging, pile-driving, cable-laying, and explosions. These activities are known to cause behavioral disturbance and physical damage to marine mammals (NRC 2003a). While most of these activities are coastal, offshore construction does occur in the Northeast Pacific Ocean. All or some of these activities may occur within the action area and can affect ESA-listed marine mammals.

9.8.5 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 sound source level. Sonar systems can be divided into categories, depending on their primary frequency of operation; low-frequency for one kilohertz and less, mid-frequency for 1 to 10 kilohertz, high-frequency for 10 to 100 kilohertz; and very high-frequency for greater than 100 kilohertz (Hildebrand 2004). Low-frequency systems are designed for long-range detection (Popper et al. 2014a). The effective sound source level of a low-frequency airgun array, when viewed in the horizontal direction can be 235 dB re: 1 μPa at 1 meter or higher (Hildebrand 2004). Signal transmissions are emitted in patterned sequences that may last for days or weeks. 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 (e.g., 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 sounds, and sub-bottom profiling. They typically generate sound at frequencies of 3 to 200 kilohertz, with sound source levels ranging from 150 to 235 dB re: 1 μPa at 1 meter (Hildebrand 2004). 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.

9.8.6 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. 1995d). 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 (98.4 feet) below the water surface at levels of 134 dB re: 1 μPa (rms).

Within the action area, multiple stressors associated with military activities pose a threat to ESA-listed marine mammals. The U.S. Navy conducts training, testing, and other military readiness activities on range complexes throughout coastal and offshore areas in the United States and on the high seas. The U.S. Navy's Northwest Training and Testing range complex overlaps with the action area for the NSF and L-DEO's low-energy seismic survey. During training, existing and established weapon systems and tactics are used in realistic situations to simulate and prepare for combat. Activities include: routine gunnery, missile, surface fire support, amphibious assault and landing, bombing, sinking, torpedo, tracking, and mine exercises. Testing activities are conducted for different purposes and include at-sea research, development, evaluation, and experimentation. The U.S. Navy performs testing activities to ensure that its military forces have the latest technologies and techniques available to them.

The majority of the training and testing and research activities the U.S. Navy conducts in the action area are similar, if not identical to activities that have been occurring in the same locations for decades; therefore, the ESA-listed species located in the action area have been exposed to these military activities often and repeatedly.

The U.S. Navy's activities produce sound and visual disturbance to marine mammals throughout the action area. Anticipated impacts from harassment due to the U.S. Navy's activities include changes from foraging, resting, milling, and other behavioral states that require low energy expenditures to traveling, avoidance, and behavioral states that require lower energy expenditures to traveling, avoidance, and behavioral states that require higher energy expenditures. Based on the currently available scientific information, behavioral responses that result from stressors associated with these training and testing and research activities are expected to be temporary and will not affect the reproduction, survival, or recovery of these species. Sound (in-air and in-water) produced during U.S. Navy activities is also expected to result in instances of PTS, TTS, and behavioral harassment to marine mammals. The U.S. Navy's activities constitute a federal action and take of ESA-listed marine mammals and designated critical habitat considered for these activities have previously undergone separate ESA section 7 consultation. Through these consultations with NMFS, the U.S. Navy has implemented monitoring and conservation measures to reduce the potential effects of in-air and underwater sound from activities on ESA-listed species in the Pacific Ocean. Conservation measures include employing visual observers and implementing mitigation zones during activities using active sonar and explosives.

The U.S. Air Force conducts training and testing activities on range complexes on land and in U.S. waters. Aircraft operations and air-to-surface activities may occur in the action area. U.S. Air Force activities generally involve the firing or dropping of munitions (e.g., bombs, missiles,

rockets, and gunnery rounds) from aircraft towards targets located on the surface, though U.S. Air Force training exercises may also involve boats. These activities have the potential to impact ESA-listed species by physical disturbance, boat strikes, debris, ingestion, and effects from noise and pressure produced by detonations. U.S. Air Force training and testing activities constitute a federal action and take of ESA-listed species considered for these U.S. Air Force activities have previously undergone separate section 7 consultations.

9.9 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 Northeast Pacific Ocean, some of which extend into portions of the action area for the proposed actions. Marine mammals 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 in the action area from a variety of research activities.

Authorized research on ESA-listed marine mammals includes aerial and vessel surveys, close approaches, photography, videography, behavioral observations, active acoustics, prey mapping, remote ultrasound, passive acoustic monitoring, biological sampling (i.e., body and weight measurements, biopsy, blood, breath, clipped hair, fecal, muscle, oral and nasal, sloughed skin, urine), and tagging. In addition, capture and restraint of pinnipeds may be conducted for the injection of sedative, administration of drugs (intramuscular, subcutaneous, or topical), attachment of instruments to hair or flippers, and ultrasound. Research activities generally involve non-lethal "takes" of these marine mammals.

There have been numerous research permits issued since 2009 under the provisions of both the MMPA and ESA authorizing scientific research on marine mammals all over the world, including for research activities in the action area. The consultations which took place on the issuance of these ESA scientific research permits each found that the authorized research activities will have no more than short-term effects on individuals or populations and were not determined to result in jeopardy to the species or adverse modification of designated critical habitat.

Additional "take" is likely to be authorized in the future as additional permits are issued. It is noteworthy that although the numbers tabulated below in the Effects of the Action section represent the maximum number of "takes" authorized in a given year, monitoring and reporting indicate that the actual number of "takes" rarely approach the number authorized. Therefore, it is unlikely that the level of exposure indicated below has or will occur in the near term. However, our analysis assumes that these "takes" will occur since they have been authorized. It is also noteworthy that these "takes" are distributed across the Pacific Ocean. Although marine

mammals are generally wide-ranging, we do not expect many of the authorized "takes" to involve individuals that will also be "taken" under the proposed low-energy seismic survey and research activities.

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

Collectively, the baseline described above has had, and likely continues to have, lasting impacts on the ESA-listed species considered in this consultation. Some of these stressors result in mortality or serious injury to individual animals (e.g., vessel strikes, incidental bycatch, and entanglement), whereas others result in more indirect (e.g., fishing that impacts prey availability) or non-lethal (e.g., whale watching) impacts.

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

We consider the best indicator of the aggregate impact of the Environmental Baseline section on ESA-listed resources to be the status and trends of those species. As noted in Section 8.1, 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 activities identified in the Environmental Baseline section are impacting species in different ways. The species experiencing increasing population abundances are doing so despite the potential negative impacts of the activities described in the Environmental Baseline section. Therefore, while the impacts addressed in the Environmental Baseline section 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 the Environmental Baseline section is preventing their recovery. However, 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 is discussed in the Status of Species Likely to be Adversely Affected section (Section 8.1) of this consultation and what this means for the populations is discussed in the Integration and Synthesis section (Section 12).

10 EFFECTS OF THE ACTIONS

Section 7 regulations refers to "effects of the action" as the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 C.F.R. §402.02). This effects analyses section is organized following the stressor, exposure, response, and risk assessment framework described in Section 2 above.

In this section, we further describe the potential stressors associated with the proposed actions, 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 (given their 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 assessment and, ultimately, of this consultation is to determine if it is reasonable to expect the proposed action to have effects on ESA-listed species that could appreciably reduce their likelihood of surviving and recovering in the wild.

10.1 Stressors Associated with the Proposed Actions

Stressors are any physical, chemical, or biological entity that may induce an adverse response either in an ESA-listed species or their designated critical habitat. The seismic survey activities and issuance of an IHA will authorize activities that may expose ESA-listed cetaceans and pinnipeds 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 and interaction in the airgun array, towed hydrophone streamer, and heat flow measurement probe;
5. Sound fields produced by the sub-bottom profiler, multi-beam echosounder, and acoustic Doppler current profiler, and pinger; 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 Sections 7 and 8. 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 (Section 10.3).

During consultation we determined that sound fields produced by the airgun array will likely adversely affect ESA-listed species by introducing acoustic energy introduced into the marine environment. This stressor and the likely effects on ESA-listed species are discussed starting in Section 10.3.2.

10.2 Mitigation to Minimize or Avoid Exposure

As described in the Description of the Proposed Actions section (Section 3), the NSF and L-DEO's proposed action and NMFS Permits Division's proposed IHA requires monitoring and mitigation measures that include the use of proposed exclusion and buffer zones, shut-down procedures, pre-start clearance and ramp-up procedures, vessel-based visual monitoring with NMFS-approved PSOs, 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 19).

Also, the NSF and L-DEO will use a 100 meter (328.1 feet) exclusion zone for the two GI airgun array as the shut-down distance for sea turtles. If a sea turtle is detected in or about to enter the exclusion zone, the airgun array will be shut-down (i.e., shut off) immediately.

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

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.

In this section, we quantify the likely exposure of ESA-listed species to sound from the airgun array. For this consultation, the NSF, L-DEO, 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 IHA and incidental take statement 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 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 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 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 the likely nature of these behavioral responses 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 low-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 and by regulation, 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 Exposure Estimates of Endangered Species Act-Listed Marine Mammals

As discussed in the Status of Species Likely to be Adversely Affected section, there are seven ESA-listed marine mammal species or populations that are likely to be adversely affected by the proposed actions: blue whales, fin whales, Central America DPS of humpback whales, Mexico DPS of humpback whales, sei whales, sperm whales, and Guadalupe fur seals.

The NSF and L-DEO applied acoustic thresholds to determine at what point during exposure to the airgun arrays marine mammals are "harassed," based on definitions provided in the MMPA (16 U.S.C. §1362(18)(a)). As part of the application for the IHA pursuant to the MMPA, the NSF provided an estimate of the number of marine mammals that will be exposed to levels of sound in which they should be considered "taken" under the MMPA during the proposed low-energy and high-energy seismic survey. We used the same values to determine the type and extent of take for ESA-listed marine mammals. An estimate of the number of marine mammals

that will be exposed to sounds from the airgun array is also included in the NSF's draft environmental assessment. The NSF, L-DEO, and NMFS Permits Division did not provide any exposure or take estimates from sound sources other than the airgun array, although other equipment producing sound will be used during airgun array operations (e.g., the sub-bottom profiler, multi-beam echosounder, and acoustic Doppler current profiler, and pinger). We determined that ESA-listed species are not likely to be adversely affected from these sound sources above in Section 7.1.5.

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 ESA-listed marine mammals considered in this consultation. Possible responses considered in this analysis consist of:

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

In their *Federal Register* notice of the proposed IHA and request for comments and possible renewal, the NMFS 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 NMFS Permits Division did not expect additional exposure from sound sources other than the airgun array. We agree with this assessment and similarly focus our analysis on exposure from the airgun array. The sub-bottom profiler, multi-beam echosounder, acoustic Doppler current profiler, and pinger 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 (see Section 7.1.5).

During the development of the IHA, the NMFS Permits Division conducted an independent exposure analysis that is usually informed by comments received during the public comment period that was required on the proposed IHA. The exposure analysis does not include estimates of the number of ESA-listed marine mammals likely to be exposed to received levels at MMPA Level A harassment thresholds due to the small ensonified areas and the anticipated effectiveness of monitoring and mitigation measures (i.e., proposed exclusion and buffer zones, shut-down procedures, pre-start clearance and ramp-up procedures, vessel-based visual monitoring by NMFS-approved PSOs, vessel strike avoidance measures, and additional mitigation measures).

In this section, we describe the NSF, L-DEO, and NMFS Permits Division's analytical methods to estimate the number of ESA-listed marine mammal species that might be exposed to the sound field.

Marine Mammal Occurrence – Density Estimates

Of the 23 species of marine mammals that have the reasonable potential to co-occur with the proposed seismic survey activities, the blue whale, fin whale, Central America DPS of humpback

whales, Mexico DPS of humpback whale, sei whale, sperm whale, and Guadalupe fur seal is ESA-listed. Blue whales, fin whales, Central America DPS of humpback whales, Mexico DPS of humpback whales, and sei whales are classified as low-frequency hearing group. Sperm whale is classified as mid-frequency group. Guadalupe fur seal is classified as otariid hearing group.

We reviewed available cetacean and pinniped densities and group dynamics with the NSF, L-DEO, and the NMFS Permits Division and agreed upon which densities constituted the best available scientific information for each ESA-listed marine mammal species. The NMFS Permits Division adopted these estimates for use in their proposed IHA and we have adopted them for our ESA exposure analysis.

In developing the NSF and L-DEO's draft environmental assessment and IHA application, they utilized estimates of cetacean and pinniped densities in the action area. NMFS Permits Division concurred with these data. Extensive systematic aircraft- and vessel-based surveys have been conducted for marine mammals in offshore waters of Oregon and Washington (e.g., Bonnell et al. 1992; Green et al. 1992, 1993; Barlow 1997, 2003; Barlow and Taylor 2001; Calambokidis and Barlow 2004; Barlow and Forney 2007; Forney 2007; Barlow 2010). Vessel surveys for cetaceans in slope and offshore waters of Oregon and Washington were conducted by NMFS Southwest Fisheries Science Center in 1991, 1993, 1996, 2001, 2005, 2008, and 2014 and synthesized by Barlow (2016); these surveys were conducted up to approximately 556 kilometers (300.2 nautical miles) from shore from June or August through November or December. These data were used by NMFS Southwest Fisheries Science Center to develop spatial models of cetacean densities for the California Current Ecosystem. Systematic, offshore, at-sea survey data for pinnipeds are more limited; the most comprehensive studies are reported by Bonnell et al. (1992) based on systematic aerial surveys conducted in 1989 through 1990.

The U.S. Navy primarily used NMFS Southwest Fisheries Science Center spatial models to develop a marine species density database for the Northwest Training and Testing Study Area, which encompasses the seismic survey area. If no density spatial modeling was available for species, other data sources were used. The U.S. Navy marine species density database is currently the most comprehensive density data set available for the California Current Ecosystem, which encompasses waters off the coast of California, Oregon, and Washington. However, GIS data layers are currently unavailable for the database; thus, in this analysis the U.S. Navy data were used only for species for which density data were not available from an alternative spatially-explicit model (i.e., for minke, sei, gray, killer, and short-finned pilot whales, *Kogia* spp., and pinnipeds).

For most pinniped species, the highest densities for spring, summer, or fall from the U.S. Navy (2019) are used, but corrected the estimates by projecting the most recent population growth/updated population estimates to 2022, when available. This same approach was used by NMFS for a previous NSF and L-DEO high-energy seismic survey in the region in 2021 (85 FR 19580, April 7, 2020). For the Guadalupe fur seal, summer densities for the 200 meter (656.2 feet) isobath to 300 kilometers (162 nautical miles) from shore were used. For the gray whale,

the summer/fall density for the 10 to 47 kilometer (5.4 to 25.4 nautical miles) from shore distance band (U.S. Navy 2019) was used for the Oregon survey region; a density of zero was used for all other survey regions.

Spatially-explicit density data from summer/fall from the NOAA CetSound website (https://cetsound.noaa.gov/cda) were used for most other species (e.g., blue whale, fin whale, humpback whale, sperm whale, etc.). Oceanographic conditions, including occasional El Niño and La Niña events, influence, the distribution and numbers of marine mammals present in the North Pacific Ocean, resulting in considerable year-to-year variation in the distribution and abundance of many marine mammal species (Forney and Barlow 1998; Buchanen et al. 2002; Philbrick et al. 2003; Escorza-Trevino 2009).

The CetMap website (https://cetsound.noaa.gov/cda) provides output of summer/fall habitat-based density models for cetaceans in the California Current Ecosystem (Becker et al. 2020) in the form of GIS layers; these were used to calculate takes in the seismic survey area. The density estimates were available in the form of a GIS grid with each cell in the grid measuring approximately 7 kilometers (3.8 nautical miles) east-west by 10 kilometers (5.4 nautical miles) north-south. This grid was intersected with a GIS layer of the area expected to be ensonified to greater than 160 dB re: 1 μPa (rms) sound pressure level (SPL) from the seismic survey area. North, west, and south boundaries are based on overlap/intersection with geographic extents of all four combined survey regions; eastern grid coverage limit was defined by inclusion of cells that contained greater than 25 percent overlap with the angled boundary of the seismic survey area polygon. The densities from all grid cells overlapping the ensonified areas were averaged to calculate an average species-specific density for each species (Table 16).

Data sources and density calculations are described in detail in the NSF's environmental assessment and L-DEO's IHA application. There is uncertainty about the representativeness of the density data and the assumptions used to estimate exposures. For some marine mammal species, the densities derived from past surveys may not be precisely representative of the densities that will be encountered during the proposed seismic surveys activities. Density estimates for each marine mammal species are found in Table 16. The approach used here is based on the best available data.

The low-energy seismic survey will consist of approximately 1,135 kilometers (612.9 nautical miles) tracklines in the Northeast Pacific Ocean. The ensonified area (for the 160 dB re: 1 μPa [rms] harassment threshold) is estimated to be approximately 1,255.3 square kilometers (366 square nautical miles), based on the distances multiplied by the isopleth for deep water depth anticipated to be ensonified to the predicted 160 dB re: 1 μPa (rms) distance around the planned tracklines (0.553 kilometers [1,814.3 feet] times two in deep water).

To determine exposures, the NSF, L-DEO and NMFS Permits Division calculated ESA harassment by using the radial distances from the airgun array to the predicted isopleths corresponding to the ESA harassment threshold. The entirety of the proposed low-energy seismic survey will be conducted in deep waters depths greater than 1,600 meters (5,249.3 feet). The

product is then multiplied by 1.25 to account for the additional 25 percent contingency (e.g., potential delays) to allow for additional airgun array operations such as testing of the sound source or re-surveying tracklines with poor data quality. This also considers uncertainties in the density estimates used to estimate take.

This results in an estimate of the total area (square kilometers) expected to be ensonified to the ESA harm and harassment thresholds. The total area ensonified at 160 dB re: 1 µPa (rms) is 1,255.3 square kilometers (366 square nautical miles. The ensonified area adjusted for the 25 percent contingency is estimated to be approximately 1,569.1 square kilometers (457.5 square nautical miles) in deep waters. 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 seasonal density (when available) of animals in the area (see Table 16). Summing exposures along all of the tracklines yields the total exposures for each species for the proposed actions for the two GI airgun array configuration for the seismic survey activities and NMFS Permits Division's proposed issuance of an IHA and possible renewal. Requested takes for some ESA-listed species (e.g., blue whale, humpback whale, sei whale, and sperm whale) were also increased to mean group size (Barlow 2016).

Based on the small anticipated isopleths for ESA harm (MMPA Level A harassment) and in consideration of the proposed mitigation measures, take by ESA harm (MMPA Level A harassment) is not expected to occur and has not been proposed to be authorized by the NMFS Permits Division. The estimated exposure of ESA-listed marine mammals at the ESA harassment (MMPA Level B harassment) threshold during the NSF and L-DEO's low-energy seismic survey on the R/V *Marcus G. Langseth* in the Northeast Pacific Ocean can be found in Table 24. The approach assumes that no blue whales, fin whales, Central America DPS and Mexico DPS of humpback whales, sei whales, sperm whales, and Guadalupe fur seals 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.

Table 16. Densities of Endangered Species Act-listed marine mammals in the action area during National Science Foundation and Lamont-Doherty Earth Observatory's low-energy seismic survey in the Northeast Pacific Ocean and National Marine Fisheries Service Permits Division's proposed issuance of an incidental harassment authorization and possible renewal.

Species	Season	Density (Individuals per km^2)
Blue Whale	Summer/Fall	0.000226[1]
Fin Whale	Summer/Fall	0.002410[1]
Humpback Whale	Summer/Fall	0.000464[1]
Sei Whale	Summer/Fall	0.000400[2]

Species	Season	Density (Individuals per km^2)
Sperm Whale	Summer/Fall	0.002859[1]
Guadalupe Fur Seal	Summer/Fall	0.029450[2]

km^2=square kilometers, [1]=Becker et al. (2020), [2]=U.S. Navy (2019)

For cetaceans, the best densities available were for summer/fall and for pinnipeds, the best (highest) densities available were for spring, summer, or fall.

Total Ensonified Area

The tracklines will occur in four survey regions in the Northeast Pacific Ocean: Coast (200 kilometers [108 nautical miles], Nubbin (95 kilometers [51.3 nautical miles]), Pseudofault (440 kilometers [237.6 nautical miles]), and Oregon (400 kilometers [216 nautical miles]). The approximate ensonified areas for each survey region are 221 square kilometers (64.4 square nautical miles) for Coast, 105 square kilometers (30.6 square nautical miles) for Nubbin, 486 square kilometers (141.7 square nautical miles) for Pseudofault, and 442 square kilometers (128.9 square nautical miles) for Oregon.

To determine the total ensonified area, the NSF, L-DEO, and NMFS Permits Division also used a daily ensonified area of 221 square kilometers (64.4 square nautical miles) and multiplied it by the number of days (six) with airgun array operations. They selected seismic survey tracklines that could be surveyed on one day (approximately 200 kilometers [108 nautical miles]) that is roughly similar to that of the entire seismic survey. The area expected to be ensonified on that day was determined by entering the planned tracklines into a MapInfo GIS, using GIS to identify the relevant areas by "drawing" the applicable MMPA Level B harassment buffers around the trackline. The ensonified area (increased by 25 percent) is then multiplied by the number of seismic survey days (six).

Table 17. Relevant isopleths, trackline distance, ensonified area, percent increase, and total ensonified areas during the National Science Foundation and Lamont-Doherty Earth Observatory's low-energy seismic survey in the Northeast Pacific Ocean and National Marine Fisheries Service Permits Division's proposed issuance of an incidental harassment authorization and possible renewal.

Criteria (Depth)	Radius (km)	Diameter (km)	Trackline Distance (km)	Ensonified Area (km^2)	Ensonified Area with 25 Percent Increase (km^2)
Source – Two GI Airgun Array					
160 dB re: 1 µPa (rms)	0.553	1.106	1,135	1,255.3	1,569.1

Criteria (Depth)	Radius (km)	Diameter (km)	Trackline Distance (km)	Ensonified Area (km^2)	Ensonified Area with 25 Percent Increase (km^2)
(>1,000 m)					

km=kilometers, km^2=square kilometers

Blue whales, fin whales, Central America DPS and Mexico DPS of humpback whales, sei whales, and sperm whales of all age classes are likely to be exposed during the proposed seismic survey activities. Adult and juvenile Guadalupe fur seals are likely to be exposed during the proposed seismic survey activities. Given that the proposed low-energy seismic survey will be conducted in summer, we expect that most animals will be on or migrating to/from their feeding grounds. Blue whales, fin whales, Central America DPS of humpback whales, Mexico DPS of humpback whales, sei whales, and sperm whales are expected to be feeding, traveling, or migrating in the action area and some females will have young-of-the-year accompanying them. Mature sperm whales are generally expected to be further north in the Pacific Ocean. Therefore, we expect a juvenile male and female bias to sperm whale exposure. For sperm whales, exposure of adult males is expected to lower than other age and sex class combinations as they are generally solitary and may migrate toward the northern portion of their range (poleward of about 40 to 50 degrees latitude). For blue whales, fin whales, Central America DPS and Mexico DPS of humpback whales, sei whales, sperm whales, and Guadalupe fur seals, these individuals can be exposed to the proposed seismic survey activities while they are transiting through the action area. We will normally assume that sex distribution is even for blue whales, fin whales, Central America DPS and Mexico DPS of humpback whales, sei whales, and Guadalupe fur seals and sexes are exposed at a relatively equal level.

It should be noted that the proposed exposure numbers by ESA harassment (MMPA Level B harassment) are expected to be conservative for several reasons. First, in the calculations of estimated exposure, 25 percent has been added in the form of operational seismic survey days or total ensonified area to account for the possibility of additional seismic survey activities associated with airgun array testing and repeat coverage of any areas where initial data quality is sub-standard, and in recognition of the uncertainties in the density estimates used to estimate exposures as described above. Additionally, marine mammals will be expected to move away from a loud sound source that represents an aversive stimulus, such as an airgun array, potentially reducing the number of exposures by ESA harm and harassment (MMPA Level A and B harassment). However, the extent to which marine mammals (blue whales, fin whales, Central America DPS of humpback whales, Mexico DPS of humpback whales, sei whales, sperm whales, and Guadalupe fur seals) will move away from the sound source is difficult to quantify and is, therefore, not accounted for in the exposure estimates.

Exposures as a Percentage of Population

Marine mammal (i.e., blue whale, fin whale, Central America DPS of humpback whale, Mexico DPS of humpback whale, sei whale, sperm whale, and Guadalupe fur seal) abundance estimates presented in this consultation represent the total number of individuals that make up a given stock or the total number estimated within a particular study or survey area. NMFS' stock abundance estimates for most species represent the total estimate of individuals within the geographic area, if known, that comprises the stock. For most species of marine mammals, stock abundance estimates are based on sightings within the U.S. Exclusive Economic Zone, however for some species, this geographic area may extend beyond U.S. waters. Survey abundance estimates may be used for other species. All managed stocks in this region are assessed in NMFS' U.S. Pacific stock assessment reports (Caretta et al. 2021).

Blue Whale

The estimated exposure of the regional population (approximately 1,898) of blue whales is a total of two, which is approximately 0.11 percent of the regional population. For reasons previously described, this estimate is conservative, that is, it is likely higher than the actual exposures and a fewer number are not likely to be exposed given the mitigation and monitoring measures that will be implemented. Because of the large range of this species compared to the relatively small size of the NSF and L-DEO's action area, combined with the relatively short duration of the seismic survey activities, it is more likely that there will be multiple exposures of a smaller number of individuals that will occur within the action area.

Fin Whale

The estimated exposure of the regional population (approximately 11,065) of fin whales is a total of four, which is approximately 0.04 percent of the regional population. For reasons previously described, this estimate is conservative, that is, it is likely higher than the actual exposures and a fewer number are not likely to be exposed given the mitigation and monitoring measures that will be implemented. Because of the large range of this species compared to the relatively small size of the NSF and L-DEO's action area, combined with the relatively short duration of the seismic survey activities, it is more likely that there will be multiple exposures of a smaller number of individuals that will occur within the action area.

Humpback Whale – Central America DPS and Mexico DPS

The estimated exposure of the regional population (approximately 4,973) of Central America DPS and Mexico DPS of humpback whales is a total of two, which is approximately 0.04 percent of the regional population. For reasons previously described, this estimate is conservative, that is, it is likely higher than the actual exposures and a fewer number are not likely to be exposed given the mitigation and monitoring measures that will be implemented. Because of the large range of this species compared to the relatively small size of the NSF and L-DEO's action area, combined with the relatively short duration of the seismic survey activities, it is more likely that

there will be multiple exposures of a smaller number of individuals that will occur within the action area.

For humpback whales off the coasts of California, Oregon, and Washington, takes are apportioned between different DPSs (i.e., Hawaii DPS, Mexico DPS, and Central America DPS) present off Oregon and Washington based on Wade et al. (2021) and NMFS guidance (Table 18). There are two recognized feeding areas along the U.S. West Coast, California/Oregon and Washington/Southern British Columbia. Based on the best available information, all humpback whales from the Central America DPS of humpback whales migrate to feed only off the U.S. west coast. Humpback whales from the Mexico DPS migrate in varying proportions to the U.S. west coast, British Columbia, and various areas off Alaska. For Washington and Oregon, we use the percentage estimates from Wade et al. (2021) in the greater Northeast Pacific Ocean area from which the NSF, L-DEO, and NMFS Permits Division estimated takes. The seismic survey activities will take place in waters inside of the U.S. Exclusive Economic Zone off Oregon and Washington. We use each location specified in Wade et al. (2021) (Southern British Columbia/Washington and Oregon/California) and the probability of encountering the DPS breakdown percentages across the action area. Movement probabilities also help to inform us of the mixing proportions of the Central America DPS and Mexico DPS of humpback whales foraging off the U.S. west coast, particularly off the California/Oregon area where only the two ESA-listed DPSs of humpback whales forage there (and therefore summing the proportions of the Central America DPS and Mexico DPS of humpback whales equate to 100 percent of the animals expected in that area). The percentages are directly multiplied by the takes specified in Table 18 to estimate the number of individual humpback whales from each DPS that will be exposed to seismic survey activities under the MMPA IHA. At this time, this method of estimating exposure of humpback whale DPSs represent the best available data and method given the granularity of the NSF, L-DEO, and NMFS Permits Division is able to project in their seismic survey activities and MMPA IHA.

Table 18. Probability of encountering humpback whales from each distinct population segment in the North Pacific Ocean found off the U.S. West Coast. Adapted from Wade et al. (2021).

Action Area	Central America DPS	Mexico DPS	Hawaii DPS
California/Oregon	42 Percent	58 Percent	0 Percent
Washington	6 Percent	25 Percent	69 Percent

DPS=distinct population segment

The tracklines in the action area for the seismic survey activities are off Washington and Oregon. Therefore, we will use the percentages in the Washington and California/Oregon areas for proportioning the number of exposures of ESA-listed Central America DPS and Mexico DPS of humpback whales. Using the percentages from Wade et al. (2021), the expected potential instances of take is one ESA harassment for the Central America DPS of humpback whale and

one ESA harassment for the Mexico DPS of humpback whales for a total of two ESA harassment.

Sei Whale

The estimated exposure of the regional population (approximately 519) of sei whales is a total of two, which is approximately 0.39 percent of the regional population. For reasons previously described, this estimate is conservative, that is, it is likely higher than the actual exposures and a fewer number are not likely to be exposed given the mitigation and monitoring measures that will be implemented. Because of the large range of this species compared to the relatively small size of the NSF's action area, combined with the relatively short duration of the seismic survey activities, it is more likely that there will be multiple exposures of a smaller number of individuals that will occur within the action area.

Sperm Whale

The estimated exposure of the regional population (approximately 1,997) of sperm whales is a total of seven, which is approximately 0.35 percent of the regional population. For reasons previously described, this estimate is conservative, that is, it is likely higher than the actual exposures and a fewer number are likely to be exposed given the mitigation and monitoring measures that will be implemented. Because of the large range of this species compared to the relatively small size of the NSF and L-DEO's action area, combined with the relatively short duration of the seismic survey activities, it is more likely that there may be multiple exposures of a smaller number of individuals that will occur within the action area.

Guadalupe Fur Seal

The estimated exposure of the regional population (approximately 34,187) of Guadalupe fur seals is a total of 46, which is approximately 0.13 percent of the regional population (Conn et al. 2014). For reasons previously described, this estimate is conservative, that is, it is likely higher than the actual exposures and a fewer number are likely to be exposed given the mitigation and monitoring measures that will be implemented. Because of the large range of this species compared to the relatively small size of the NSF and L-DEO's action area, combined with the relatively short duration of the seismic survey activities, it is more likely that there may be multiple exposures of a smaller number of individuals that will occur within the action area.

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 considered in this consultation. 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 section also considers information on the potential for stranding and the potential effects on prey of ESA-listed marine mammals in the action area.

As discussed in The Assessment Framework section (Section 2) of this consultation, response analyses determine how ESA-listed resources are likely to respond after exposure to an action's effects on the environment 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. Ideally, 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 may be exposed to sound from the airgun array. The NSF, L-DEO, and NMFS Permits Division provided 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 source. Our exposure estimates stem from the best available information on marine mammal densities and a predicted radial distance (Table 20 and Table 21) based on isopleths corresponding to harm and harassment thresholds along tracklines for the low-energy seismic survey. Based upon information presented in the Response Analysis section, ESA-listed marine mammals exposed to these sound sources could be harmed, exhibit changes in behavior, suffer stress, or even strand.

In consideration of the received sound levels in the nearfield, we expect the potential for ESA harm of low-frequency cetaceans (blue whales, fin whales, Central America DPS of humpback whales, Mexico DPS of humpback whales, and sei whales), mid-frequency cetaceans (sperm whales), and otariid 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 ESA harm and in consideration of the proposed mitigation and monitoring measures, take by ESA harm is not expected to occur and MMPA Level A harassment has not been proposed to be authorized by the NMFS Permits Division. The estimated exposure of ESA-listed marine mammals at the ESA harassment threshold during the NSF and L-DEO's low-energy seismic survey on the R/V *Marcus G. Langseth* in the Northeast Pacific Ocean can be found in Table 24. 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 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.

In this section, we describe the NSF, L-DEO, and NMFS Permits Division's 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 that may be considered take under the ESA such as harassment, then 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 generated by the airgun array that are likely to result in adverse effects to the animals.

For our ESA section 7 consultation, we evaluated both the NSF, L-DEO, and the NMFS Permit and Conservation 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 generally 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.

10.3.2.1 Acoustic Thresholds

To determine at what point during exposure to airgun arrays marine mammals are considered "harassed" under the MMPA, 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/action/user-manual-optional-spreadsheet-tool-2018-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 is 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 IHA for the airgun array operations during the low-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 19). 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 19) 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 19. 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 underwater (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 kilohertz	$L_{pk,flat}$: 219 dB $L_{E,LF,24h}$: 183 dB	213 dB peak SPL 168 dB SEL
Mid-Frequency Cetaceans (Dolphins, Toothed Whales, Beaked Whales, Bottlenose Whales) (LE,MF,24 hour)	150 Hertz to 160 kilohertz	$L_{pk,flat}$: 230 dB $L_{E,LF,24h}$: 185 dB	224 dB peak SPL 170 dB SEL

Hearing Group	Generalized Hearing Range*	Permanent Threshold Shift Onset	Temporary Threshold Shift Onset
Otariid Pinnipeds (Guadalupe Fur Seals) (LE,MF,24 Hour) – Underwater	60 Hertz to 39 kilohertz	$L_{pk,flat}$: 232 dB $L_{E,MF,24h}$: 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 was 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 μPa^2s. In this table, thresholds are abbreviated to reflect American National Standards Institute standards (ANSI 2013). However, peak sound pressure is defined by ANSI as incorporating frequency weighting, which is not the intent for this technical guidance. Hence, the subscript "flat" is being included to indicate peak sound pressure should be flat weighted or unweighted within the generalized hearing range. The subscript associated with cumulative sound exposure level thresholds indicates the designated marine mammal auditory weighting function and that the recommended accumulation period is 24 hours. The cumulative sound exposure level thresholds could be exceeded in a multitude of ways (i.e., varying exposure levels and durations, duty cycle). When possible, it is valuable for action proponents to indicate the conditions under which these acoustic thresholds will be exceeded.

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.

10.3.2.2 Modeled Sound Fields of the Airgun Array

In this section, we first evaluate the likelihood that marine mammals will be exposed to sound fields from the low-energy seismic survey at or above 160 dB re: 1 µPa (rms) based upon the information described above, and the acoustic thresholds correlating to the onset of PTS or TTS provided in Table 19. If we find that such exposure above any particular threshold is likely, we then estimate the number of instances in which we expect marine mammals to be exposed to these sound levels, based on the ensonified areas at or above these sound levels and information on marine mammal density.

The methodologies for estimating the number of ESA-listed species that might be exposed to the sound field used by the NSF and NMFS Permits Division were largely the same. Both estimated the number of marine mammals predicted to be exposed to sound levels that will result in ESA-defined harassment and harm by using radial distances to predicted isopleths. Both used those radial distances to calculate the ensonified area around the airgun array for the 160 dB re: 1 µPa (rms) zone, which corresponds to the ESA harassment threshold for ESA-listed marine mammals. The area estimated to be ensonified (within each depth category and functional hearing group) of the seismic survey activities is then calculated, based on the areas predicted to be ensonified around the airgun array and the estimated trackline distance traveled by the R/V *Marcus G. Langseth*. Overlap was not considered in the exposure and response analysis, as the extent of overlap of the tracklines is unknown. To account for possible delays during the seismic survey (e.g., weather, equipment malfunction) and additional seismic survey activities, a 25

percent contingency was added to the number of exposures using the quantitative method devised by the NSF and used by the NMFS Permits Division. The product is multiplied by 1.25 to account for the additional 25 percent contingency. 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.

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 harassment will occur. From modeling by the L-DEO, the NSF provided sound source levels of the airgun array and estimated distances for the 160 dB re: 1 µPa (rms) sound levels as well as ESA harm thresholds generated by the airgun array configurations and water depth. The predicted and modeled radial distances for the various ESA harm and harassment thresholds for marine mammals for the R/V *Marcus G. Langseth*'s airgun arrays can be found in Table 20 and Table 21.

Table 20. Predicted radial distances in meters from the Research Vessel *Marcus G. Langseth* seismic sound sources to isopleth corresponding to the harassment (160 dB re: 1 µPa [rms]) threshold.

Source	Volume (in^3)	Maximum Tow Depth (m)	Water Depth (m)	Predicted Distance to Threshold (160 dB re: 1 µPa [rms]) (m)[1]
2 (45/105 in^3) GI Airguns	90	4	Greater than 1,000	553

in^3=cubic inches, m=meters, GI=Generator Injector, Distances for depths greater than 1,000 meters (3,281 feet) are based on Lamont-Doherty Earth Observatory's model results.

Table 21. Modeled radial distances in meters from the Research Vessel *Marcus G. Langseth*'s two Generator Injector airgun array corresponding to harm thresholds.

Functional Hearing Group	SEL_{cum} Threshold (dB)	Airgun Array Distance (m)	Peak SPL_{flat} Threshold (dB)	Airgun Array Distance (m)	Exclusion Zone for all Water Depths (m)
Source – 2 GI Airgun Array					
Low Frequency Cetaceans (L_{pk} flat: 219 dB; LE,LF,24_h: 183 dB)	183	28.6	219	5.6	100
Mid Frequency Cetaceans (L_{pk} flat: 230 dB;	185	0	230	1.1	100

Functional Hearing Group	SEL_{cum} Threshold (dB)	Airgun Array Distance (m)	Peak SPL_{flat} Threshold (dB)	Airgun Array Distance (m)	Exclusion Zone for all Water Depths (m)
LE,LF,24_h: 185 dB)					
Otariid Pinnipeds (L_{pk} flat: 232 dB; LE,LF,24_h: 203 dB)	203	0	232	0.4	100

SELcum=cumulative sound exposure level, dB=Decibel, GI=Generator Injector, m=meters, SPL=sound pressure level, LF=low frequency, h=hours, MF=mid-frequency

Note: The largest distances of the dual criteria (SEL_{cum} or Peak SPL_{flat}) were used to calculate takes and harm threshold distances. Because of some of the assumptions included in the methods used, isopleths produced may be overestimated to some degree, which will ultimately result in some degree of overestimate of takes by harm. However, these tools offer the best way to predict appropriate isopleths when more sophisticated three-dimensional modeling methods are not available, and NMFS continues to develop ways to quantitatively refine these tools and will qualitatively address the output where appropriate. For mobile sources, such as the proposed seismic surveys, the NMFS user spreadsheet predicts the closest distance at which a stationary animal will not incur PTS if the sound source traveled by the animal in a straight line at a constant speed.

10.3.2.3 Total Ensonified Area for Harm and Harassment

Table 22. Total ensonified areas (with 25 percent increase) for Endangered Species Act-listed marine mammals in the action area during National Science Foundation and Lamont-Doherty Earth Observatory's low-energy seismic survey in the Northeast Pacific Ocean and National Marine Fisheries Service Permits Division's proposed issuance of an incidental harassment authorization and possible renewal.

Species	Potential Harassment 160 dB re: 1 µPa (rms) Ensonified Area (km^2) (Total)	Potential Harassment 160 dB re: 1 µPa (rms) Ensonified Area with 25 Percent Increase (km^2) (Total)
Blue Whale	1,255.3	1,569.1
Fin Whale	1,255.3	1,569.1
Humpback Whale	1,255.3	1,569.1
Sei Whale	1,255.3	1,569.1
Sperm Whale	1,255.3	1,569.1
Guadalupe Fur Seal	1,255.3	1,569.1

dB=decibel, rms=root mean square, km^2=square kilometers

Table 23. Density, total ensonified area, and calculated exposures during the National Science Foundation and Lamont-Doherty Earth Observatory's low-energy seismic survey in the Northeast Pacific Ocean and National Marine

Fisheries Service Permits on Division's proposed issuance of an incidental harassment authorization and possible renewal.

Species	Density (Individuals per km^2)	Potential Harassment 160 dB re: 1 µPa (rms) Total Ensonified Area (km^2)	Potential Harassment 160 dB re: 1 µPa (rms) Calculated Exposures of Animals (*)
Blue Whale	0.000226	1,569.1	0.4 (2)
Fin Whale	0.002410	1,569.1	4
Humpback Whale	0.000464	1,569.1	0.7 (2)
Sei Whale	0.0004	1,569.1	0.6 (2)
Sperm Whale	0.002859	1,569.1	4.5 (7)
Guadalupe Fur Seal	0.02945	1,569.1	46

km^2=square kilometers
*Increased to mean group size.

Table 24. Estimated exposure of Endangered Species Act-listed marine mammals calculated by the National Marine Fisheries Service Endangered Species Act Interagency Cooperation Division to the airgun arrays during the low-energy seismic survey in the Northeast Pacific Ocean.

Species	Potential Permanent Threshold Shift	Potential Temporary Threshold Shift and Behavioral Harassment*
Blue Whale	0	2
Fin Whale	0	4
Humpback Whale – Central America DPS and Mexico DPS	0	2
Sei Whale	0	2
Sperm Whale	0	7
Guadalupe Fur Seal	0	46

*Exposures for blue whales, humpback whales, sei whales, and sperm whales are increased to mean group size.

Table 25. Estimated exposure of Endangered Species Act-listed marine mammals calculated by the National Science Foundation, Lamont-Doherty Earth

Observatory, and National Marine Fisheries Service Permits Division to the airgun arrays during the low-energy seismic survey in the Northeast Pacific Ocean.

Species	Density (Individuals per km^2)	Daily Ensonified Area (km^2)	Number of Days of Airgun Array Operations	Potential Harassment 160 dB re: 1 µPa (rms) Calculated Exposures of Animals	Calculated Exposures of Animals Adjusted for Mean Group Size*
Blue Whale	0.000226	221	6	0	2
Fin Whale	0.00241	221	6	4	4
Humpback Whale – Central America DPS and Mexico DPS	0.000464	221	6	1	2
Sei Whale	0.0004	221	6	1	2
Sperm Whale	0.002859	221	6	5	7
Guadalupe Fur Seal	0.02945	221	6	49	49

km^2=square kilometers
*Exposures for blue whales, humpback whales, sei whales, and sperm whales are increased to mean group size.

It should be noted that the proposed exposure numbers by ESA harassment are expected to be conservative for several reasons. First, in the calculations of estimated exposure, 25 percent has been added in the form of operational seismic survey days or total ensonified area to account for the possibility of additional seismic survey activities associated with airgun array testing and repeat coverage of any areas where initial data quality is sub-standard or insufficient, and in recognition of the uncertainties in the density estimates used to estimate exposures as described above. This approach assumes that no marine mammals will move away or toward the trackline in response to increasing sound levels before they reach the threshold as the R/V *Marcus G. Langseth* approaches. Additionally, marine mammals will be expected to move away from a loud sound source that represents an aversive stimulus, such as an airgun array, potentially reducing the number of exposures by ESA harm. However, the extent to which marine mammals will move away from the sound source is difficult to quantify and is, therefore, not accounted for in the exposure estimates.

10.3.2.4 Potential Response of Marine Mammals to Acoustic Sources

Marine Mammals and Hearing Thresholds

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. A 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 nerves of 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, permanent threshold shift 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. Instances of 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 actions (Kastak 2005; Ketten 2012; Schlundt 2000)).

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 Hertz to 35 kilohertz and sperm whales have an estimated functional hearing frequency range of 150 Hertz to 160 kilohertz (see Table 4) (Southall 2007). For pinnipeds in water, data were limited to measurements of TTS in harbor seals (*Phoca vitulina*), a northern elephant seal, and California sea lions (*Zalophus californianus*) (Kastak et al. 1999; Kastelein et al. 2012). Phocid pinnipeds (true seals) have an estimated functional hearing range of 50 Hertz to 86 kilohertz. Otariid pinnipeds (sea lions and fur seals), like Guadalupe fur seals, have an estimated functional hearing range of 60 Hertz to 39 kilohertz.

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). Permanent threshold shift is expected at levels approximately 6 dB greater than TTS levels on a peak-pressure basis, 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 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) (Caldwell and Dragoset 2000b). If an individual experienced exposure to several airgun pulses of

approximately 219 dB for low-frequency cetaceans, 230 dB for mid-frequency cetaceans, and 232 dB for otariid pinnipeds, PTS could occur. Marine mammals (cetaceans and pinnipeds) will have to be within certain modeled radial distances specified in Table 20 and Table 21 from the R/V *Marcus G. Langseth*'s two GI airgun array to be within the ESA harm threshold isopleth and risk a TTS and behavioral responses.

As stated earlier in Section 10.3.1, only ESA harassment in the form of TTS and/or behavioral harassment of ESA-listed cetaceans and pinnipeds is expected to occur during the proposed low-energy seismic survey. Behavioral reactions will be short-term, likely lasting the duration of the exposure, and long-term consequences for individuals or populations are unlikely. Take in the form of ESA harm (i.e., PTS) is not expected (see Section 10.3.1).

Research and observations show pinnipeds in the water are tolerant of anthropogenic noise and activity. 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. 2003b; Götz and Janik 2011; Kvadsheim et al. 2010). Significant behavioral reactions would not be expected in most cases, and long-term consequences for individuals or the population are unlikely.

As stated earlier in Section 10.3.1, only ESA harassment in the form of TTS and/or behavioral harassment of ESA-listed cetaceans and pinnipeds is expected to occur during the proposed low-energy seismic survey. Behavioral reactions will be short-term, likely lasting the duration of the exposure, and long-term consequences for individuals or populations are unlikely. Take in the form of ESA harm (i.e., PTS) is not expected (see Section 10.3.1).

Ranges to some behavioral impacts can take place at distances exceeding 100 kilometers (54 nautical miles), although significant behavioral effects are much more likely at higher received levels within a few kilometers of the sound source. Behavioral reactions will be short-term, likely lasting the duration of the exposure, and long-term consequences for individuals or populations are unlikely.

Overall, we do not expect TTS to occur to any ESA-listed marine mammals as a result of exposure to the airgun array for several reasons. 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, but we expect the probability to be extremely 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 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 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 100 meter (328.1 feet) exclusion zone during two GI airgun array operations, respectively, which is beyond the distances believed to have the potential for PTS in any of the ESA-listed marine mammals as described above. As stated in the Exposure Analysis section, each individual is expected to potentially be exposed to 160 dB re: 1 µPa (rms) levels. We do not expect this to produce a cumulative TTS auditory injury for several reasons. 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 has fitness consequences. 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, whereas higher frequency bandwidths are narrower (NMFS 2006h).

The sound frequency overlap of airgun array sounds and vocalizations of ESA-listed marine mammals, particularly baleen whales and to some extent sperm whales and pinnipeds. The proposed low-energy seismic survey could mask baleen whale, sperm whale, and pinniped 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 2006h). Most of the energy of sperm whale clicks is concentrated at 2 to 4 kilohertz and 10 to 16 kilohertz and, through 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 Hertz (0 to 188 Hertz 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. In addition, the proposed seismic survey activities on the R/V *Marcus G. Langseth* are planned to occur over the course of approximately 23 days (i.e., approximately six days of airgun array operations, approximately 14 days of heat flow measurements, and approximately three days of transit).

Given the disparity between sperm whale echolocation and pinniped communication-related sounds with the dominant frequencies for seismic surveys, masking is not likely to be significant for sperm whales and Guadalupe fur seals (NMFS 2006h). Overlap of the dominant low frequencies of airgun pulses with low-frequency baleen whale calls will be expected to pose a

somewhat greater risk of masking. Nieukirk et al. (2012) analyzed ten years of recordings from the Mid-Atlantic Ridge. When several surveys were recorded simultaneously, whale sounds were masked (drowned out), and the airgun noise became the dominant part of background noise levels. The R/V *Marcus G. Langseth*'s airgun array will emit an approximately 0.01 second pulse when fired approximately every 5.3 to 10.6 seconds for the low-energy seismic survey, with sperm whale calls lasting 0.5 to 1 second. Therefore, pulses will not "cover up" the vocalizations of ESA-listed marine mammals to a significant extent (Madsen et al. 2002b). We address the response of ESA-listed marine mammals stopping vocalizations as a result of sound from the airgun array 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. 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 detectible 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 and Dahlheim 1994; Bain et al. 1993; 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 1975; Au et al. 1974; Au 1974; Lesage 1999; Moore 1990; Romanenko and Kitain 1992; Romanenko 1992; Thomas 1990). A few marine mammal species increase the source levels or alter the frequency of their calls in the presence of elevated sound levels (Au 1993; Dahlheim 1987; Foote 2004; Holt et al. 2009; Holt 2009; Lesage 1999; Lesage 1993; Parks 2009b; Parks 2009a; Parks et al. 2007b; Parks 2007; Terhune 1999).

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 as 18 kilohertz, in contrast to the pronounced effect at higher frequencies. Studies have noted direction hearing at frequencies as low as 0.5 to 2 kilohertz in several marine mammals, including killer whales (Richardson et al. 1995b). This ability may be useful in reducing masking at these frequencies.

In summary, high levels of sound generated by the proposed seismic survey activities may act to mask the detection of weaker biologically important sounds by some marine mammals considered in this consultation. This masking is expected to be more prominent for baleen whales, (including blue whales, fin whales, humpback whales, and sei whales), given the lower frequencies at which they hear best and produce calls. For toothed whales (e.g., sperm whales) and pinnipeds (e.g., Guadalupe fur seals), which hear best at frequencies above the predominant ones produced by airguns, may have adaptations to allow them to reduce the effects of masking on higher frequency sounds such as echolocation clocks like other toothed whales mentioned above (e.g., belugas, Au et al. 1985). As such, toothed whales and pinnipeds are not expected to experience significant masking during the period of time the airgun arrays are producing sound for the proposed actions.

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, in which case some of the responses can equate to harassment of individuals but are unlikely to result in meaningful behavioral responses at the population level. Displacement from important feeding or breeding areas over a prolonged period would likely be more significant for individuals and could affect the population depending on the extent of the feeding area and duration of displacement. This has been suggested for humpback whales along the Brazilian coast as a result of increased seismic survey activity (Parente et al. 2007). Marine mammal responses to anthropogenic sound vary by species, state of maturity, prior exposure, current activity, reproductive state, time of day, and other factors (Ellison et al. 2012; Harris et al. 2018); this is reflected in a variety of aquatic, aerial, and terrestrial animal responses to anthropogenic noise that may ultimately have fitness consequences (Costa et al. 2016; Fleishman et al. 2016; Francis and Barber 2013; New et al. 2014; NRC 2005). Although some studies are available which address responses of ESA-listed marine mammals considered in this consultation directly, additional studies to other related whales (such as bowhead, gray, and North Atlantic right 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 would to predators, increasing vigilance, and altering habitat selection (Reep et al. 2011). There is increasing support that this 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 and request for comments and possible renewal (87 FR 37560 to 37598) as well as one of several reviews (Gomez et al. 2016; e.g., Southall et al. 2007b).

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 may continue calling while seismic surveys are operating locally (Greene Jr et al. 1999; Jochens et al. 2006; Madsen et al. 2002b; McDonald et al. 1993; McDonald et al. 1995a; Nieukirk et al. 2004; Richardson et al. 1986a; Smultea et al. 2004; Tyack et al. 2003). 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; Clark and Gagnon 2006; McDonald et al. 1995a). 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). The survey area affected was estimated to be about 100,000 square kilometers (29,155.3 square nautical miles) (Castellote et al. 2012b). 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 and found no 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 also 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 ceased 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 2009a; Parks and Clark 2007; Parks et al. 2007a; Parks et al. 2007b; Parks et al. 2011a; Parks et al. 2011b; Parks et al. 2012; Parks et al. 2009; 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) (Madsen et al. 2002a; McCall Howard 1999a; McCall Howard 1999b). For the species considered in this consultation, some exposed individuals 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 brief given 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 low-energy 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 consultation 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. 1995b). Activity of individuals at the time of exposure seems to influence response (Robertson et al. 2013), as feeding individuals respond less than mother and calf pairs and migrating individuals (Harris et al. 2007; Malme and Miles 1985; Malme et al. 1984a; Miller et al. 1999; Miller et al. 2005; Richardson et al. 1995c; Richardson et al. 1995b; Richardson et al. 1999). Migrating bowhead whales show strong avoidance reactions to received 120 to 130 dB re: 1 μPa (rms) exposures 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 avoidance at higher received sound levels (152 to 178 dB re: 1 μPa [rms]) (Harris et al. 2007; Ljungblad et al. 1988; Miller et al. 1999; Miller et al. 2005; Richardson et al. 1995c; Richardson et al. 1995b; Richardson et al. 1999; Richardson et al. 1986a; Richardson et al. 1986b). Nations et al. (2009) also found that bowhead whales were displaced during migration in the Beaufort Sea during active seismic surveys. In fact, as mentioned previously, the available data indicate that most, if not all, baleen whale species exhibit avoidance of active seismic airguns (Barkaszi et al. 2012; Castellote et al. 2012b; Castellote et al. 2012a; Gordon et al. 2003; NAS 2017; Potter et al. 2007; Southall et al. 2007a; Southall et al. 2007b; Stone et al. 2017; Stone and Tasker 2006). 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 as those 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 will lower the likelihood that marine mammals will be exposed to sounds from the airgun array.

Gray whales respond similarly to seismic surveys as described for bowhead whales. Gray whales discontinued feeding and/or moved away at received sound levels of 163 dB re: 1 μPa (rms) (Bain and Williams 2006; Gailey et al. 2007; Johnson et al. 2007a; Malme and Miles 1985; Malme et al. 1984a; Malme et al. 1987; Malme et al. 1986; Meier et al. 2007; Würsig et al. 1999;

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 and Miles 1985; Malme et al. 1984b; Malme et al. 1984a). 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 proposed by the NMFS Permits Division, are taken to avoid conducting seismic surveys during certain times of the year when most gray whales are expected to be present and to closely monitor operations, gray whales may not exhibit any noticeable behavioral responses to seismic survey activities (Gailey et al. 2016). Given the similar mitigation measures that will be implemented for this proposed actions, we expect some of the ESA-listed marine mammal species considered in this consultation will respond in a similar manner as gray whales.

Humpback whales exhibit a pattern of lower threshold responses when not occupied with feeding. Migrating humpbacks altered their travel path (at least locally) along Western Australia at received levels as low as 140 dB re: 1 µPa (rms) when females with calves were present, or 7 to 12 kilometers (3.8 to 6.5 nautical miles) from the acoustic source (McCauley et al. 2000a; McCauley et al. 1998). 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 2008a).

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 et al. 2017; Stone and Tasker 2006). Other studies have found at least small differences in sighting rates (lower during seismic survey activities) as well as whales being more distant 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; Madsen et al. 2006; Miller et al. 2009; Moulton and Miller 2005a; Stone 2003; Stone et al. 2017; Stone and Tasker 2006; Weir 2008a; Weir 2008b). 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. 2006; Gordon et al. 2004; 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 (Jochens and Biggs 2004; Jochens 2003; Mate et al. 1994).

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 (Goold 1999b; Watkins et al. 1985a; Watkins and Schevill 1975a). 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 (Winsor and Mate 2013). However, no tagged whales within 5 kilometers (2.7 nautical miles) 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 Hertz) pulses produced by seismic airguns (Richardson et al. 1995b). However, sperm whales are exposed to considerable energy above 500 Hertz 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 kilohertz and 60 dB re: 1 μPa lower at 80 kilohertz compared to dominant frequencies during a seismic source calibration. Another odontocete, bottlenose dolphins, progressively reduced their vocalizations as an airgun array came closer and got louder (Woude 2013). Reactions of sperm whales to impulse noise likely vary depending on the activity at the time of exposure. For example, in the presence of abundant food or during breeding encounters, toothed whales sometimes are extremely tolerant of noise pulses (NMFS 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 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 food (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 unpleasantness of a sound, minus the more commonly studies 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 kilohertz 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. (2003a) 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 Hertz) 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) , a 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 to blue whales, fin whales, Central America DPS of humpback whales, Mexico DPS of humpback whales, sei whales, sperm whales, and Guadalupe fur seals is further supported by U.S. Navy monitoring of Navy-wide activities since 2006, which has documented hundreds of thousands of marine mammals on training and testing range complexes and there are only two instances of overt behavioral change that have been observed and there have been no demonstrable instances of injury to marine mammals as a result of non-impulsive acoustic sources such as low-frequency active sonar. Because we do not expect any fitness consequences from any individual animals to result from instances of behavioral response, we do not expect any population level effects from these behavioral responses.

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 hundred 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 (Jefferson and Curry 1994; Mate and Harvey 1987; 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 consultation 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.

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 (i.e., blue whales, fin whales, Central America DPS of humpback whales, Mexico DPS of humpback whales, and sei 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 that are 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; Tal et al. 2015; Zimmer and Tyack 2007), 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. Therefore, we do not expect ESA-listed marine mammals to experience any of these more severe physical and physiological responses as a result 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 (Busch and Hayward 2009; Gregory and Schmid 2001; Gulland et al. 1999; St. Aubin and Geraci 1988; St. Aubin et al. 1996; Thomson and Geraci 1986). These hormones subsequently can cause short-term weight loss, the liberation of glucose into the bloodstream, impairment of the immune and nervous systems, elevated heart rate, body temperature, blood pressure, and alertness, and other responses (Busch and Hayward 2009; Cattet et al. 2003a; Cattet et al. 2003b; Costantini et al. 2011; Dickens et al. 2010; Dierauf and Gulland 2001; Elftman et al. 2007; Fonfara et al. 2007; Kaufman and Kaufman 1994; Mancia et al. 2008; Noda et al. 2007; Thomson and Geraci 1986). 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; Cowan 2008; Herraez et al. 2007). 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 (Gardiner and Hall 1997; Hunt et al. 2006; Keay et al. 2006; Romero et al. 2008; St. Aubin et al. 1996). 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 watergun (up to 228 dB re: 1 μPa at 1 meter 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. 2012a; Rolland et al. 2012b). These levels returned to baseline after 24 hours of vessel traffic resuming.

As whales use hearing for communication 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 (NMFS 2006a; NRC 2003b). Finally, we assume that some individuals exposed at sound levels below those required to induce a TTS, but above the ESA harassment 160 dB re: 1 μPa (rms) threshold, will experience a stress response, which may also be associated with an overt behavioral response. However, since in all cases exposure to sounds from airgun arrays (or fisheries echosounder) are expected to be temporary, 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 before returning to a baseline state as compared to exposure to levels below the TTS threshold). Although we do not have a way to determine the health of the animal at the time of exposure, we assume that the stress responses resulting from these exposures could be more significant or exacerbate other factors if an animal is already in a compromised state.

Data specific to cetaceans are not readily available to access 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. Fish eggs and embryos exposed to sound levels only 15 dB greater than background showed increased mortality and surviving fry and slower growth rates, although the opposite trends have also been found in sea bream. 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 sounds 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 the 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 influences 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 activities otherwise 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 that will be expected to produce a more intense, frequent, and/or earlier response to subsequent exposures (see *Response Analysis* section). Nonetheless, seismic survey activities can potentially lead cetaceans and pinnipeds to habituate to sounds from airgun arrays which may lead to additional energetic costs or reductions in foraging success (Nowacek et al. 2015). Nevertheless, the proposed actions will take place over approximately 23 days (approximately six days of airgun array operations, approximately 14 days of heat flow measurements, and approximately three days of transit); 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 through.

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 the general area 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 pre-dispose 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 (Creel 2005; Fair and Becker 2000; Kerby et al. 2004; Moberg 2000; Romano et al. 2004). 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.

We do not expect ESA-listed marine mammals to strand as a result of the proposed low-energy seismic survey. The low-energy seismic survey will take place in the Northeast Pacific Ocean, and the closest approach to the coastline of Oregon and Washington will be at least approximately 46.9 kilometers (25.3 nautical miles) for the low-energy seismic survey 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 strand.

Responses of Marine Mammal Prey

Seismic surveys may also have indirect, adverse effects on ESA-listed marine mammals by affecting their prey availability (including larval stages) through lethal or sub-lethal damage, stress responses, or alterations in their behavior or distribution. Such prey includes fishes, zooplankton, cephalopods, and other invertebrates such as crustaceans, molluscs, and jellyfish. Studies described herein provide extensive support for this, which is the basis for later discussion on implications for ESA-listed marine mammals. In a fairly exhaustive review, Carroll et al. (2017) summarized the available information on the impacts seismic surveys have on fishes and invertebrates. In many cases, species-specific information on the prey of ESA-listed marine mammals is not generally available. Until more specific information is available, we expect that prey (e.g., teleosts, zooplankton, cephalopods) of ESA-listed marine mammals considered in this consultation will react in manners similar to those fish and invertebrates described herein.

Like with marine mammals, 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 a recent 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, as reviewed by, we assume that some fishes and invertebrates that serve as prey may experience physical and physiological effects, including mortality, but in most cases, such effects are only expected at relatively close distances to the sound source.

The prey of ESA-listed marine mammals 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 others 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 oyster 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, behavioral responses by fishes and invertebrates may also be associated with a stress response.

There has been research suggesting that 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 2,458.1 cubic centimeters [150 cubic inches]) lead 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 survey 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 actions take place over a broad spatial area, with survey regions spaced far apart and will last for 23 days (six days of airgun array operations), meaning that we do not believe that the spatial or temporal scale of the low-energy seismic survey is large in relation to the marine environment off the United States West Coast.

However, Fields et al. (2019) has demonstrated different results through a series of control experiments using seismic shots from two airguns (260 cubic inches) during 2009 and 2010 on *Calanus finmarchicus*. Their data show that seismic blasts have limited effects on the mortality or escape response 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 greater than 5 meters (16.4 feet) from the airgun and a higher cumulative mortality (seven days after exposure) at a distance somewhere between 10 to 20 meters (32.8 to 65.6 feet) from the airgun, and observed nor sublethal effects, but did see changes in gene expression (Fields et al. 2019). Furthermore, Fields et al. (2019) demonstrated that shots from seismic airguns had no effect on the escape response of *C. finmarchicus*. They conclude that the effects of shots from seismic airguns are much less than reported by McCauley et al. (2017).

Given the results from each of these studies, it is difficult to fully assess the exact impact seismic airgun arrays may have on the instantaneous or long-term survivability of zooplankton/krill that are exposed. Furthermore, the energy of the proposed seismic survey activities (90 cubic inches versus 150 or 260 cubic inches) proposed in this consultation suggests that any copepod or crustacean directly exposed to the seismic airgun array (underneath or within 5 meters [16.4 feet] would likely suffer mortality to an extent less than described by McCauley et al. (2017)

Additionally, the majority of copepod prey available to baleen whales or fishes which are prey to these marine mammals, are expected to be near the water's surface (Witherington et al. 2012), results of McCauley et al. (2017) provide little information on the effects to copepods at the water surface since their analyses excluded zooplankton at the surface bubble layer. Nonetheless, given that airguns primarily transmit sound downward, and that those associated with the proposed actions will be towed at depths of two to four meters (6.6 to 13.1 feet), we expect that sounds from airgun array will be relatively low at the water surface (i.e., above the airgun array) and as such, will affect copepod prey within the action area less than that reported in McCauley et al. (2017). While the proposed low-energy seismic survey may temporarily alter copepod or crustacean abundance in the action area, we expect such effects to be insignificant because most copepods will be near the water surface where the sound from airgun arrays is expected to be relatively low and the high turnover rate of zooplankton and ocean circulation will minimize any effects.

Some support has been found for fish or invertebrate mortality resulting from exposure to airguns, and this is limited to close-range exposure to high amplitudes (Bjarti 2002; D'Amelio

1999; Falk and Lawrence 1973; Hassel et al. 2003; Holliday et al. 1987; Kostyuchenko 1973; La Bella et al. 1996; McCauley et al. 2000a; McCauley et al. 2000b; McCauley et al. 2003; Popper et al. 2005; Santulli et al. 1999). Lethal effects, if any, are expected within a few meters of the airgun array (Buchanan et al. 2004; Dalen and Knutsen 1986). For fishes that are located at distances greater than this, we expect that if fishes 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 and will return to the area as available prey for marine mammals. For example, a common response by fishes to airgun sound is a startle or distributional response, where fish react momentarily by changing orientation or swimming speed, or change their vertical distribution in the water column (Davidsen et al. 2019; Fewtrell 2013a). During airgun studies in which the received sound levels were not reported, Fewtrell (2013a) observed caged *Pelates* spp., pink snapper, and trevally (*Caranx ignobilis*) to generally exhibited startle, displacement, and/or grouping responses upon exposure to airguns. This effect generally persisted for several minutes, although subsequent exposures to the same individuals did not necessarily elicit a response (Fewtrell 2013a). In addition, Davidsen et al. (2019) performed controlled exposure experiments on Atlantic cod (*Gadus morhua*) and saithe (*Pollachius virens*) to test their response to airgun noise. Davidsen et al. (2019) noted the cod exhibited reduced heart rate (bradycardia) in response to the particle motion component of the sound from the airgun, indicative of an initial flight response, however, no behavioral startle response to the airgun was observed. Furthermore, both the Atlantic cod and saithe changed both swimming depth and horizontal position more frequently during airgun sound production (Davidsen et al. 2019). We expect that if fish detect the sound and perceive it as a threat or some other signal that induces them to leave the area they are capable of moving away from the sound source (e.g., airgun array) if it causes them discomfort and will return to the area and available as prey for marine mammals.

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). Effects from TTS were not found in whitefish at received levels of approximately 175 dB re: 1 μPa^2-second, 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).

By far the most common response by fishes is a startle or distributional response, where fish react momentarily by changing orientation or swimming speed or change their vertical distribution in the water column. 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). This effect generally persisted for several minutes, although subsequent exposures to 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 dB 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 kilometers (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; Engås et al. 1996; Engås et al. 1993; Løkkeborg 1991; Løkkeborg and Soldal 1993; Turnpenny et al. 1994).

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 known to be 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 (Fewtrell 2013b; McCauley et al. 2000a; McCauley et al. 2000b). 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 Hertz 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 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; Payne et al. 2013). However, feeding did increase in exposed individuals (Christian 2013; Payne et al. 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.

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. However, we do not expect krill to experience effects from sounds of airguns. 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 lack of prey availability in localized areas to baleen

whales (i.e., blue whales, fin whales, Central America DPS of humpback whales, Mexico DPS of humpback whales, and sei whales). 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. Guadalupe fur seals regularly feed on fishes and marine invertebrates 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. We do not expect indirect effects from airgun array operations through reduced feeding opportunities for ESA-listed marine mammals to be sufficient to reach a significant level. Effects are likely to be temporary and, if displaced, both marine mammals 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 the 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 immediate impact on ESA-listed marine mammals. As described above, we believe that in most cases, ESA-listed marine mammals will avoid closely approaching the airgun array when active, and as such will not be in areas where prey have been temporarily displaced or otherwise effected.

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 up to two blue whales, four fin whales, two humpback whales, two sei whales, seven sperm whales, and 46 Guadalupe fur seals (see Table 24), to be exposed to the airgun array within 160 dB re: 1 μPa (rms) ensonified areas during the seismic survey activities.

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 in the NMFS Permits Division's proposed IHA, and the nature of the seismic survey activities (low-energy airgun array and

reduced zones of ensonification), as described above, we do not expect 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 whale, fin whale, Central America DPS of humpback whale, Mexico DPS of humpback whale, sei whale, sperm whale, and Guadalupe fur seal). Harassment is not expected to have more than short-term effects on individual ESA-listed marine mammal species (blue whale, fin whale, Central America DPS of humpback whale, Mexico DPS of humpback whale, sei whale, sperm whale, and Guadalupe fur seal). 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-start clearance and ramp-up procedures, vessel-based visual monitoring by NMFS-approved PSOs, vessel strike avoidance measures, and additional mitigation measures) in place for the proposed seismic survey activities to protect ESA-listed species.

Given that individual blue whales, fin whales, Central America DPS of humpback whales, Mexico DPS of humpback whales, sei whales, sperm whales, and Guadalupe fur seals may experience temporary behavioral responses from the proposed seismic survey activities and those exposures are a small percentage of the regional population (0.11 percent of blue whales, 0.04 percent of fin whales, two percent of Central America DPS and Mexico DPS of humpback whales, 0.39 percent of sei whales, 0.35 percent of sperm whales, and 0.13 percent of Guadalupe fur seals), we do not expect any population level effects. These estimates are also considered conservative (i.e., they are 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 effected compared to the relatively small size of the action area, combined with the relatively short duration of the seismic survey activities, there is the potential 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 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 designated critical habitat for these species will be adversely affected by the seismic survey activities associated with the proposed actions (Section 7.5).

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

actions are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

We expect that those aspects described in the Environmental Baseline section (Section 9) will continue to impact ESA-listed resources into the foreseeable future. We expect climate change, oceanic temperature regimes, unusual mortality events, vessel interactions (vessel strikes and whale watching), fisheries (fisheries interactions), pollution (marine debris, pollutants and contaminants, and hydrocarbons), anthropogenic sound (vessel sound and commercial shipping, aircraft, seismic surveys, marine construction, active sonar, and military activities), and scientific research activities to continue into the future for marine mammals.

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. However, movement towards bycatch reduction and greater foreign protections are generally occurring throughout the Northeast Pacific Ocean, which may aid in abating the downward trajectory of some populations due to activities such as fishing in the action area.

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. We are not aware of any state, tribal, or private activities that are likely to occur in the action area during the foreseeable future that were not considered in the Environmental Baseline section of this consultation.

An increase in these activities could similarly increase their effect on ESA-listed species and for some, an increase in the future is considered reasonably certain to occur. Given current trends in global population growth, threats, associated with climate change, pollution, fisheries, bycatch, aquaculture, vessel strikes and approaches, and sound are likely to continue to increase in the future, although any increase in effect may be somewhat countered by an increase in conservation and management activities. In contrast, more historical threats such as whaling are likely to remain low or potentially decrease. For the remaining activities and associated threats identified in the Environmental Baseline section, and other unforeseen threats, the magnitude of increase and significance of any anticipated effects remain unknown. The best scientific and commercial data available provide little specific information on any long-term effects of these potential sources of disturbance on ESA-listed species. Thus, this consultation assumed effects in the future would be similar to those in the past and, therefore, are reflected in the anticipated trends described in the Status of the Species Likely to be Adversely Affected and Environmental Baseline sections, respectively.

12 INTEGRATION AND SYNTHESIS

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and their designated critical habitat as a result of implementing the proposed actions. In this section, we add the Effects of the Action section (Section 10) to the Environmental Baseline section (Section 9) and the Cumulative Effects section (Section 11) to formulate the agency's biological opinion as to whether the proposed action is likely to 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. This assessment is made in full consideration of the Species and Critical Habitat Not Likely to be Adversely Affected section (Section 7), Species Likely to be Adversely Affected section (Section 8), and Status of the Species Likely to be Adversely Affected section (Section 8.1).

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

The following discussions separately summarize the probable risks the proposed actions pose to threatened and endangered species that are likely to be exposed (and be adversely affected) to the stressors associated with the seismic survey activities. These summaries integrate the exposure profiles presented previously with the results of our response analyses for each of the actions considered in this consultation.

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 effect analysis, adverse effect to ESA-listed species are likely to result from the proposed actions. The following discussions summarize the probably risks that seismic survey activities pose to ESA-listed species that are likely to be exposed over the approximately 23 days (six days of airgun array operations) of the low-energy seismic survey. These summaries integrate our exposure, response, and risk analyses from the Effects of the Actions section (Section 10).

12.2 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 low-energy seismic survey will depend on the duration and severity of exposure.

The blue whale is endangered as a result of past commercial whaling. Commercial whaling no longer occurs, but blue whales are threatened by vessel strikes, entanglement in fishing gear, pollution, harassment due to whale watching, and reduced prey abundance and habitat degradation due to climate change. Because populations appear to be increasing in size, the species appears to be somewhat resilient to current threats; however, the species has not recovered to pre-exploitation levels.

The minimum population size for Eastern North Pacific Ocean blue whales is 1,050; the more recent abundance estimate is 1,496 (Carretta et al. 2020). Current estimates indicate the Eastern North Pacific stock shows no signs of population growth since the early 1990s, perhaps because the population is nearly at carrying capacity (Carretta et al. 2018). An overall population growth rate for the species or growth rates for the two other individual U.S. stocks are not available at this time.

No reduction in the distribution of blue whales from the Northeast 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 NMFS Permits Division's issuance of an IHA and possible renewal.

No reduction in numbers is anticipated as part of the proposed actions. Therefore, no reduction in reproduction is expected as a result of the proposed actions. Non-lethal take of two 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. 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 NMFS Permits Division's issuance of an IHA and possible renewal, a reduction in the species' likelihood of survival is not expected.

The 2020 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:

- Increase blue whale resiliency and ensure geographic and ecological representation by achieving sufficient and viable populations in all ocean basins and in each recognized subspecies..
- Increase blue whale resiliency by managing or eliminating significant anthropogenic threats.

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 NMFS Permits Division's issuance of an IHA and possible renewal will impede the recovery objectives for blue whales. In conclusion, we believe the non-lethal effects associated with the proposed actions will not expected to appreciably reduce the likelihood of survival and recovery of blue whales in the wild by reducing the reproduction, numbers, or distribution of the species.

12.3 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 an animal's response to noise associated with the low-energy seismic survey will depend on the duration and severity of exposure.

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 commercial whaling program, and Iceland's formal objection to the International Whaling Commission's ban on commercial whaling. Additional threats include vessel strikes, reduced prey availability due to overfishing or climate change, and sound. The species' overall large population size may provide some resilience to current threats, but trends are largely unknown.

Current estimates indicate approximately 10,000 fin whales in the U.S. Pacific Ocean waters, with an annual growth rate of 4.8 percent in the Northeast Pacific stock and a stable population abundance in the California/Oregon/Washington stock (Nadeem et al. 2016a). The best current abundance estimate for fin whales in California, Oregon, and Washington waters out to 555.6 kilometers (300 nautical miles) is 9,029 (CV=0.12) (Nadeem et al. 2016a); the minimum population estimate is 8,127 individuals (Carretta 2019b). An overall population trend in U.S. Pacific Ocean waters 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 through 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 2019b).

No reduction in the distribution of fin whales from the Northeast 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 NMFS Permits Division's issuance of an IHA and possible renewal.

No reduction in numbers is anticipated as part of the proposed actions. Therefore, no reduction in reproduction is expected as a result of the proposed actions. Non-lethal take of four 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. Because we do not anticipate a reduction in numbers or reproduction of fin whales as a result of the proposed seismic survey activities and the NMFS Permits Division's issuance of an IHA and possible renewal, 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 abundance, distribution, and reproduction of fin whale populations are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the NMFS Permits Division's issuance of an IHA and possible renewal will impede the recovery objectives for fin whales. In conclusion, we believe the non-lethal effects associated with the proposed actions will not expected to appreciably reduce the likelihood of survival and recovery of fin whales in the wild by reducing the reproduction, numbers, or distribution of the species.

12.4 Humpback Whale – Central America Distinct Population Segment

Adult and juvenile Central America DPS of humpback 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 low-energy seismic survey will depend on the duration and severity of exposure.

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. 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). 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 DPS of humpback whales were taken, based on where the whalers were hunting (i.e., the purported feeding grounds for these DPSs). Humpback whales may be killed under "aboriginal subsistence whaling" and "scientific permit whaling" provisions of the International Whaling Commission. Additional threats include vessel strikes, fisheries interactions (including entanglement), energy development, harassment from whaling watching noise, harmful algal blooms, disease, parasites, and climate change. The species' large population size and increasing trends indicate that it is resilient to current threats, but the Central America DPS still faces a risk of extinction.

The global, pre-exploitation for humpback whales is 1,000,000 (Roman and Palumbi 2003). The current abundance of the Central America DPS of humpback whale is 1,496 with an estimated annual population growth rate is 1.6 percent (Curtis et al. 2022).

No reduction in the distribution of Central America DPS of humpback whales from the Northeast 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 NMFS Permits Division's issuance of an IHA and possible renewal.

No reduction in numbers is anticipated as part of the proposed actions. Therefore, no reduction in reproduction is expected as a result of the proposed actions. Non-lethal take of one 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. Because we do not anticipate a reduction in numbers or reproduction of Central America DPS of humpback whales as a result of the proposed seismic survey activities and the NMFS Permits Division's issuance of an IHA and possible renewal, a reduction in the species' likelihood of survival is not expected.

The 2022 Recovery Outline for Central America DPS, Mexico DPS, and Western North Pacific DPS of humpback whales includes interim guidance to direct recovery efforts. The following interim recovery program objectives are relevant to the impacts of the proposed actions:

- Management activities that continue to protect humpback whales and their critical habitat.
- Management activities that reduce medium and high risk threats to humpback whales, including vessel strike and entanglement in fishing gear.

Because no mortalities or effects on the abundance, distribution, and reproduction of Central America DPS of humpback whale populations are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the NMFS Permits Division's issuance of an IHA and possible renewal will impede the recovery objectives for Central America DPS of humpback whales. In conclusion, we believe the effects associated with the proposed actions will not expected to appreciably reduce the likelihood of survival and recovery of Central America DPS of humpback whales in the wild by reducing the reproduction, numbers, or distribution of the species.

12.5 Humpback Whale – Mexico Distinct Population Segment

Adult and juvenile humpback 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 low-energy seismic survey will depend on the duration and severity of exposure.

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. 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). 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 DPS of humpback whales were taken, based on where the whalers were hunting (i.e., the purported feeding grounds for these DPSs). Humpback whales may be killed under "aboriginal subsistence whaling" and "scientific permit whaling" provisions of the International Whaling Commission. Additional threats include vessel strikes, fisheries interactions (including entanglement), energy development, harassment from whaling watching noise, harmful algal blooms, disease, parasites, and climate change. The species' large population size and increasing trends indicate that it is resilient to current threats, but the Central America DPS still faces a risk of extinction.

The global, pre-exploitation for humpback whales is 1,000,000 (Roman and Palumbi 2003). The current abundance of the Mexico DPS of humpback whale is unavailable. A population growth rate is currently unavailable for the Mexico DPS of humpback whales. While the current trend is unknown, Calambokidis and Barlow (2020) reported an approximate 8.2 percent annual growth rate from 1989 through 2018 for humpback whales off California and Oregon, where animals from the Central America DPS and Mexico DPS of humpback whales overlap.

No reduction in the distribution of Mexico DPS of humpback whales from the Northeast 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 NMFS Permits Division's issuance of an IHA and possible renewal.

No reduction in numbers is anticipated as part of the proposed actions. Therefore, no reduction in reproduction is expected as a result of the proposed actions. Non-lethal take of one 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. Because we do not anticipate a reduction in numbers or reproduction of humpback whales as a result of the proposed seismic survey activities and the NMFS Permits Division's issuance of an IHA and possible renewal, a reduction in the species' likelihood of survival is not expected.

The 2022 Recovery Outline for Central America DPS, Mexico DPS, and Western North Pacific DPS of humpback whales includes interim guidance to direct recovery efforts. The following interim recovery program objectives are relevant to the impacts of the proposed actions:

- Management activities that continue to protect humpback whales and their critical habitat.
- Management activities that reduce medium and high risk threats to humpback whales, including vessel strike and entanglement in fishing gear.

Because no mortalities or effects on the abundance, distribution, and reproduction of Mexico DPS of humpback whale populations are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the NMFS Permits Division's issuance of an IHA and possible renewal will impede the recovery objectives for Mexico DPS of humpback whales. In conclusion, we believe the non-lethal effects associated with the proposed actions will not expected to appreciably reduce the likelihood of survival and recovery of Mexico DPS of humpback whales in the wild by reducing the reproduction, numbers, or distribution of the species.

12.6 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 animal's response to noise associated with the low-energy seismic survey will depend on the duration and severity of exposure.

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 2019b). Now, only a few individuals are taken each year by Japan; however, Iceland has expressed an interest in targeting sei whales. Current threats include vessel strikes, fisheries interactions (including entanglement), climate change (habitat loss and reduced prey availability), and anthropogenic noise. Given the species' overall abundance, they may be somewhat resilient to current threats. However, trends are largely unknown, especially for individual stocks, many of which have relatively low abundance estimates.

Models indicate that total abundance declined from 42,000 to 8,600 individuals between 1963 through 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 2016a; Thomas et al. 2016). The best abundance estimate for sei whales for the waters of the U.S. West Coast is 519 (CV=0.40) (Carretta 2019b). 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.

No reduction in the distribution of sei whales from the Northeast 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 NMFS Permits Division's issuance of an IHA and possible renewal.

No reduction in numbers is anticipated as part of the proposed actions. Therefore, no reduction in reproduction is expected as a result of the proposed actions. Non-lethal take of two 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. 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 NMFS Permits Division's issuance of an IHA and possible renewal, 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 abundance, distribution, and reproduction of sei whale populations are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the NMFS Permits Division's issuance of an IHA and possible renewal will impede the recovery objectives for sei whales. In conclusion, we believe the non-lethal effects associated with the proposed actions will not expected to appreciably reduce the likelihood of survival and recovery of sei whales in the wild by reducing the reproduction, numbers, or distribution of the species.

12.7 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 severity of an animal's response to noise associated with the low-energy seismic survey will depend on the duration and severity of exposure.

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. Commercial whaling is no longer allowed; however, illegal hunting may occur at biologically unsustainable levels. Continued threats to sperm whale populations include vessel strikes, entanglement and entrapment in fishing gear, competition for resources due to overfishing, pollution, loss of prey and habitat degradation due to climate change, and noise. This species' large population size shows that it is somewhat resilient to current threats.

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 2009a). The higher estimates may be approaching population sizes prior to commercial whaling, the reason for ESA-listing. In the Northeast Pacific Ocean, the abundance of sperm whales was estimated to be between 26,300 and 32,100 in 1997. Population estimates are also available for two of three U.S. stocks that occur in the Pacific Ocean, the California/Oregon/ Washington stock, estimated to consist of 2,106 individuals (N_{min}=1,332), and the Hawaii stock, estimated to consist of 4,559 individuals (N_{min}=3,478). There are insufficient data to estimate the population abundance of the North Pacific stock. There is insufficient data to evaluate trends in abundance and growth rates of sperm whales at this time.

No reduction in the distribution of sperm whales from the Northeast 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 NMFS Permits Division's issuance of an IHA and possible renewal.

No reduction in numbers is anticipated as part of the proposed actions. Therefore, no reduction in reproduction is expected as a result of the proposed actions. Non-lethal take of seven 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. 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 NMFS Permits Division's issuance of an IHA and possible renewal, 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 abundance, distribution, and reproduction of sperm whale populations are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the NMFS Permits Division's issuance of an IHA and possible renewal will impede the recovery objectives for sperm whales. In conclusion, we believe the non-lethal effects associated with the proposed actions are not expected to appreciably reduce the likelihood of survival and recovery of sperm whales in the wild by reducing the reproduction, numbers, or distribution of the species.

12.8 Guadalupe Fur Seal

Adult and juvenile Guadalupe fur seals 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 low-energy seismic survey will depend on the duration and severity of exposure.

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 as 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 that over the last 50 years the population has been increasing since being severely depleted, we believe that the Guadalupe fur seal population is resilient to future perturbations.

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 30 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; more recent evidence indicates that this trend is continuing (Aurioles-Gamboa et al. 2010; Esperon-Rodriguez and Gallo-Reynoso 2012). From 1984 through 2013 at Guadalupe Island, the Guadalupe fur seal population increased at an average growth rate of 5.9 percent (range of 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 through 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 2019a). Based on direct counts of animals from 1955 and 1993, the estimated annual population growth rate is 13.7 percent (Carretta 2019a). 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 2019a).

No reduction in the distribution of Guadalupe fur seals from the Northeast 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 NMFS Permits Division's issuance of an IHA and possible renewal.

No reduction in numbers is anticipated as part of the proposed actions. Therefore, no reduction in reproduction is expected as a result of the proposed actions. Non-lethal take of 46 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. 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 NMFS Permits Division's issuance of an IHA and possible renewal, a reduction in the species' likelihood of survival is not expected.

NMFS has not prepared a Recovery Plan for the Guadalupe fur seal.

Because no mortalities or effects on the abundance, distribution, and reproduction of Guadalupe fur seal populations are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the NMFS Permits Division's issuance of an IHA and possible renewal will impede the recovery objectives for Guadalupe fur seals. In conclusion, we believe the non-lethal effects of take associated with the proposed actions are not expected to appreciably reduce the likelihood of survival and recovery of Guadalupe fur seals in the wild by reducing the reproduction, numbers, or distribution of the species.

13 CONCLUSION

After reviewing the current status of the ESA-listed species, the environmental baseline within the action area, the effects of the proposed actions, and cumulative effects, it is NMFS' biological opinion that the proposed actions are not likely to jeopardize the continued existence or recovery of blue whale, fin whale, Central America DPS of humpback whale, Mexico DPS of humpback whale, sei whale, sperm whale, and Guadalupe fur seal.

It is also NMFS' biological opinion that the proposed actions are not likely to adversely affect the Western North Pacific DPS of gray whales, Southern Resident DPS of killer whale, North Pacific right whale, Eastern DPS of green turtle, leatherback turtle, North Pacific Ocean DPS of loggerhead turtle, Mexico's Pacific coast breeding colonies population of olive ridley turtle, California Coastal ESU of Chinook salmon, Central Valley Spring-Run ESU of Chinook salmon, Lower Columbia River ESU of Chinook salmon, Puget Sound ESU of chinook salmon, Sacramento River Winter-Run ESU of Chinook salmon, Snake River Fall-Run ESU of Chinook salmon, Snake River Spring/Summer-Run ESU of Chinook salmon, Upper Columbia River Spring-Run ESU of Chinook salmon, Upper Willamette River ESU of Chinook salmon, Columbia River ESU of chum salmon, Hood Canal Summer-Run ESU of chum salmon, Central California Coast ESU of Coho salmon, Lower Columbia River ESU of Coho salmon, Oregon Coast ESU of Coho salmon, Southern Oregon and Northern California Coasts ESU of Coho salmon, Southern DPS of eulachon, Southern DPS of green sturgeon, Ozette Lake ESU of Sockeye salmon, Snake River ESU of Sockeye salmon, California Central Valley DPS of steelhead trout, Central California Coast DPS of steelhead trout, Lower Columbia River DPS of steelhead trout, Middle Columbia River DPS of steelhead trout, Northern California DPS of steelhead trout, Puget Sound DPS of steelhead trout, Snake River Basin DPS of steelhead trout, South-Central California Coast DPS of steelhead trout, Southern California DPS of steelhead trout, Upper Columbia River DPS of steelhead trout, and Upper Willamette River DPS of steelhead trout. Also, the proposed actions will not adversely affect the designated critical habitat of Central America DPS of humpback whale, Mexico DPS of humpback whale, Southern Resident DPS of killer whale, leatherback turtle, and Southern DPS of green sturgeon.

14 INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of threatened and endangered 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 (16 U.S.C. §1532(19)). "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, spawning, rearing, migrating, feeding, or sheltering (50 C.F.R. §222.102). 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).

Section 9 take prohibitions do not apply to threatened species. This incidental take statement, however, includes limits on taking of threatened species since those numbers were analyzed in the jeopardy analysis and to provide guidance to the action agency on its requirement to reinitiate consultation if the take limit for any species covered by this opinion is exceeded. The ESA does not prohibit the take of threatened species unless special regulations have been promulgated, pursuant to section 4(d), to promote the conservation of the species. ESA section 4(d) rules have been promulgated for Mexico DPS of humpback whales and Guadalupe fur seals; therefore, section 9 take prohibitions do apply to these two species. This incidental take statement includes numeric limits on the take of these species because specific amounts of take were analyzed in our jeopardy analysis. These numeric limits provide guidance to the action agency on its requirements to reinitiate consultation if the amount of take estimated in the jeopardy analysis of this opinion is exceeded. This incidental take statement includes reasonable and prudent measures and terms and conditions designed to minimize and monitor take of these threatened species.

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.

ESA section 7(b)(4) states that take of ESA-listed marine mammals (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 IHA 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 IHA for the tentative period of July 2022 through July 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 threatened or endangered 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 and may be used if we cannot assign numerical limits of 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 low-energy seismic survey changes, or the number of seismic survey days is increased, then incidental take for marine mammals may be exceeded. As such, if more tracklines are conducted during the low-energy seismic survey, an increase in the number of days beyond the 25 percent contingency, greater estimates of sound propagation, and/or increases in the airgun array source levels occur, reinitiation of consultation will be necessary.

The NMFS ESA Interagency Cooperation Division and NMFS Permits Division anticipate the proposed low-energy seismic survey in the Northeast Pacific Ocean is likely to result in the incidental take of ESA-listed marine mammals by harassment (Table 26). 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. It is believed that no ESA harm or PTS will be incurred in these marine mammals as a result of the proposed seismic survey activities, because of the constant movement of both the R/V *Marcus G. Langseth* and of the marine mammals in the action area, the fact that the research vessel is not expected to remain in any one area in which individual marine mammals will be expected to concentrate for an extended period of time (i.e., since the duration of exposure to loud sounds will be relatively short), and the implementation of monitoring and mitigation measures. Also, as described above, we expect that marine mammals will be likely to move away from a sound source that represents an aversive stimulus, especially at levels that will be expected to result in PTS, given sufficient notice of the R/V *Marcus G. Langseth*'s approach due to the research vessel's relatively slow speed when conducting seismic survey activities.

Table 26. Estimated amount of incidental take of Endangered Species Act-listed marine mammals anticipated as a result of the proposed actions in the Northeast Pacific Ocean.

Species	Anticipated Incidental Take by Harassment (Potential Temporary Threshold Shift and Behavioral) by Seismic Survey Activities
Marine Mammals – Cetaceans	
Blue Whale	2
Fin Whale	4
Humpback Whale – Central America DPS	1
Humpback Whale – Mexico DPS	1
Sei Whale	2
Sperm Whale	7
Marine Mammals – Pinnipeds	
Guadalupe Fur Seal	46

DPS=distinct population segment

14.2 Reasonable and Prudent Measures

"Reasonable and prudent measures" are measures that are necessary or appropriate to minimize the amount or extent of incidental take (50 C.F.R. §402.02). The measures described below must be undertaken by the NSF, L-DEO, and the NMFS 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, we will issue a statement that specifies the impact of any incidental taking of threatened or endangered species. To minimize such impacts, reasonable and prudent measures, and term and conditions to implement the measures, must be provided. 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.

We believe the reasonable and prudent measures described below are necessary and appropriate to minimize the impacts of incidental take on threatened and endangered species:

- The NMFS Permits Division must ensure that the NSF and L-DEO implements a program to mitigate and report the potential effects of seismic survey activities as well as the effectiveness of mitigation measures incorporated as part of the proposed IHA and possible renewal for the incidental taking of blue whales, fin whales, Central America DPS of humpback whales, Mexico DPS of humpback whales, sei whales, sperm whales, and Guadalupe fur seals pursuant to section 101(a)(5)(D) of the MMPA. In addition, the

NMFS Permits Division must ensure that the provisions of the IHA and possible renewal are carried out, and must inform us if take is exceeded.

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 Federal action agency (i.e., NSF and NMFS Permits Division) must comply (or must ensure that any applicant complies) with the following terms and conditions. These include the take minimization, monitoring and reporting measures required by the section 7 regulations (50 C.F.R. §402.14(i)).

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

1. The NSF must provide 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 IHA, whichever comes sooner.
2. Any reports of injured or dead ESA-listed species must be provided by the NSF to the ESA Interagency Cooperation Division immediately to Lisamarie Carrubba, Acting Chief, ESA Interagency Cooperation Division by e-mail at lisamarie.carrubba@noaa.gov.

15 Conservation Recommendations

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 make the following discretionary conservation recommendations that we believe are consistent with this obligation and therefore may be considered by the NSF, L-DEO, and NMFS 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 and L-DEO promote and fund research examining the potential effects of seismic surveys on ESA-listed marine mammal, sea turtle, fish, and marine invertebrate species.
2. We recommend that the NSF and L-DEO develop a more robust propagation model that incorporates environmental variables into estimates of how far sound levels reach from airgun arrays.
3. We recommend that the NSF and L-DEO model potential impacts to ESA-listed species, validate assumptions, through refinements of current models and use of other relevant

models, validate assumptions used in effects analyses, and seek information and high quality data for use in such efforts.

4. We recommend that the NSF and L-DEO conduct a sound source verification in the study area (and future locations) to validate predicted and modeled isopleth distances to ESA harm and harassment thresholds and incorporate the results of that study into buffer and exclusion zones prior to starting seismic survey activities.
5. We recommend that the NMFS Permits Division develops a flow chart with decision points for mitigation and monitoring measures to be included in future MMPA incidental take authorizations for seismic surveys.
6. We recommend the NSF and L-DEO use (and NMFS Permits Division require in MMPA incidental take authorizations) thermal imaging cameras, in addition to reticled binoculars (Big-Eye and handheld) and the naked eye, for use during daytime and nighttime visual observations and test their effectiveness at detecting ESA-listed species.
7. We recommend the NSF and L-DEO use (and NMFS Permits Division require in MMPA incidental take authorizations) clinometers or geometers, such as those described in Hansen et al. 2020, to accurately measure lateral distances from the research vessel to ESA-listed species for potential implementation of mitigation measures (e.g., shutdown procedure) during daytime and nighttime visual observations.
8. We recommend the NSF and L-DEO use the Marine Mammal Commission's recommended method for estimating the number of cetaceans in the vicinity of seismic surveys based on the number of groups detected for post-seismic survey activities take analysis and use in monitoring reports.
9. We recommend the NSF, L-DEO, and NMFS 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.
10. We recommend the NSF and L-DEO utilize real-time sighting services such as the WhaleAlert application (http://www.whalealert.org/) for marine mammals or the Ocean Alert mobile application (https://www.boem.gov/boem-harnessing-citizen-science-new-ocean-alert-mobile-app) for marine megafauna (e.g., sea turtles, sharks, and marine mammals). We recognize that the research vessel may not have reliable internet access during operations far offshore, but nearshore, where many of the ESA-listed species considered in this consultation 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 species sightings, and may also be

valuable during other activities to alert others of ESA-listed species within the area, which they can then avoid.

11. We recommend the NSF and L-DEO submit their monitoring data (i.e., visual sightings) by PSOs to the Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations online database so that it can be added to the aggregate marine mammal, seabird, sea turtle, and fish observation data from around the world.
12. We recommend the research vessel operator and other relevant vessel personnel (e.g., crew members) on the R/V *Marcus G. Langseth* take the U.S. Navy's marine species awareness training available on the following website at: https://www.youtube.com/watch?v=KKo3r1yVBBA in order to detect ESA-listed species and relay information to PSOs.
13. We recommend NSF and L-DEO attempt to maintain a distance of 45 meters (147.6 feet) or greater whenever possible from the R/V *Marcus G. Langseth*, when sea turtles are visually sighted, as a vessel strike avoidance measure.
14. We recommend the NSF, L-DEO, and NMFS Permits Division implement a program to mitigate, monitor, and report any potential effects and interactions between seismic survey activities as well as any effectiveness of mitigation and monitoring measures on ESA-listed species of marine mammals, sea turtles, and fish.

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 NSF, L-DEO, and NMFS Permits Division should notify the NMFS 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 low-energy marine seismic survey by the R/V *Marcus G. Langseth* in the Northeast Pacific Ocean and NMFS Permits Division's issuance of an IHA for the proposed low-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 NMFS, where discretionary Federal agency involvement or control over the action has been retained or is authorized by law and if:

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 identified action.

If the amount of tracklines, location of tracklines, acoustic characteristics of the airgun arrays, timing of the low-energy seismic 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 Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response

Section 305(b) of the MSA directs Federal agencies to consult with NMFS on all actions or proposed actions that may adversely affect EFH. Under the MSA, this consultation is intended to promote the conservation of EFH as necessary to support sustainable fisheries and the managed species' contribution to a healthy ecosystem. For the purposes of the MSA, EFH means "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity," and includes the physical, biological, and chemical properties that are used by fish (50 C.F.R. §600.10).

Adverse effect means any impact that reduces quality or quantity of EFH, and may include direct or indirect physical, chemical, or biological alteration of the waters or substrate and loss of (or injury to) benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality or quantity of EFH. Adverse effects on EFH may result from actions occurring within EFH or outside of it and may include site-specific or EFH-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 C.F.R. §600.810). Section 305(b) of the MSA also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH. Such recommendations may include measures to avoid, minimize, mitigate, or otherwise offset the adverse effects of the action on EFH (50 C.F.R. §600.905(b)).This analysis is based, in part, on the descriptions of EFH for Pacific Coast groundfish (PFMC 2005), coastal pelagic species (PFMC 1998), Pacific Coast salmon (PFMC 2014), and highly migratory species (PFMC 2007) contained in the fishery management plans developed by the Pacific Fishery Management Council (PFMC) and approved by the Secretary of Commerce.

17.1 Essential Fish Habitat Affected by the Project

The proposed actions and action area for this consultation are described in the ESA sections of this document (Sections 3 and 4). The action area includes areas designated as EFH for various life history stages of Pacific Coast groundfish, coastal pelagic species, Pacific Coast salmon, and highly migratory species (PFMC 2005, PFMC 1998, PFMC 2014, PFMC 2008). In addition, the action area includes many Habitat Areas of Particular Concern (HAPC) for Pacific Coast groundfish EFH (https://archive.fisheries.noaa.gov/wcr/publications/gis_maps/maps/groundfish/map-gfish-hapc.pdf).

Rocky reefs (those waters, substrates and other biogenic features associated with hard substrate) and canopy kelp (those waters, substrate, and other biogenic habitat associated with canopy-forming kelp species) are HAPCs because of their importance to many species managed by the PFMC. Areas of interest are discrete areas that are of special interest due to their unique geological and ecological characteristics.

17.2 Adverse Effects on Essential Fish Habitat

The ESA effects analysis (Sections 6 and 7) describes the adverse effects of this proposed action on several ESUs and DPSs. Some of these species covered in the ESA effects analysis are also species covered under the MSA and that have designated EFH. Notably, the Chinook salmon and Coho salmon ESA analyses are relevant to Pacific Coast salmon EFH. Because of the breadth of species covered in this consultation, we are also reasonably certain the ESA effects analysis is relevant to the effects on EFH.

The ESA consultation (Section 6) analyzed several potential stressors, including:

1. Pollution;
2. Vessel strike;
3. Acoustic noise from the airgun array, vessel noise, and visual disturbance;
4. Acoustic noise from the sub-bottom profiler, multi-beam echosounder, acoustic Doppler current profiler, and pinger; and
5. Gear entanglement and interaction.

The ESA analysis found none of the above stressors were likely to adversely affect ESA-listed fish. While the ESA analysis of effects is relevant to EFH, the effects on the essential habitat of some species protected under the MSA are adverse, albeit briefly. In particular, sound pressure waves generated may acutely modify the aquatic habitat to the detriment of northern anchovy and Pacific sardine (included in the coastal pelagic species fishery management plan), which have swim bladders connected to the inner ear for enhanced hearing and are more sensitive to sound effects from the airgun array (Popper et al., 2014a; Ladich and Schulz-Mirbach 2016). Pollution diminishes water quality. Disturbance in the substrate can alter conditions supporting species and prey for those species. However, each of these modifications is expected to be spatially and temporally limited in each location where it occurs. Sound pressure waves cease when operation stops, and pollutants dilute and disperse as to no longer have the magnitude to induce an area of intense change; distributed bottom sediments settle, and benthic areas recover their ability to support EFH species quickly after disturbance.

In addition as noted previously, rocky reefs are a designated HAPC and are preferred habitat for a number of Federally-managed species. Rockfish (*Sebastes* spp.) in particular exhibit strong affinities for hard substrate and even specific locations (Love et al. 2002; PFMC 2005). Moreover, hard bottom habitat provides an attachment surface, which is important for canopy kelp (also a HAPC) and most deep-sea corals, and has also been strongly associated with many sponge taxa (Huff et al. 2013). Deep-sea corals and sponges contribute significantly to biodiversity, serve an important ecological function for benthic communities, and enhance the diversity and structural component of fish habitat (Tissot et al. 2006; Henry et al. 2013). Direct impacts to these sensitive habitat could result from the deployment of anchoring systems and temperature probes.

17.3 Essential Fish Habitat Conservation Recommendations

Some impacts to EFH have already been minimized as part of the proposed action, or cannot be minimized. We determined that the following five EFH conservation recommendations are necessary to avoid, minimize, mitigate, or otherwise offset the impact of the proposed action on EFH.

The action agencies should minimize adverse effects from sound fields produced by the proposed action by implementing the following recommendations:

1. NSF should ensure that all benthic habitat types throughout the project area are accurately delineated and mapped. It is particularly important to identify and delineate sensitive habitats, such as HAPCs and deep-sea corals to avoid impacts.
2. NSF should avoid sensitive habitats (e.g., HAPCs, deep-sea corals) to the greatest extent practicable when deploying anchoring systems and temperature probes. The following NOAA Deep-Sea Coral and Sponge Map Portal contains information regarding observed coral and sponge locations within the action area: https://www.ncei.noaa.gov/maps/deep-sea-corals/mapSites.htm.
3. NSF should promote and fund research for the behavior and physiological response effects within different ecological habitats, life stages, and locations for fishes exposed to the airgun array on a population level scale.
4. Much of the research available to date on the effects of seismic survey methods and how to minimize and mitigate those effects have been focused on marine mammals, not fish, and benthic invertebrates. Therefore, NSF should promote and fund research examining the potential effects of seismic surveys on EFH. Additional research and monitoring should be undertaken to gain a better understanding of the potential effects these seismic survey may have on EFH, federally managed species, their prey and other NMFS trust resources. This research should be a component of future NSF-funded seismic survey activities. This will aid in the development of site and project specific EFH conservation recommendations for future projects, as appropriate including future programmatic biological opinions and EFH responses.
5. NSF should develop a more robust propagation model that incorporates environmental variable into estimates of how far elevated sound levels extend from airgun arrays.

17.4 Statutory Response Requirement

As required by section 305(b)(4)(B) of the MSA, the NSF and NMFS Permits Division must provide a detailed response in writing to us within 30 days after receiving EFH Conservation Recommendations. Such a response must be provided at least ten days prior to final approval of the action if the response is consistent with any of our EFH Conservation Recommendations unless the Federal agencies and we have agreed to use alternative time frames for the Federal agency response. The response must include a description of the measures proposed by the agency for avoiding, minimizing, mitigating, or otherwise offsetting the impact of the activity on EFH. In the case of a response that is inconsistent with the Conservation Recommendations, the

Federal agencies must explain their reasons for not following the recommendations, including the scientific justification for any disagreements with us over the anticipated effects of the action and measures needed to avoid, minimize, mitigate, or offset such effects (50 C.F.R. §600.920(k)(1)). In response to increased oversight of overall EFH program effectiveness by the Office of Management and Budget, we established a quarterly reporting requirement to determine how many conservation recommendations are provided as part of each EFH consultation and how many are adopted by the action agency. Therefore, we ask that in your statutory reply to the EFH portion of this consultation, you clearly identify the number of conservation recommendations accepted.

17.5 Supplemental Consultation

The NSF and NMFS Permits Division must reinitiate EFH consultation with us if the proposed action is substantially revised in a way that may adversely affect EFH, or if new information becomes available that affects the basis for our EFH Conservation Recommendations (50 C.F.R. §600.920(1)).

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19 APPENDICES

Appendix A – Proposed Incidental Harassment Authorization and Possible Renewal

The text below was taken directly from the proposed IHA provided to us in the consultation initiation package from the NMFS Permits Division, in the notice of proposed IHA and request for comments and possible renewal published in the *Federal Register* on June 23, 2022 (87 FR 37560 to 37598), as well as from revisions after the public comment period. The final IHA may have minor changes that will not affect this opinion.

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

INCIDENTAL HARASSMENT AUTHORIZATION

The Lamont-Doherty Earth Observatory of Columbia University (L-DEO) 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 is valid only for geophysical survey activity as specified in L-DEO's 2022 IHA application and for use of an airgun array aboard the R/V *Langseth* with characteristics specified in the IHA application, in the Northeast Pacific Ocean at the Cascadia Subduction Zone and Juan de Fuca Plate.

3. <u>General Conditions</u>

    a. A copy of this IHA must be in the possession of L-DEO, the vessel operator, the lead protected species observer (PSO), and any other relevant designees of L-DEO operating under the authority of this IHA.

b. The species and/or stocks authorized for taking are listed in Table 1. Authorized take, by Level B harassment only, is limited to the species and numbers listed in Table 1.

c. The taking by Level A harassment, 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 appear within or enter the Level B harassment zone (Table 2) the acoustic source must be shut down.

e. L-DEO must ensure that relevant vessel personnel and the PSO team participate in a joint onboard briefing led by the vessel operator and lead PSO to ensure that responsibilities, communication procedures, protected species monitoring protocols, operational procedures, and IHA requirements are clearly understood.

4. Mitigation Requirements

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

a. L-DEO must use independent, dedicated, trained visual 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.

b. At least one visual PSO must have a minimum of 90 days at-sea experience working in that role during a shallow penetration or low energy 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).

ii. Visual monitoring of the exclusion and buffer zones must begin no less than 30 minutes prior to ramp-up, including for nighttime ramp-ups, and must

continue until one hour after use of the acoustic source ceases or until 30 minutes past sunset.

iii. Visual PSOs must coordinate to ensure 360° visual coverage around the vessel from the most appropriate observation posts, and must conduct visual observations using binoculars and the naked eye while free from distractions and in a consistent, systematic, and diligent manner. The estimated harassment zone is provided in Table 2 for reference.

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.

d. Exclusion zones and buffer zones

i. Except as provided below in 4(d)(ii), the PSOs must establish and monitor exclusion zones and additional buffer zones. During all survey effort, the exclusion zone shall be 100 m with an additional 100 m buffer zone (total 200 m). The 200-m zone shall serve to focus observational effort but not limit such effort; observations of marine mammals beyond these distances 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 the defined distance from the edges of the airgun array (rather than being based on the center of the array or around the vessel itself). The buffer zone encompasses the area at and below the sea surface from the edge of the exclusion zone, out to the defined distance from the edges of the airgun array. 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 500-m exclusion zone must be established for Beaked whales (*Ziphiidae* spp.), Dwarf and pygmy sperm whales (*Kogia* spp.), killer whale (*Orcinus orca*), a large whale[1] with a calf, and groups of 6 or more large whales during all survey effort. No buffer zone is required.

e. Pre-start clearance and Ramp-up

[1] Large whale defined as sperm whale or any baleen whale; calf is defined as an animal less than two-thirds the body size of an adult observed to be in close association with an adult.

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(e)(v). Ramp-up must begin with activation of on 45 in^3 airgun, with the second 45 in^3 airgun added after 5 minutes.

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, pygmy sperm whales, dwarf sperm whales, beaked whales, pilot whales, killer whales, Risso's dolphin).

iii. 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 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.

iv. 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 observation and no 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.

v. 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.

f. Shutdown requirements

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 a marine mammal appears within or enters 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 shutdown requirements described in 4(f)(iii) shall be waived for small dolphins of the following genera: *Delphinus, Stenella, and Lissodelphis.*

1. If a small delphinid (individual of the Family Delphinidae, which includes the aforementioned dolphin genera), is visually detected and localized within the exclusion zone, no shutdown is required unless the PSO confirms the individual to be of a genera other than those listed above, in which case a shutdown is required.

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

v. Upon implementation of shutdown, the source may be reactivated after the marine mammal(s) has been observed exiting the applicable 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, pilot whales, killer whales, and Risso's dolphin) with no further observation of the marine mammal(s).

vi. Shutdown of the array is required upon observation of a species for which authorization has not been granted, or a species for which authorization has been granted but the authorized number of takes has been met, approaching or observed with in any harassment zone (Table 2).

g. Vessel strike avoidance

i. Vessel operators and crews must maintain a vigilant watch for all protected species and slow down, stop their vessel, or alter course, as appropriate and regardless of vessel size, to avoid striking any protected species. 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 protected species from other phenomena and 2) broadly to identify a marine mammal to taxonomic group (i.e., as a large whale or other marine mammal).

ii. Vessel speeds must also 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 500 m from North Pacific right whales. If a whale is observed but cannot be confirmed as a species other than a right whale, the vessel operator must assume that it is a right whale and take appropriate action.

iv. All vessels must maintain a minimum separation distance of 100 m from sperm whales and all other baleen whales.

v. All vessels 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).

vi. When protected species 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 protected species 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.

vii. 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

The holder of this Authorization is required to conduct marine mammal monitoring during survey activity. Monitoring must be conducted in accordance with the following requirements:

a. The operator must provide a night-vision device suited for the marine environment for use during nighttime ramp-up pre-clearance, at the discretion of the PSOs. At minimum, the device should feature automatic brightness and gain control, bright light protection, infrared illumination, and optics suited for low-light situations.

b. 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.

c. 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. Reticle binoculars (e.g., 7 x 50) of appropriate quality (at least one per PSO, plus backups).

ii. Global Positioning Unit (GPS) (plus backup).

iii. Digital single-lens reflex cameras of appropriate quality that capture photographs and video (plus backup).

iv. Compass (plus backup)

v. Radios for communication among vessel crew and PSOs (at least one per PSO, plus backups).

vi. Any other tools necessary to adequately perform necessary PSO tasks.

d. Protected Species Observers Qualifications

i. PSOs must have successfully completed an approved PSO training course.

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 PSO with experience as shown in 4(b) shall be designated as the lead for the PSO team. The lead must coordinate duty schedules and roles for the PSO team and serve as primary point of contact for the vessel operator. (Note that the responsibility of coordinating duty schedules and roles may instead be assigned to a shore-based, third-party monitoring coordinator.) To the maximum extent practicable, the lead PSO must devise the duty schedule such that experienced PSOs are on duty with those PSOs with appropriate training but who have not yet gained relevant experience.

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.

e. 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:

1. Vessel name and call sign;
2. PSO names and affiliations;
3. Date and participants of PSO briefings (as discussed in General Requirement);
4. Dates of departure and return to port with port name;
5. Dates and times (Greenwich Mean Time) of survey effort and times corresponding with PSO effort;
6. Vessel location (latitude/longitude) when survey effort began and ended and vessel location at beginning and end of visual PSO duty shifts;
7. Vessel heading and speed at beginning and end of visual PSO duty shifts and upon any line change;
8. 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;
9. 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
10. 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 protected species, the following information must be recorded:

1. Watch status (sighting made by PSO on/off effort, opportunistic, crew, alternate vessel/platform);
2. PSO who sighted the animal;
3. Time of sighting;
4. Vessel location at time of sighting;
5. Water depth;
6. Direction of vessel's travel (compass direction);
7. Direction of animal's travel relative to the vessel;
8. Pace of the animal;
9. Estimated distance to the animal and its heading relative to vessel at initial sighting;
10. 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;
11. Estimated number of animals (high/low/best);
12. Estimated number of animals by cohort (adults, yearlings, juveniles, calves, group composition, etc.);
13. 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);
14. 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);
15. Animal's closest point of approach (CPA) and/or closest distance from any element of the acoustic source;
16. Platform activity at time of sighting (e.g., deploying, recovering, testing, shooting, data acquisition, other); and
17. Description of any actions implemented in response to the sighting (e.g., delays, shutdown, ramp-up) and time and location of the action.

6. <u>Reporting</u>

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 protected species 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;

   iv. Summary of dates and locations of survey operations (including (1) the number of days on which the airgun array was active, including which array was being used and (2) the percentage of time and total time the array was active during daylight vs. nighttime hours (including dawn and dusk)) and all marine mammal sightings (dates, times, locations, activities, associated survey activities);

   v. Geo-referenced time-stamped vessel tracklines for all time periods during which airguns were operating. Tracklines should include points recording any change in airgun status (e.g., when the airguns began operating, when they were turned off, or when they changed from full array to single gun or vice versa);

   vi. GIS files in ESRI shapefile format and UTC date and time, latitude in decimal degrees, and longitude in decimal degrees. All coordinates must be referenced to the WGS84 geographic coordinate system;

   vii. Raw observational data.

b. Reporting injured or dead marine mammals:

   i. Discovery of injured or dead marine mammal – In the event that personnel involved in the survey activities covered by the authorization discover an injured or dead marine mammal, L-DEO must report the incident to the Office of Protected Resources (OPR) (301-427-8401), NMFS and to the NMFS West Coast regional Stranding Coordinator (866-767-6114). The report must include the following information:

      1. Time, date, and location (latitude/longitude) of the first discovery (and updated location information if known and applicable);

      2. Species identification (if known) or description of the animal(s) involved;

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

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

5. If available, photographs or video footage of the animal(s); and

6. General circumstances under which the animal was discovered.

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

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

2. Species identification (if known) or description of the animal(s) involved;

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

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

5. Status of all sound sources in use;

6. Description of avoidance measures/requirements that were in place at the time of the strike and what additional measures were taken, if any, to avoid strike;

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

8. Estimated size and length of animal that was struck;

9. Description of the behavior of the marine mammal immediately preceding and following the strike;

10. If available, description of the presence and behavior of any other marine mammals immediately preceding the strike;

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

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

c. Reporting Species of Concern – L-DEO must immediately report all observations of Southern Resident killer whales and North Pacific Right Whales to OPR, NMFS (301-427-8401). The report must include the following information:

i. Time, date, and location (latitude/longitude, water depth) of the observation;

ii. Description of the animal(s) seen, including number of animals, estimated age and sex classes observed, and distinguishing features;

iii. Behavior observations (e.g., number of blows/breaths, number of surfaces, breaching, spyhopping, diving, feeding, traveling; as explicit and detailed as possible);

iv. Direction of vessel's travel (compass direction) and direction of animal's travel relative to the vessel; and

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

7. This Authorization may be modified, suspended or revoked if the holder fails to abide by the conditions prescribed herein (including, but not limited to, failure to comply with monitoring or reporting requirements), or if NMFS determines: (1) the authorized taking is likely to have or is having more than a negligible impact on the species or stocks of affected marine mammals, or (2) the prescribed measures are likely not or are not effecting the least practicable adverse impact on the affected species or stocks and their habitat.

8. <u>Renewals</u>

a. On a case-by-case basis, NMFS may issue a one-time, one-year Renewal IHA following notice to the public providing an additional 15 days for public comments when (1) up to another year of identical, or nearly identical, activities are planned or (2) the specified activities would not be completed by the time this IHA expires and a Renewal would allow for completion of the activities, provided all of the following conditions are met:

i. A request for renewal is received no later than 60 days prior to the needed Renewal IHA effective date (the Renewal IHA expiration date cannot extend beyond one year from expiration of this IHA).

ii. The request for renewal must include the following:

1. An explanation that the activities to be conducted under the requested Renewal IHA are identical to the activities analyzed for this IHA, are a subset of the activities, or include changes so minor (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).

2. A preliminary monitoring report showing the results of the required monitoring to date and an explanation showing that the monitoring results do not indicate impacts of a scale or nature not previously analyzed or authorized.

iii. Upon review of the request for Renewal, the status of the affected species or stocks, and any other pertinent information, NMFS determines that there are no more than minor changes in the activities, the mitigation and monitoring measures will remain the same and appropriate, and the findings made in support of this IHA remain valid.

Kimberly Damon-Randall,

Director, Office of Protected Resources,

National Marine Fisheries Service.

Table 1. Numbers of Incidental Take of Marine Mammals Authorized.

Species	MMPA Stock	Authorized Take by Level B Harassment
Humpback whale (*Megaptera novaeangliae*)	California/Oregon/Washington	2
Blue whale (*Balaenoptera musculus)*	Eastern North Pacific	2
Fin whale (*Balaenoptera physalus*)	California/Oregon/Washington	4
Sei whale (*Valaenoptera borealis*)	Eastern North Pacific	2
Minke whale (*Balaenoptera acutorostrata*)	California/Oregon/Washington	2
Sperm whale (*Physeter macroccephalus*)	California/Oregon/Washington	7
Baird's beaked whale (*Berardius Bairdii*)	California/Oregon/Washington	9
Small beaked whale (*Mesoplodon* spp.)	California/Oregon/Washington	4[1]
Striped dolphin (*Stenella coeruleoalba*)	California/Oregon/Washington	46
Short-beaked common dolphin (*Delphinus delphis*)	California/Oregon/Washington	179
Pacific white-sided dolphin (*Lagenorhynchus obliquidens*)	California/Oregon/Washington	99
Northern right whale dolphin (*Lissodelphis borealis*)	California/Oregon/Washington	82
Risso's dolphin (*Grampus griseus*)	California/Oregon/Washington	22
Killer whale (*Orcinus orca)*	West Coast Transient	7
	North Pacific Offshore	
Pygmy/dwarf sperm whale (*Kogia* spp.*)*	California/Oregon/Washington	3

Dall's porpoise (*Phocoenoides dalli)*	California/Oregon/Washington	155
Northern fur seal (*Callorhinus ursinus)*	Eastern Pacific	17
	California	
Guadalupe fur seal (*Arctocephalus townsendi)*	Mexico	49
California sea lion (*Zalophus californianus)*	United States	9
Steller sea lion (*Eumetopias jubatus*)	Eastern	4
Northern elephant seal (*Mirounga angustirostris*)	California Breeding	62

[1]Includes one take of each: Balinville's beaked whale, Stejneger's beaked whale, Cuvier's beaked whale, and Hubbs' beaked whale.

Table 2. Level B Harassment Zones

Airgun Configuration	Water Depth (m)	Level B harassment zone (m)
Two 45 in^3 GI guns	>1,000	553