

# PROTECTED SPECIES MITIGATION AND MONITORING REPORT

Geophysical Seismic Survey, Cascadia Subduction Zone (Cruise ID No. SR2519)

*R/V Sally Ride* (Callsign: WSAF)

05 September 2025 to 09 September 2025



Version 3  
Dec 18, 2025

**REPORT**

**Report Author**

Name	Draft Submission Date
Zackary Forest	October 09, 2025
Zackary Forest	December 02, 2025
Zackary Forest	December 18, 2025

**Report Reviewer**

Name	Date of Review
Ben Finkes	October 09, 2025
Ben Finkes	December 02, 2025
Ben Finkes	December 18, 2025

**Final Report Approval**

Name	Stephanie Milne
Title	Team Leader – Senior Environmental Manager
Signature	Signed by:  <small>D79CCDBA1D504DC...</small>
Date	Dec 18, 2025

**This deliverable was prepared by Tetra Tech RPS Energy in accordance with generally accepted professional practices that are typically utilized for scientific work products. The work was performed within the limitations and assumptions of our approved scope of work, and the descriptive documentation associated with this deliverable. Unless explicitly included in our approved scope of work, information provided in this deliverable has not been prepared to meet industry standards for engineering and should not be used for construction.**

Prepared by:

Prepared for:

**Tetra Tech RPS Energy**

**The National Science Foundation**

Stephanie Milne  
 Team Leader – Senior Environmental Manager  
 575 N Dairy Ashford Rd  
 Building 1, Suite 700  
 Houston, TX 77079  
**T** +1 281 589 7257  
**E** stephanie.milne@tetrattech.com

For Submission to:  
 National Marine Fisheries Service  
 Office of Protected Resources  
 1315 East-West Hwy, Silver Spring, MD  
 20910-3282

**REPORT**

**Contents**

Acronyms and Abbreviations ..... iv

**1 EXECUTIVE SUMMARY ..... 5**

**2 INTRODUCTION ..... 7**

2.1 Project Overview and Location ..... 7

2.1.1 Energy source and receiving systems ..... 9

**3 MONITORING AND MITIGATION PROGRAM ..... 10**

3.1 Visual Monitoring: Protocols and Methods ..... 10

3.2 Visual Monitoring Survey Methodology ..... 12

**4 MONITORING EFFORT SUMMARY ..... 15**

4.1 Survey Operations Summary ..... 15

4.1.1 General survey parameters ..... 15

4.1.2 Acoustic source operations ..... 16

4.2 Visual Monitoring Survey Summary ..... 16

4.3 Environmental Conditions ..... 17

**5 MONITORING AND DETECTION RESULTS ..... 19**

5.1 Visual Detections of Protected Species ..... 19

5.2 Other Wildlife ..... 21

**6 MITIGATION ACTION SUMMARY ..... 22**

6.1 Vessel Strike Avoidance (VSA) Maneuvers ..... 22

6.2 Protected Species Known to Have Been Exposed to 160 Decibels or Greater of Received Sound Levels ..... 22

6.3 Implementation and Effectiveness of the Biological Opinion and IHA ..... 23

**Tables**

Table 1: Specific detections of protected species and their required mitigation actions..... 11

Table 2: Separation distances, buffer and shutdown zones sizes for each species / species group expected to occur in the survey area during the survey. .... 11

Table 3: Predicted 160 and 175 dB zones implemented during the seismic survey..... 12

Table 4: Survey parameters..... 15

Table 5: Suspension of source operations during the survey ..... 15

Table 6: Total acoustic source operations during the survey ..... 16

Table 7: Initiation and termination of visual monitoring during the survey..... 16

Table 8: Total visual monitoring effort during the survey ..... 17

Table 9: Visibility during the survey (in km) ..... 17

Table 10: Precipitation during the survey ..... 17

Table 11: BSS during the survey ..... 18

Table 12: Wind speed during the survey ..... 18

Table 13: Swell height during the survey ..... 18

Table 14: Glare during the survey..... 18

Table 15: Number of visual detection records collected for each protected species during the survey. .... 19

Table 16: Number of authorized and potential Level A and B harassment exposures during the survey. .... 22

## REPORT

---

### Figures

Figure 1: Area and planned survey lines of the seismic survey .....	8
Figure 2: All Protected Species Observed by Group During the Survey .....	20
Figure 3: All Protected Species Observed by Common Name During the Survey.....	21

### Appendices

**APPENDIX A : INCIDENTAL HARASSMENT AUTHORIZATION**

**APPENDIX B : BIOLOGICAL OPINION**

**APPENDIX C : PROTECTED SPECIES OBSERVERS ONBOARD THE *R/V SALLY RIDE***

**APPENDIX D : COMPLETE SURVEY DATASHEETS (PROVIDED IN ATTACHED FILE IN EXCEL FORMAT)**

**APPENDIX E : PHOTOS OF PROTECTED SPECIES DURING THE SURVEY**

**APPENDIX F : TRACKLINE SHAPEFILES (PROVIDED SEPARATELY)**

**APPENDIX G : RETICLE BINOCULAR CALIBRATION TABLE**

## REPORT

---

### Acronyms and Abbreviations

ADCP – Acoustic doppler current profiler  
BiOp – Biological Opinion  
BSS – Beaufort Sea State  
BZ – Buffer zone  
DPS – Distinct population segment  
EA – Environmental Assessment  
EEZ – Exclusive Economic Zone  
ESA – Endangered Species Act  
ft – Feet  
GI – Generator-injector  
Hz – Hertz  
IHA – Incidental Harassment Authorization  
in – Inch  
kHz – Kilohertz  
km – Kilometer  
kn – knot  
MBES – Multi-beam echosounder  
MCS – Multi-channel seismic  
MMPA – Marine Mammal Protection Act  
NMFS – National Marine Fisheries Service  
NMT – New Mexico Institute of Mining and Technology  
NSF – National Science Foundation  
OR – Oregon  
OSU – Oregon State University  
PSO – Protected species observer  
PTS – Permanent threshold shift  
RMS – Root mean square  
R/V – Research vessel  
SIO – Scripps Institution of Oceanography  
SD – Separation distance  
SZ – Shutdown zone  
TTS – Temporary threshold shift  
μPa – Micropascal  
VSA – Vessel strike avoidance  
WA – Washington

**REPORT**

---

# 1 EXECUTIVE SUMMARY

The Research Vessel (*R/V Sally Ride*), which is owned by the United States Navy, and operated by the Scripps Institution of Oceanography (SIO), conducted a geophysical seismic survey in the Cascadia Subduction Zone off the United States coasts of Oregon (OR) and Washington (WA) states, in the Northeast Pacific Ocean, using a portable multi-channel seismic (MCS) system operated by marine technicians from SIO. The vessel mobilized in Newport, OR and transited to the survey site on 05 September 2025. The seismic survey (referred to herein as “survey”) was conducted between 06 September 2025 and 08 September 2025. The operational activities were funded by the National Science Foundation (NSF) and conducted in support of research by New Mexico Institute of Mining and Technology (NMT) and Oregon State University (OSU). The research activities were led by Principal Investigators (PIs) Dr. G. Spinelli (NMT), and Co-PIs Drs. R. Harris and A. Tréhu (OSU).

The primary goal of the seismic survey was to quantify the thermal effects of fluid circulation in oceanic crust entering the Cascadia Subduction Zone. This seismic data would be used to define the basement topography and overlying sedimentary structure. This information is needed to both plan the heat flow survey and interpret the heat flow results.

This report was prepared to meet the reporting requirements for the survey required under the Marine Mammal Protection Act (MMPA) and Endangered Species Act (ESA). On 17 February 2025, SIO applied to the US National Marine Fisheries Service (NMFS), on behalf of the action agencies, for an Incidental Harassment Authorization (IHA) that would allow for the potential harassment of small numbers of protected marine mammals incidentally during the seismic survey. NSF was issued the final Environmental Assessment (EA) on 15 August 2025. NMFS issued their Biological Opinion (BiOp) on 26 August 2025 and the IHA on 27 August 2025.

Mitigation measures were implemented to minimize potential impacts to marine mammals and sea turtles. These measures included, but were not limited to, the use of NMFS approved protected species observers (PSOs) for visual monitoring, the designation and implementation of buffer zones (BZ) and shutdown zones (SZ) where the presence of a protected species would require a mitigation action, and the implementation of ramp-up procedures, mitigation actions (including delayed operations and shutdowns), and vessel strike avoidance (VSA) maneuvers. Continuous protected species observation coverage during daytime survey operations was provided by Tetra Tech RPS Energy, the PSO provider contracted for the survey. PSOs monitored and reported on the presence and behavior of protected species and directed the implementation of the mitigation measures, as described in the regulatory documents issued for the survey.

A team of three PSOs were deployed to the *R/V Sally Ride* to undertake visual observations and implement mitigation to support day-time survey operations. Visual observations were conducted by PSOs for a total of 49 hours and 28 minutes. The seismic source was active for a total of 34 hours and 56 minutes.

A total of 29 visual detections of marine mammals were made during the survey. Visual detections of marine mammals consisted of three whale species, one delphinid species, one phocoenid species, two pinniped species, and one mustelid species. Whale species observed consisted of a gray whale (*Eschrichtius robustus*), a fin whale (*Balaenoptera physalus*), and humpback whales (*Megaptera novaeangliae*). Pacific white-sided dolphins (*Lagenorhynchus obliquidens*) was the only delphinid observed. Harbor porpoise (*Phocoena phocoena*) were the only phocoenid observed. Pinnipeds observed included a harbor seal (*Phoca vitulina*) and California sea lions (*Zalophus californianus californianus*). Sea otters (*Enhydra lutris*) were the only mustelid observed. There were also additional unidentified whales and pinnipeds observed. There were no visual detections of other protected species during the survey.

Additionally, no dead or injured animals were observed.

In accordance with stipulations set forth in regulatory documents, a total of five mitigation actions were implemented for vessel strike avoidance. Zero mitigation actions were required or implemented for the seismic source.

The IHA issued by NMFS authorized 435 Level B takes for 21 species, including six individual species listed as endangered, and one species group (beaked whales). There were zero Level A takes authorized for this survey.

## REPORT

---

For this report, the definition of Level A and Level B takes are the same as found in the MMPA and the NMFS issued BiOp regarding what constitutes a take. There was no specified number of authorized takes for ESA-listed sea turtle species.

Throughout the survey program, there were zero marine mammals or sea turtles observed within the predicted 160-decibel (dB) radius or within the predicted 175 dB radius, constituting potential Level B takes. There were no protected species observed within the predicted radius at which there is a potential for auditory injury (based upon each species hearing range and how that overlaps with the frequencies produced by the sound source), constituting potential Level A takes.

**REPORT**

---

## 2 INTRODUCTION

The following report details protected species monitoring and mitigation as well as seismic survey operations undertaken as part of the geophysical survey onboard the *R/V Sally Ride* in the Cascadia Subduction Zone off the United States coasts of OR and WA, in the Northeast Pacific Ocean, from 05 September 2025 to 09 September 2025, with seismic source operations occurring from 06 September 2025 to 08 September 2025.

This document serves to meet the reporting requirements dictated in the IHA and BiOp issued to NSF by NMFS on 27 August 2025 and 26 August 2025, respectively. The IHA authorized takes of specific protected species incidental to the survey. NMFS has stated that seismic source received sound levels equal to or greater than 160 dB re 1  $\mu$ Pa (micropascal) root mean square (RMS) (160 dB) could potentially disturb marine mammals, temporarily disrupting behavior, such that they could be considered non-lethal ‘takes’ (Level B harassment). In April 2018, NMFS released a revised version of technical guidance for assessing the effects of anthropogenic sound on marine mammal hearing, which established thresholds for permanent threshold shift (PTS) onset, temporary threshold shift (TTS), and Level A harassment (auditory injury), for marine mammal species. Predicted distances to Level A harassment vary based on species specific hearing groups – low frequency cetaceans, mid frequency cetaceans, high frequency cetaceans, phocid pinnipeds, and otariid pinnipeds– and how each group’s hearing range overlaps with the frequencies produced by the sound source. For sea turtles, per the ESA, NMFS has stated that received sound levels equal to or greater than 175 dB represents the current best understanding of the threshold at which they exhibit behavioral responses. The most recent NMFS Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (NMFS 2024) replaced PTS with auditory injury.

NMFS requires that measures such as BZs, SZs, delayed operations, ramp-ups, and shutdowns be implemented to mitigate for potentially adverse effects of the acoustic source sounds on protected species. The BZs and SZs were established from any element on the acoustic source array as areas where the presence of a protected species would require the implementation of a mitigation action (see Section 3.1). For all protected species, the occurrence of an individual detected approaching, entering, or within their designated SZ would require the implementation of a shutdown of the seismic source. NMFS specified a 100-meter (m) and a 500 m SZ for the survey for differing marine mammals, and a 150 m SZ for sea turtles. These SZs encompass all zones within which auditory injury (Level A harassment) could occur on the basis of instantaneous exposure, provides additional protection from the potential for more severe behavioral reactions for marine mammals at relatively close range to the acoustic source, provides a consistent area for PSOs to conduct effective observational effort, and is a distance within which detection probabilities are reasonably high for most species under typical conditions.

In accordance with the IHA, the PSO team conducted an onboard environmental management briefing with the vessel personnel prior to the start of source operations of the survey. The Lead PSO covered the mitigation and monitoring protocols, communication procedures, roles and responsibilities of the monitoring team and any additional operational procedures for this survey.

The IHA is attached as Appendix A and the BiOp as Appendix B.

### 2.1 Project Overview and Location

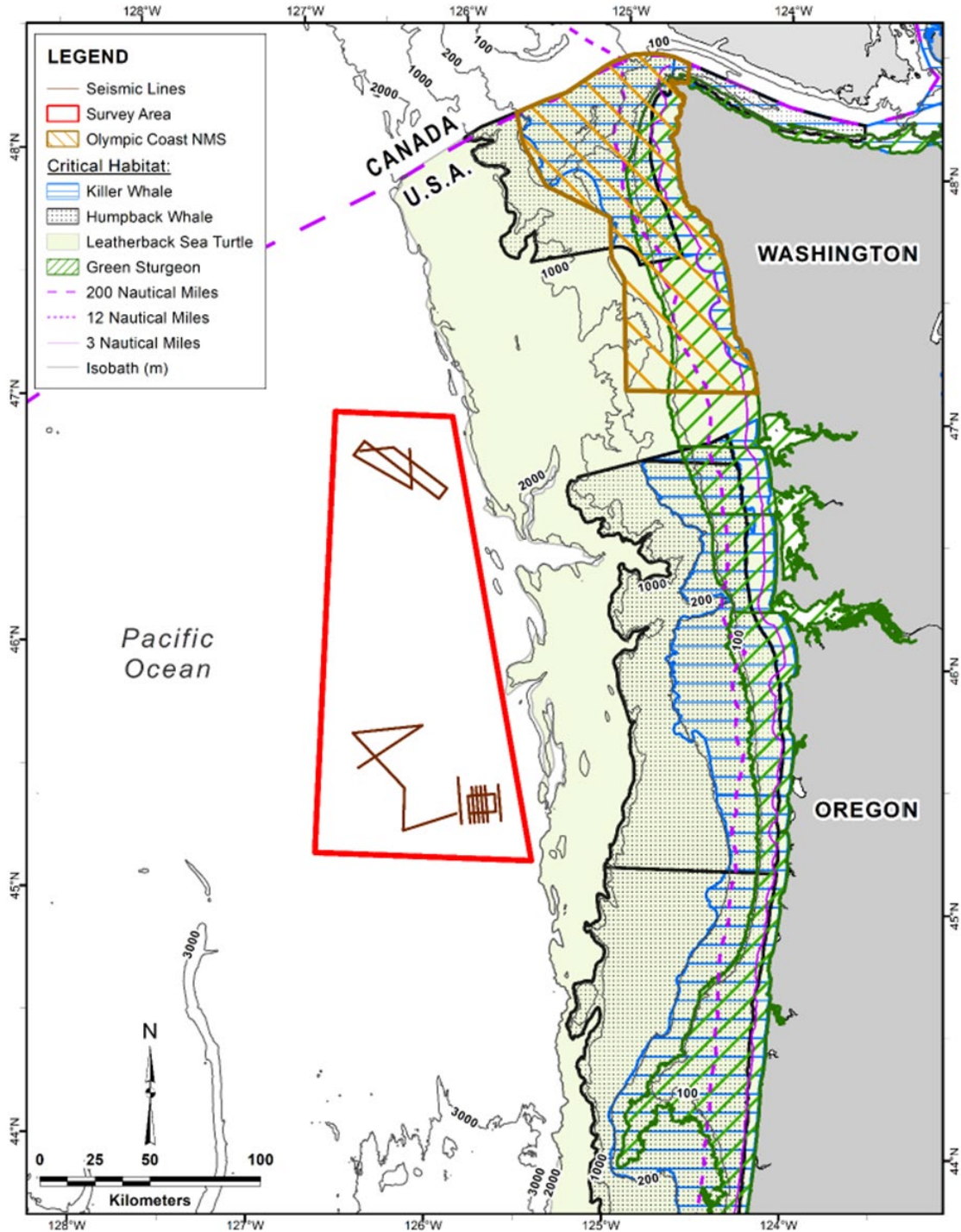
The research activities involved a marine geophysical seismic survey located over the Cascadia Subduction Zone of the Northeast Pacific Ocean, off the coasts of Washington and Oregon, and within the Exclusive Economic Zone (EEZ) of the United States (Figure 1). Water depths in the survey area were between 2,000 and 3,500 m (6,562 to 11,483 feet (ft)).

The primary goal of the seismic survey was to quantify the thermal effects of fluid circulation in oceanic crust entering the Cascadia Subduction Zone.

**REPORT**

All operations for the survey were conducted solely by *R/V Sally Ride*. The vessel is 72.5 m (238 ft) in length and has a beam of ~15 meters (50 ft) and a maximum draft of ~4.6 meters (15.1 ft). The vessel’s cruising speed was approximately 10 knots (kn) during transits and varied between two and five kn during seismic survey acquisition operations.

Seismic source operations for the survey were conducted between 06 - 08 September 2025 for a total of three days. In the map in Figure 1, the red lines indicate the survey area.



**Figure 1: Area and planned survey lines of the seismic survey**

**REPORT**

---

**2.1.1 Energy source and receiving systems**

For the survey, the energy sources consisted of two towed seismic sources. The source array utilized Generator-Injector (GI) airguns with a maximum discharge volume of ~45 cubic inches (in<sup>3</sup>) each. The dominant frequency components ranged from zero to 188 hertz (Hz), and nominal source levels ranged from 234.3 dB re: 1 µPa (zero to peak) to 239.6 dB re: 1 µPa (peak-to-peak). The maximum source volume of both source elements was ~90 in<sup>3</sup>. The source elements were towed at a depth of four meters. The shot point interval was approximately ~12.5 - 25 m (5 – 10 seconds). The source was situated 25 m from the stern.

The receiving system consisted of a single 1 kilometer (km) long hydrophone streamer towed behind the vessel. As the airguns were towed along the survey line, the solid-state (solid flexible polymer made from extruded polyurethane, not gel or oil filled) hydrophone streamer received the returning acoustic signals and transferred the data to the on-board processing system.

Additional sound sources used in support of research efforts included a Kongsberg EM124 and a Kongsberg EM712 multi-beam echosounder (MBES), a Kongsberg SBP29 sub-bottom profiler (SBP), Teledyne RDI Ocean Surveyor acoustic doppler current profiler (ADCP), Teledyne RDI Workhorse II Mariner ADCP, Kongsberg EC150 fisheries echosounder and ADCP, and fisheries echosounder EK80. The EM124 MBES operated at frequency of 12 kilohertz (kHz) and the EM712 MBES operated at frequencies between 40 and 100 kHz. The Kongsberg EM712 has a 0.5-degree x 1 degree transducer array. The SBP is a parametric source operated with a primary frequency range of 2 - 9 kHz and a 3°, 6°, or 12° transmit beam width, with up to 21 beams across per ping, and a source level at 4 kHz of 228 dB for the 3° system. The EC150 operates at a frequency of 150 kHz. The fisheries echosounder EK80 operates at frequencies of 200 kHz, 70 kHz, 38 kHz, or 18 kHz. The Teledyne RDI Ocean Surveyor had three available transducers which operated at frequencies of 38 kHz, 75 kHz, or 150 kHz.

### 3 MONITORING AND MITIGATION PROGRAM

The PSO monitoring program on the *R/V Sally Ride* was established to meet the standards set forth in the IHA and BiOp requirements. Survey mitigation measures were designed to minimize potential impacts of the *R/V Sally Ride* seismic source activities on marine mammals and sea turtles.

The following monitoring protocols were implemented to meet these objectives, and each are described in detail in a sub-section below:

- Visual observations were conducted during daytime while geophysical operations took place, and during transit for strike avoidance, to provide daytime sighting data, allowing for the implementation of mitigation procedures as necessary.
- Species specific separation distances (SDs) were established around the vessels where strike avoidance maneuvers were implemented when protected species were detected inside or approaching those distances.
- Species specific BZs and SZs were established around the airguns in accordance with the regulatory documents. Delays to initiation and shutdowns of the airguns were to be implemented if protected species were detected inside these zones.
- Effects of marine species exposed to sound levels constituting a defined take were observed and documented. The nature of the probable consequences was discussed when possible.

In addition to the mitigation objectives outlined in the project regulatory documents, PSOs collected and analyzed necessary data mandated by the IHA.

#### 3.1 Visual Monitoring: Protocols and Methods

Mitigation actions were implemented for visual detections of protected species, including marine mammals and sea turtles as outlined in the IHA and BiOp. These actions included the establishment of BZs and SZs as the areas in which the presence of a protected species would trigger a mitigation action, and the implementation of delayed operations and shutdowns (where the seismic source was fully silenced) for protected species detected approaching, entering, or within their designated BZ and SZ (Table 1 and Table 2). Throughout the detections, PSOs would keep in frequent contact with the seismic team, relaying information on the location and movement of the protected species, and the implementation of any needed mitigation actions and clearances to begin/resume operation of the seismic source.

Before the seismic source could be activated from silence during daytime, a 30-minute clearance search period of the BZs and SZs was conducted. This search period was conducted by two PSOs. In the event of a detection of protected species within their designated zones (Table 2) or as outlined in Table 1, a delay of source activation operations would be implemented. Source operations would not be cleared to begin until the protected species were observed exiting their designated zones, or if they were not observed exiting their zone, then 15 or 30 minutes (species dependent, see Table 2) following the final detection of the individual(s) within their zone.

Once the seismic source was active, the BZs from any element on the source array were established as areas in which the presence of a protected species would initiate an alert to the seismic operators that the animal was detected, and that the implementation of a mitigation action may soon be required. The SZs from any active source element were established as areas in which the detection of a protected species would require a shutdown of the seismic source. For marine mammals and sea turtles, the detection of one approaching, entering, or within their designated zone would require a shutdown (excluding the specified shut-down exempt delphinid species per the IHA and BiOp).

Upon the implementation of a shutdown for a detection of marine mammals, a ramp-up was required to resume source activity once the protected species were confirmed to have exited their designated SZs. For sea turtles, source activity could resume to the previous operative volume without a ramp-up once the protected species were confirmed to have exited their designated SZs. If the protected species could not be confirmed to have

**REPORT**

exited their designated SZ (i.e., if they dove/submerged within the zone and were not re-sighted), then clearance for source activity to resume would not be given until 15 or 30 minutes (species dependent, see Table 2) following the final detection of the individual(s) within their zone.

The IHA also outlined additional mitigation actions for specific protected species while the acoustic source was active as outlined in Table 1.

**Table 1: Specific detections of protected species and their required mitigation actions**

Detection of:	Mitigation Action Required
A large whale with a calf detected within 500 m from the seismic source.	Delayed operation of inactive source and shutdown of active source.
An aggregation of six or more large whales detected within 500 m from the seismic source.	Delayed operation of inactive source and shutdown of active source.
Any beaked whale detected at 500 m from the seismic source.	Delayed operation of inactive source and shutdown of active source.
Any marine mammal species not authorized for take observed approaching, entering, or within the 160-dB radius.	Delayed operation of inactive source and shutdown of active source.
Any marine mammal species for which the total authorized takes has been met observed approaching, entering, or within the 160-dB radius.	Delayed operation of inactive source and shutdown of active source.
Any other marine mammals detected approaching, entering, or within their designated buffer and shutdown zones.	Delayed operation of inactive source (buffer zone) and shutdown of active source (shutdown zone).
Any sea turtle species detected approaching, entering, or within their shutdown zone.	Delayed operation of inactive source and shutdown of active source (shutdown zone).
Any dolphin species with a shut-down exemption detected approaching, entering, or within their designated shutdown zones with an active source.	None.

**Table 2: Separation distances, buffer and shutdown zones sizes for each species / species group expected to occur in the survey area during the survey.**

Species/Species Groups	Separation Distance (m)	Buffer Zones (m)	Shutdown Zones (m)	Delay Duration (m)
Sperm whales and baleen whales	100	200	100	30
Large whale with a calf, and groups of six or more large whales	100	Not required	500	30
Beaked whales	50	Not required	500	30
Small delphinids and pinnipeds	50*	200	100*	15

**REPORT**

Species/Species Groups	Separation Distance (m)	Buffer Zones (m)	Shutdown Zones (m)	Delay Duration (m)
Other marine mammals	50*	200	100	30
Sea turtles	100**	N/A	150	15

\*Understanding that at times this may not be possible (e.g., for animals that approach the vessel)

\*\*100-meter separation distance for sea turtles is best practice, not regulator required.

\*\*\*Waived for small dolphins of the following genera: *Lagenorhynchus*, *Lissodelphis*, and *Delphinus*

Specific acoustic source operation procedures outlined in the IHA and BiOp that were relevant to these surveys included:

1. Ramp up consists of activating a single airgun, then activating the second airgun at minimum five minutes later (so long as the zone is still clear of marine mammals and sea turtles). The time between ramp-up completion and start of data acquisition had to be minimized.
2. Testing of individual elements required a 30-minute clearance search period but no ramp-up. Testing of more than one element or string required both a 30-minute clearance search and a ramp-up to the maximum source volume being tested.
3. Brief periods (less than 30 minutes) of operational silence for reasons other than a protected species shut-down did not required a ramp-up to resume source operations provided that: (1) PSOs maintained constant visual observations, and (2) no detections of protected species occurred within the applicable shutdown zone during that silent period. Any brief period of silence at night or in periods of poor visibility (e.g., Beaufort Sea State (BSS) of four or greater) required a ramp-up to resume source operations, but if constant monitoring was maintained, a 30-minute clearance search period was not required. Any longer shutdowns required both a 30-minute clearance search period and a ramp-up.

Table 3 outlines the predicted 160 dB radius (Level B harassment zone for marine mammals) and the predicted 175 dB radius (Level B harassment zone for sea turtles).

**Table 3: Predicted 160 and 175 dB zones implemented during the seismic survey.**

Source	Volume (in <sup>3</sup> )	Water Depth (m)	160 dB radius (m) – Level B harassment zone for marine mammals	175 dB radius (m) – Level B harassment zone for sea turtles
2 GI Airgun Array	~90	>1,000	505	89

Distances are from any single element on the array.

### 3.2 Visual Monitoring Survey Methodology

There were three experienced PSOs on board the *R/V Sally Ride* throughout the survey program to conduct monitoring for protected species, record and report detections, and request mitigation actions in accordance with the IHA and BiOp. The PSOs onboard were NMFS approved and held certifications from a recognized Bureau of Ocean Energy Management PSO course and are listed in Appendix C. Visual monitoring was primarily carried out from the bridge deck located 12.6 m above the surface of the water, with one PSO watching forward and one PSO watching back at all times during daylight hours which allowed a 360-degree viewpoint around the vessel and seismic source.

## REPORT

---

Visual monitoring methods were implemented in accordance with the survey requirements outlined in the IHA. A minimum of two PSOs were required to be on duty conducting monitoring during all daylight hours (30 minutes before sunrise to 30 minutes after sunset) when the seismic source(s) were deployed. A minimum of one PSO or visual observer was required to be on watch during daytime transits. Visual monitoring during the transits with the survey gear secured onboard was conducted to implement any needed VSA maneuvers and to gather baseline data on the presence and abundance of protected species in the areas during periods of acoustic source silence. Scheduled watches were a maximum of four hours followed by at least one hour of scheduled break time.

Visual observations were conducted around the entire area of the vessel and acoustic source, divided between the two PSOs on watch. The smaller monitoring area for each observer increased the probability of protected species being sighted. PSOs searched for blows, fins, splashes or disturbances of the sea surface, large flocks of feeding sea birds, and other sighting cues indicating the possible presence of a protected species. Upon the visual detection of a protected species, PSOs would identify the animals' range to the vessel and acoustic source. Range estimations were made using reticle binoculars, the naked eye, and by relating the animal(s) to an object at a known distance. PSOs would also identify to species, if possible, upon initial detection to ensure that the proper mitigation measures were implemented, should any be required.

As required by the IHA (section 5(c)(iii)), PSOs recorded the following information for each protected species detection:

1. Sighting ID (numeric);
2. Watch status (sighting made by PSO on/off effort, opportunistic, crew, alternate vessel/platform);
3. Location of PSO/observer (description);
4. Vessel activity at the time of the sighting (e.g., deploying, recovering, testing, shooting, data acquisition, other);
5. PSO who sighted the animal/ID;
6. Time/date of sighting (GMT/UTC, MM/DD/YYYY);
7. Initial detection method (description);
8. Sighting cue (description);
9. Vessel location at time of sighting (decimal degrees);
10. Water depth (meters);
11. Direction of vessel's travel (compass direction);
12. Speed (knots) of the vessel from which the observation was made;
13. Direction of animal's travel relative to the vessel (description, compass heading);
14. Bearing to sighting (degrees);
15. Identification of the animal (e.g., genus/species, lowest possible taxonomic level, or unidentified) and the composition of the group if there is a mix of species;
16. Species reliability (an indicator of confidence in identification)
17. Estimated distance to the animal (meters) and method of estimating distance;
18. Estimated number of animals (high/low/best) (numeric);
19. Estimated number of animals by cohort (adults, yearlings, juveniles, calves, group composition, etc.);
20. Description (as many distinguishing features as possible of each individual seen, including length, shape, color, pattern, scars or markings, shape and size of dorsal fin, shape of head, and blow characteristics);

**REPORT**

---

21. Detailed behavior observations (*e.g.*, number of blows/ breaths, number of surfaces, breaching, spyhopping, diving, feeding, traveling; as explicit and detailed as possible; note any observed changes in behavior);
22. Animal's closest point of approach (CPA) (meters) and/or closest distance from any element of the airgun array;
23. Description of any actions implemented in response to the sighting (*e.g.*, delays, shutdown, ramp-up) and time and location of the action.
24. Photos (Yes/No);
25. Photo Frame Numbers (list of numbers); and
26. Conditions at a time of sighting (*e.g.*, visibility, BSS)

PSOs took notes during the sighting event, and once the detection concluded, the detection details were recorded in a datasheet per the requirements of the IHA. Each sighting event was linked to an entry on an effort datasheet where specific environmental conditions (*e.g.*, Beaufort Sea State, wind force, swell height, visibility, and glare) and vessel activity were logged.

Species identifications were made whenever the distance from the observer, length of the sighting, and visual observation conditions allowed. Marine mammal identification manuals (*e.g.* Guide to Marine Mammals of Alaska, Marine Mammals and Turtles of the U.S. Atlantic & Gulf of Mexico) were consulted, and photos were examined to confirm identifications.

REPORT

## 4 MONITORING EFFORT SUMMARY

### 4.1 Survey Operations Summary

#### 4.1.1 General survey parameters

The survey program was conducted between 05 September 2025 and 09 September 2025. The vessel mobilized and demobilized in Newport, OR (Table 4). During survey operations, data was acquired continuously according to the survey plan from 06 September 2025 to 09 September 2025 with source operations only suspended when operationally necessary as outlined in Table 5. All dates and times provided in tables below are in Coordinated Universal Time (UTC).

**Table 4: Survey parameters**

Survey Parameter	Date (UTC)	Time (UTC)	Location
<b>Seismic Survey</b>			
Mobilization – depart port	05 September 2025	19:03	Newport, OR
Start of first pre-clearance watch	06 September 2025	13:20	Survey site
First seismic source activity	06 September 2025	14:06	Survey site
Start of acquisition	06 September 2025	14:18	Survey site
End of acquisition	08 September 2025	03:19	Survey site
All gear onboard	08 September 2025	15:08	Survey site
De-mobilization – arrive at port	09 September 2025	02:38	Newport, OR

**Table 5: Suspension of source operations during the survey**

Date (UTC)	Time Source Silenced (UTC)	Date (UTC)	Time Source Re-activated (UTC)	Reason for Interruption to Acquisition
06 September 2025	17:36	06 September 2025	18:35	Line change
06 September 2025	20:09	06 September 2025	08:14	Equipment recovery
07 September 2025	10:02	07 September 2025	10:38	Data acquisition error restart planned line
07 September 2025	12:26	07 September 2025	14:42	Data acquisition error restart planned line
07 September 2025	16:30	07 September 2025	17:25	Line change
07 September 2025	19:11	07 September 2025	19:59	Line change
07 September 2025	21:22	07 September 2025	21:51	Line change
07 September 2025	23:19	07 September 2025	23:21	Line change
08 September 2025	00:02	08 September 2025	00:06	Line change
08 September 2025	01:42	08 September 2025	01:58	Line change
08 September 2025	05:31	08 September 2025	05:43	Data acquisition error restart planned line
08 September 2025	08:22	08 September 2025	08:58	Data acquisition error restart planned line

**REPORT**

Date (UTC)	Time Source Silenced (UTC)	Date (UTC)	Time Source Re-activated (UTC)	Reason for Interruption to Acquisition
08 September 2025	13:11	08 September 2025	N/A	End of Survey

**4.1.2 Acoustic source operations**

Throughout the entire survey program, the seismic source was active on three days for a total of 34 hours 56 minutes. This total included: 33 minutes of ramp-up, 26 hours and 56 minutes of operations on a survey line, and 7 hours and 27 minutes not on a survey line. Table 6 summarizes the seismic source operations over the course of the survey program.

For the survey, the seismic source was ramped-up three times, with the ramp-ups having a duration between 10 and 12 minutes. Two ramp-ups occurred during daylight hours and one ramp-up occurred at night.

The geospatial data for source operations are provided as a shapefile attachment to this report.

The monitoring effort, source operations and protected species detections for this survey are provided as an excel dataset in Appendix D.

**Table 6: Total acoustic source operations during the survey**

Acoustic Source Operation	Overall Project	
	Number	Duration (hh:mm)
<b>Ramp-up</b>	<b>3</b>	<b>00:33</b>
Day-time ramp-ups	2	00:22
Reduced visibility ramp-ups (night/dawn/dusk)	1	00:11
<b>Full/Reduced Volume on a Survey Line</b>		<b>26:56</b>
<b>Full/Reduced Volume not on a Survey Line</b>		<b>07:27</b>
<b>Total Time Acoustic Source Was Active</b>		<b>34:56</b>

**4.2 Visual Monitoring Survey Summary**

Visual monitoring was conducted by one or two PSOs during all daylight hours, beginning 30 minutes before sunrise and ending 30 minutes after sunset each day, initiating when the vessel left dock at the beginning of the program and terminating upon the vessels return to dock at the end of the program (Table 7). During transit and other periods with no source operations, observations were undertaken by one PSO for VSA and to collect baseline data about protected species abundance in the survey areas. Visual monitoring was not conducted by PSOs during nighttime.

**Table 7: Initiation and termination of visual monitoring during the survey**

Visual Monitoring	Date (UTC)	Time (UTC)
Initiation (for VSA during transit)	05 September 2025	19:03
Termination (end of daylight)	06 September 2025	03:15
Initiation (start of daylight)	06 September 2025	13:20
Termination (end of daylight)	07 September 2025	03:22
Initiation (start of daylight)	07 September 2025	13:20

**REPORT**

Visual Monitoring	Date (UTC)	Time (UTC)
Termination (end of daylight)	08 September 2025	03:19
Initiation (start of daylight)	08 September 2025	13:23
Termination (for VSA during transit)	08 September 2025	02:38

Visual monitoring on the *R/V Sally Ride* was conducted over a period of five days for a total of 49 hours 28 minutes throughout the survey program. Of the overall total visual monitoring effort, 31% (15 hours and 18 minutes) was undertaken while the acoustic source was active, and 69% (34 hours and 10 minutes) was undertaken while the acoustic source was silent. Visual monitoring while the acoustic source was silent was mainly conducted during the transits and equipment deployment and retrieval. Table 8 details visual monitoring with acoustic source operations on the *R/V Sally Ride* throughout the seismic survey.

**Table 8: Total visual monitoring effort during the survey**

Visual Monitoring Effort	Duration (hh:mm)	% of Overall Effort
Total monitoring while acoustic source active	15:18	31
Total monitoring while acoustic source silent	34:10	69
<b>Total monitoring effort</b>	<b>49:28</b>	<b>100</b>

Visual observations on the *R/V Sally Ride* were conducted outside on the bridge deck and main deck, which provided a 360-degree view of the water around the vessel and the acoustic source.

### 4.3 Environmental Conditions

Environmental conditions can have an impact on the probability of detecting protected species. The environmental conditions present during visual observations undertaken during the survey program were generally considered to be ‘good’ to ‘moderate’.

Visibility was classified as ‘good’ if above 5 km. Monitoring effort on the *R/V Sally Ride* was undertaken in ‘good’ visibility conditions during 82% of the survey (Table 9).

Reduced visibility was mainly attributed to periods of rain and haze and the brief periods of reduced lighting during dawn and dusk.

**Table 9: Visibility during the survey (in km)**

Total	<0.05	0.05-0.1	0.1-0.3	0.3-0.5	0.5-1	1-2	2-5	>5
Duration (hh:mm)	00:00	01:57	00:00	00:00	00:00	02:53	04:06	40:32

Most visual monitoring aboard the *R/V Sally Ride* did not have precipitation (81%), with occasional light rain (10%) and haze (9%) (Table 10).

**Table 10: Precipitation during the survey**

Total	None	Heavy Rain	Moderate Rain	Light Rain	Heavy Fog	Moderate Fog	Thin Fog	Haze	Sleet	Snow
Duration (hh:mm)	40:09	00:00	00:00	04:45	00:00	00:00	00:00	04:34	00:00	00:00

## REPORT

The BSS recorded during visual monitoring ranged from level one to level four. 90% of visual observations aboard the *R/V Sally Ride* were undertaken in conditions where the BSS was level 1 (14%), level 2 (39%) or level 3 (37%), which are considered ‘good’ conditions for the detection of protected species (Table 11).

**Table 11: BSS during the survey**

Total	B0	B1	B2	B3	B4	B5	B6	B7	B8	B9
Duration (hh:mm)	00:00	06:59	19:35	18:12	04:42	00:00	00:00	00:00	00:00	00:00

Wind speeds recorded during visual monitoring ranged between 1 and 16 kn. Most visual monitoring aboard the *R/V Sally Ride* occurred during recorded wind speeds below 10 kn (65%) and from 10 to 15 kn (30%) (Table 12).

**Table 12: Wind speed during the survey**

Total	<10	10-15	16-20	21-25	26-30	>31
Duration (hh:mm)	31:56	14:55	02:37	00:00	00:00	00:00

Swell heights during visual observations were low, with swells of less than two meters recorded during all visual observations (Table 13).

**Table 13: Swell height during the survey**

Total	<2m	2-4m	>4m
Duration (hh:mm)	49:28	00:00	00:00

Visual monitoring was conducted primarily with no glare (53%) or mild glare (32%) (Table 14). During times of moderate to severe glare, it is possible that the detection of protected species was hindered.

**Table 14: Glare during the survey**

Total	None	Mild	Moderate	Severe
Duration (hh:mm)	26:07	15:50	04:31	03:00

REPORT

## 5 MONITORING AND DETECTION RESULTS

### 5.1 Visual Detections of Protected Species

Visual monitoring efforts during the survey program resulted in a total of 29 visual detections of protected species with 14 whale detections, two delphinid detections, ten pinniped detections, and three mustelidae detections. 24 of these detections were identified to the species level and five were only identified to the order level.

Whale detections accounted for approximately 48% of the overall detection occurrences, being comprised of a gray whale, a fin whale, humpback whales, and unidentified whales. Whales were observed swimming at surface, surfacing, blowing, diving, and fluking, and in various directions of travel relative to the vessel.

Delphinid detections accounted for approximately 6% of the overall detection occurrences and were comprised of Pacific white-sided dolphins and a harbor porpoise. Delphinids were observed travelling, swimming at and below the surface, performing acrobatics, bow riding, and in various directions of travel relative to the vessel

Pinniped detections accounted for approximately 35% of the overall detection occurrences and were comprised of a harbor seal, California seal lions, and unidentified sea lions. Pinnipeds were resting on shore, swimming at surface, slapping at water, jumping, resting at surface, diving, feeding, and porpoising.

Mustelidae detections accounted for approximately 10% of the overall detection occurrences and were comprised of sea otters. Sea otters were observed travelling, swimming at and below the surface, surfacing, and diving.

A table of all protected species detections is provided as part of an excel datasheet attachment in Appendix D.

Photographs of the identified protected species visually detected during the survey are provided in Appendix E

Table 15 lists the total number of detections and total number of individuals for each protected species observed during the survey program.

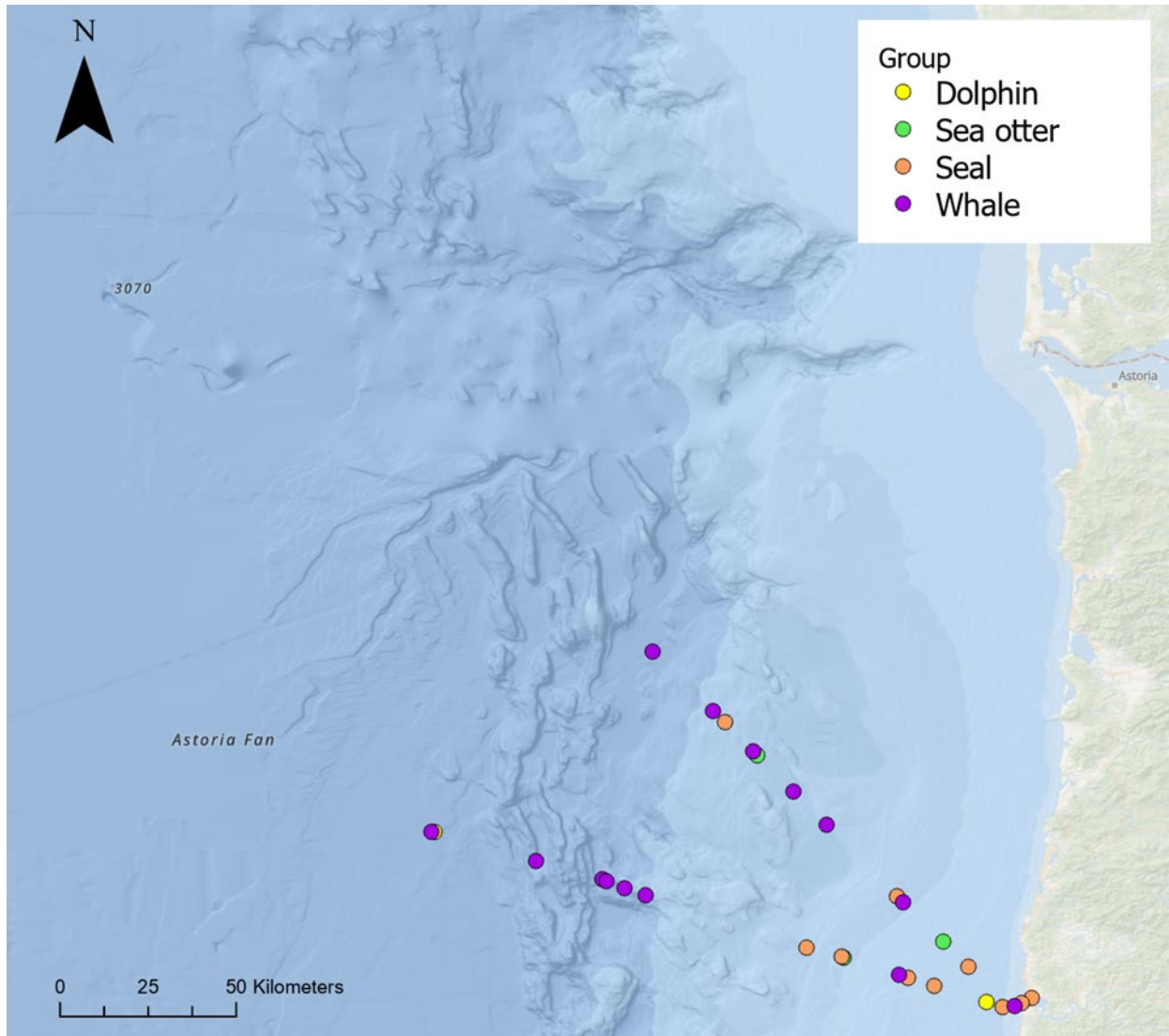
Maps of the distribution of the protected species detected during the survey is provided in Figure 2 and Figure 3.

**Table 15: Number of visual detection records collected for each protected species during the survey.**

Species	Total Number of Detection Records	Total Number of Animals
<b>Delphinid</b>		
Pacific white-sided dolphin	1	40
Harbor porpoise	1	4
<b>Whale</b>		
Gray whale	1	1
Humpback whale	8	12
Fin whale	1	1
Unidentified whale	4	4
<b>Pinniped</b>		
California sea lion	8	187
Harbor seal	1	2
Unidentified sea lion	1	1
<b>Mustelidae</b>		
Sea otter	3	4
<b>Total</b>	<b>29</b>	<b>256</b>

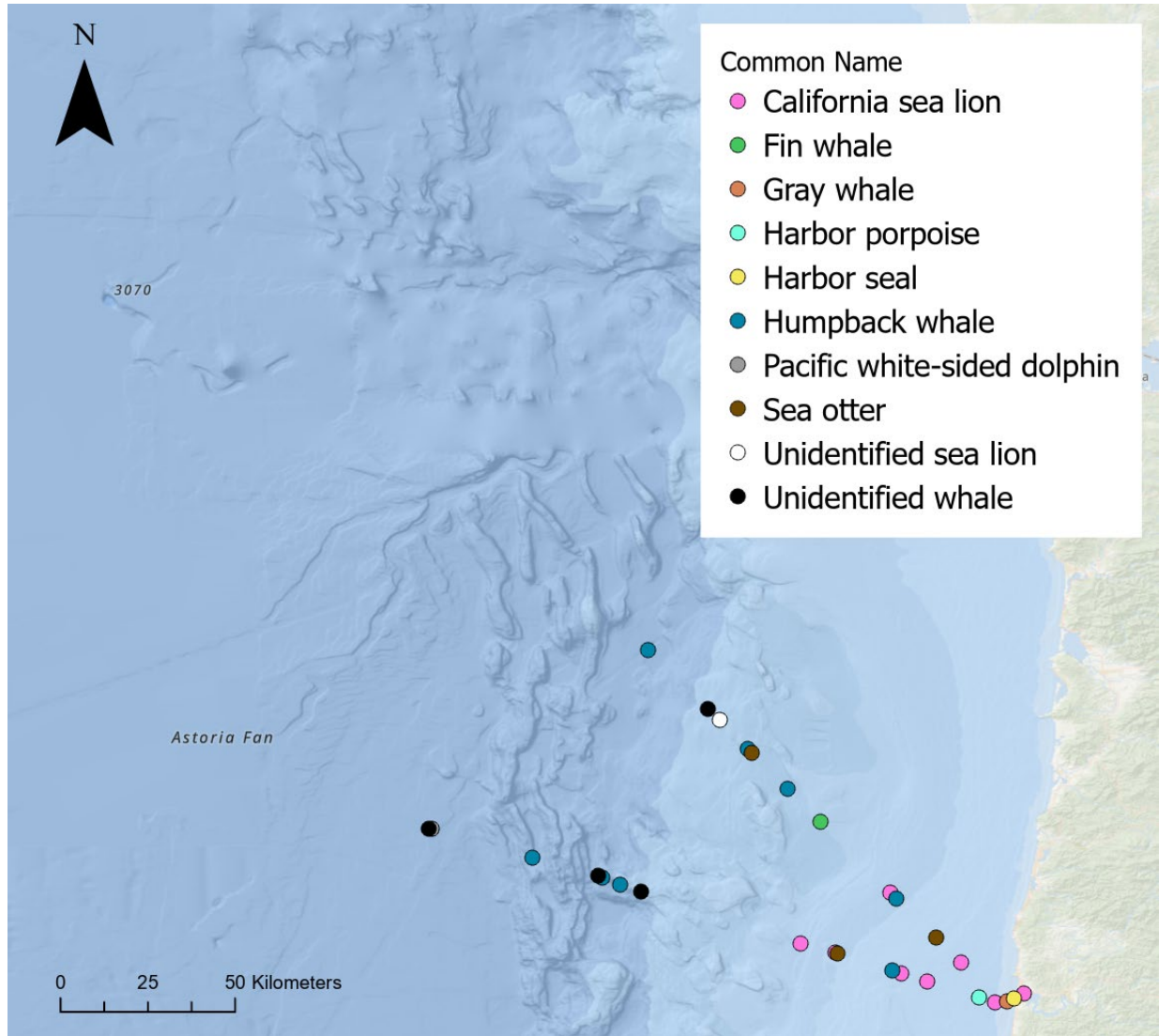
## REPORT

All 29 visual detections of protected species occurred while the acoustic source was not deployed. Detections occurred in water depths between 6 m and 2,624 m. All detections occurred outside of the survey area during transits to and from port.



**Figure 2: All Protected Species Observed by Group During the Survey**

**REPORT**



**Figure 3: All Protected Species Observed by Common Name During the Survey**

## 5.2 Other Wildlife

There were no sightings of any ESA-listed seabirds during the survey program. No adverse impacts to any other wildlife species as a result of research activities were observed.

REPORT

## 6 MITIGATION ACTION SUMMARY

Zero detections occurred that required mitigation to be implemented for the seismic source.

### 6.1 Vessel Strike Avoidance (VSA) Maneuvers

VSA maneuvering was conducted five times to prevent potential physical interactions between the survey vessel and marine mammals. In two of the cases, speed and heading of the vessel were maintained. In three detections the course and/or speed was altered/reduced to maintain a separation distance from the protected species.

Strike avoidance maneuvers were implemented for a harbor seal, a gray whale, twice for humpback whales, and for a sea otter. Two of these VSAs were precautionary VSAs for animals detected outside the SD, while three were required for animals within the SD. In each case the maneuvers were executed as necessary - PSOs detected the animals in sufficient time to alert the vessel of the need for maneuvering and maneuvering was carried out successfully to avoid physical impacts to the animals.

### 6.2 Protected Species Known to Have Been Exposed to 160 Decibels or Greater of Received Sound Levels

Numerous protected species are known to occur within the survey area, including the following threatened or endangered species: blue whale (*Balaenoptera musculus*), fin whale (*Balaenoptera physalus*), Western North Pacific distinct population segment (DPS) of gray whale (*Eschrichtius robustus*), Central America and Mexico DPSs of humpback whale (*Megaptera novaeangliae*), sei whale (*Balaenoptera borealis*), sperm whale (*Physeter macrocephalus*), North Pacific right whale (*Eubalaena japonica*), Southern Resident DPS of killer whale (*Orcinus orca*), Guadalupe fur seal (*Arctocephalus townsendi*), East Pacific DPS of green sea turtle (*Chelonia mydas*), and leatherback sea turtle (*Dermochelys coriacea*), North Pacific Ocean DPS of Loggerhead Turtle (*Caretta caretta*), and Mexico's Pacific Coast Breeding Colonies of Olive Ridley Turtle (*Lepidochelys olivacea*). Two species of ESA-listed seabirds could occur in the proposed survey area, including the *endangered* short-tailed albatross (*Phoebastria albatrus*), Hawaiian petrel (*Pterodroma sandwichensis*).

NMFS granted an IHA authorizing Level B harassment (exposure to sound pressure levels equal to or greater than 160 dB re: 1 µPa rms) where there is a potential for behavioral changes) for 435 individuals from 21 species or species groups. For this project, there were no Level A harassment (exposure to sound pressure levels where there is a potential for auditory injury based upon each species hearing range) authorization for any species. There were no specific numbers authorized for takes of sea turtles.

During seismic source operations, there were no protected species observed within the predicted 160 dB and 175dB radii (where there is a potential for a behavioral response) while the acoustic source was active, constituting potential Level B takes. There were zero protected species observed within the predicted radius at which there is a potential for auditory injury (based upon each species hearing range and how that overlaps with the frequencies produced by the sound source), constituting potential Level A takes/exposures.

The number of potential takes may be an underestimation and, therefore, may be a minimum estimate of the actual number of protected species potentially exposed to received sound levels within the predicted Level A and Level B harassment zones. It is possible that the estimated numbers of animals recorded were underestimates due to some individuals not being visually detected (Table 16).

**Table 16: Number of authorized and potential Level A and B harassment exposures during the survey.**

Species	IHA Authorized Level B Exposures	IHA Authorized Level A Exposures	Total Potential Exposures During Seismic operations
Blue whale	2	0	0
Fin whale	2	0	0

**REPORT**

Species	IHA Authorized Level B Exposures	IHA Authorized Level A Exposures	Total Potential Exposures During Seismic operations
Humpback whale	2	0	0
Minke whale	1	0	0
Sei whale	2	0	0
Sperm whale	7	0	0
Baird's beaked whale	7	0	0
Mesoplodont and goose-beaked whale*	2	0	0
Killer whale	7	0	0
Northern right whale dolphin	64	0	0
Pacific white-sided dolphin	55	0	0
Risso's dolphin	19	0	0
Short beaked common dolphin	156	0	0
Dwarf sperm whale			
Pygmy sperm whale	1	0	0
Dall's porpoise	26	0	0
California sea lion	39	0	0
Guadalupe fur seal	18	0	0
Northern fur seal	6	0	0
Steller sea lion	2	0	0
Northern elephant seal	17	-	0

\*Includes Blaineville's, Hubbs', and Stejneger's beaked whale

**6.3 Implementation and Effectiveness of the Biological Opinion and IHA**

To minimize the potential impacts to marine mammals during the seismic survey, PSOs were prepared to implement mitigation measures whenever these protected species were detected approaching, entering, or within their designated exclusion zones as outlined in the IHA and BiOp. Zero mitigation actions were required or implemented for protected species during the survey.

If an injured or dead protected species was discovered, the incident was to be reported to the NMFS Office of Protected Resources (OPR) and NMFS Coordinator as soon as possible. The report would include a detailed description of the incident (time, date, location, species identification, description of the animal, condition of the animal/carcass, observed behaviors if the animal was alive, and general circumstances under which the animal was discovered), including pictures when possible. There were no sightings of dead or injured protected species during the survey program.

To prevent the occurrence of the vessel striking a marine mammal during transits, PSOs and vessel crew members maintained a vigilant watch for marine mammals, and the vessel was prepared to slow down, stop, or alter course as appropriate to avoid striking a protected species. The vessel speed had to be reduced to 10 kn or less when mother/calf pairs, pods, or large assemblages of cetaceans were observed near the vessel. The vessel had to maintain the minimum separation distances as described in Table 2. If a marine mammal was sighted during transits, the vessel was to act as necessary to avoid violating the relevant separation distances (e.g., attempt to remain parallel to the animal's course, avoid excessive speed or abrupt changes in direction until the animal left the area). If marine mammals were sighted within the relevant separation distances, the vessel was required to reduce speed, shift the engines to neutral, and not engage the engines until the animals were clear of the area. If a whale entered the separation zone while the vessel was stationary, the vessel would not engage the engines until the whale has exited the zone. These requirements did not apply in any case where compliance would create an imminent and serious threat to a person or vessel, or if the vessel was restricted in maneuverability due to towed equipment. There were five instances of VSA maneuvers being implemented, two

**REPORT**

---

of which were precautionary for detections of protected species sighted outside of the SD, and three were required for detections of protected species within the SD.

In the event of a ship strike of a marine mammal, the incident was to be reported to NMFS and to the OPR, as soon as feasible. The report would include a detailed description of the incident (date, time, location, species identification, description of the animal(s) involved, vessel speed leading up to the incident, vessel's course/heading and what operations were being conducted, status of all sound sources in use, description of VSA measures taken if any, environmental conditions, description of the animals behavior preceding and following the strike, and estimated fate of the animal), including pictures when possible. There were no instances of the vessel striking a protected species during the survey.

PSOs likely did not detect all animals present; however, it is highly unlikely that the actual number of animals present during survey operations reached the fully authorized levels for all species. The combination of conservative predicted mitigation zones combined with conservative take estimation by NMFS (*i.e.*, the precautionary approach), appears for most species to have resulted in an overestimation of take and of overall impact on marine species from the activity. The monitoring and mitigation measures required by the IHAs appear to have been an effective means to protect the marine species encountered during survey operations.

## Appendix A: Incidental Harassment Authorization



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

## INCIDENTAL HARASSMENT AUTHORIZATION

The Scripps Institution of Oceanography (SIO) is hereby authorized under section 101(a)(5)(D) of the Marine Mammal Protection Act (MMPA; 16 U.S.C. 1371(a)(5)(D)) to incidentally harass marine mammals, under the following conditions:

1. This incidental harassment authorization (IHA) is effective from September 2, 2025 through September 1, 2026.
2. This IHA is valid only for geophysical survey activity off Oregon and Washington in the Cascadia Subduction Zone of the Northeast Pacific Ocean, as specified in SIO's IHA application.
3. General Conditions
  - (a) A copy of this IHA must be in the possession of SIO, the vessel operator, the lead protected species observer (PSO), and any other relevant designees of SIO 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/or stocks 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 numbers listed in Table 1 is prohibited and may result in the modification, suspension, or revocation of this IHA.
  - (d) During use of the acoustic source, if any marine mammal species or stock not listed in Table 1 appear within or enter the Level B harassment zone (Table 2) the acoustic source must be shut down.
  - (e) SIO must ensure that relevant vessel personnel and the PSO team participate in a joint onboard briefing led by the vessel operator and lead PSO to ensure that responsibilities, communication procedures, marine mammal monitoring protocols, operational procedures, and IHA requirements are clearly understood.
4. Mitigation Requirements



- a. SIO 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 marine mammals 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 those roles, respectively, during a shallow penetration seismic survey, with no more than 18 months elapsed since the conclusion of the at-sea experience.
- c. Visual Observation
  - i. During survey operations (e.g., any day on which use of the airgun array is planned to occur and whenever the airgun array is in the water, whether activated or not), a minimum of two PSOs must be on duty and conducting visual observations at all times during daylight hours (i.e., from 30 minutes prior to sunrise through 30 minutes following sunset) and 30 minutes prior to and during ramp-up of the airgun array.
  - ii. Visual monitoring of the exclusion and buffer zones must begin no less than 30 minutes prior to ramp-up and must continue until one hour after use of the airgun array ceases or until 30 minutes past sunset.
  - iii. Visual PSOs must coordinate to ensure 360° visual coverage around the vessel from the most appropriate observation posts, and must conduct visual observations using binoculars and the naked eye while free from distractions and in a consistent, systematic, and diligent manner.
  - iv. During good conditions (e.g., daylight hours; Beaufort sea state (BSS) 3 or less), visual PSOs must conduct observations when the airgun array is not operating for comparison of sighting rates and behavior with and without use of the airgun array and between acquisition periods, to the maximum extent practicable.
  - 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. Shutdown zones and buffer zones
  - i. Except as provided in 4(d)(ii), the PSOs must establish and monitor a 100-m shutdown zone and additional 100-m buffer zone (total 200 m). The 200-m zone must serve to focus observational effort but not limit such effort; observations of marine mammals beyond this distance shall also be recorded as described in 5(c) below and/or trigger shutdown as described in 4(f) (iii) below, as appropriate. The shutdown zone encompasses the area at and below the sea surface out to a radius of 100 m from the edges of the airgun array (rather than being based on the center of the array or

around the vessel itself) (0–100 m). The buffer zone encompasses the area at and below the sea surface from the edge of the shutdown zone, out to a radius of 200 meters from the edges of the airgun array (100–200 m). During use of the airgun array, occurrence of marine mammals within the buffer zone (but outside the shutdown zone) must be communicated to the operator to prepare for the potential shutdown of the airgun array. PSOs must monitor the shutdown zone and buffer zone for a minimum of 30 minutes prior to ramp-up (i.e., pre-start clearance).

- ii. An extended 500 m shutdown zone must be established for all beaked whales, a large whale with a calf, and groups of six or more large whales. No buffer zone is required.
- e. Pre-start clearance and Ramp-up
- i. A ramp-up procedure must be followed at all times as part of the activation of the airgun array, except as described under 4(e)(viii).
  - ii. The operator must notify a designated PSO of the planned start of ramp-up as agreed upon with the lead PSO. The notification time should not be less than 60 minutes prior to the planned ramp-up in order to allow the PSOs time to monitor the shutdown and buffer zone for 30 minutes prior to the initiation of ramp-up.
  - iii. Ramp-ups shall be scheduled so as to minimize the time spent with the source activated prior to reaching the designated run-in.
  - iv. One of the PSOs conducting the pre-start clearance observations must be notified again immediately prior to initiating ramp-up procedures and the operator must receive confirmation from the PSOs to proceed.
  - v. Ramp-up must not be initiated if any marine mammal is within the shutdown or buffer zone. If a marine mammal is observed within the shutdown zone or the buffer zone during the 30 minute pre-start clearance period, ramp-up may not begin until the animal(s) has been observed exiting the zone or until an additional time period has elapsed with no further sightings (15 minutes for small odontocetes and pinnipeds, and 30 minutes for mysticetes and all other odontocetes).
  - vi. Ramp-up must begin by activating one GI airgun followed by the second, with each stage lasting no less than 5 minutes. The operator must provide information to the PSO documenting that appropriate procedures were followed.
  - vii. PSOs must monitor the shutdown and buffer zones during ramp-up, and ramp-up must cease and the source must be shut down upon visual observation of a marine mammal within the shutdown zone. Once ramp-up has begun, observations of marine mammals within the buffer zone do not require shutdown, but such observation must be communicated to the operator to prepare for the potential shutdown.

- viii. If the airgun array is shut down for brief periods (i.e., less than 30 minutes) for reasons other than that described for shutdown (e.g., mechanical difficulty), it may be activated again without ramp-up if PSOs have maintained constant observation and no detections of marine mammals have occurred within the applicable shutdown zone. For any longer shutdown, pre-start clearance observation and ramp-up are required. For any shutdown at night or in periods of poor visibility (e.g., BSS 4 or greater), ramp-up is required.
  - ix. Testing of the airgun array involving all elements requires ramp-up. Testing limited to individual source elements or strings does not require ramp-up but does require pre-start clearance watch.
- 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 airgun array.
  - ii. The operator must establish and maintain clear lines of communication directly between PSOs on duty and crew controlling the airgun array to ensure that shutdown commands are conveyed swiftly while allowing PSOs to maintain watch.
  - iii. When the airgun array is active (i.e., anytime one or more airguns is active, including during ramp-up) and a marine mammal (excluding delphinids of the species described in 4(f)(iv)) appears within or enters the shutdown zone, the airgun array must be shut down. When shutdown is called for by a PSO, the airgun array must be immediately deactivated. Any dispute regarding a PSO shutdown must be resolved after deactivation.
  - iv. The shutdown requirement described in 4(f)(iii) shall be waived for small dolphins of the following genera: *Lagenorhynchus*, *Lissodelphis*, and *Delphinus*.
    - 1. If a dolphin of these genera is visually detected within the shutdown zone, no shutdown is required unless the PSO confirms the individual to be of a genus other than those listed above, in which case a shutdown is required.
    - 2. If there is uncertainty regarding identification, visual PSOs may use best professional judgement in making the decision to call for a shutdown.
  - v. Upon implementation of shutdown, the source may be reactivated after the marine mammal(s) has been observed exiting the applicable shutdown zone (i.e., animal is not required to fully exit the buffer zone where applicable) or following a clearance period (15 minutes for small odontocetes and pinnipeds, and 30 minutes for mysticetes and all other odontocetes) with no further observation of the marine mammal(s).

- vi. Shutdown of the array is required upon observation of a species for which authorization has not been granted or a species for which authorization has been granted but the authorized number of takes has been met, approaching or observed within the harassment zone (Table 2).

g. Vessel strike avoidance

- i. Vessel operators and crew must maintain a vigilant watch for all marine mammals and slow down, stop their vessel, or alter course, as appropriate and regardless of vessel size, to avoid striking any marine mammals. A visual observer aboard the vessel must monitor a vessel strike avoidance zone around the vessel (separation distances stated below). Visual observers monitoring the vessel strike avoidance zone may be third-party observers (i.e., PSOs) or crew members, but crew members responsible for these duties must be provided sufficient training to 1) distinguish marine mammals from other phenomena and 2) broadly to identify a marine mammal to taxonomic group (i.e., as a large whale, or other marine mammal).
- ii. Vessel speeds must be reduced to 10 knots or less when mother/calf pairs, pods, or large assemblages of cetaceans are observed near a vessel.
- iii. The vessel must maintain a minimum separation distance of 100 m from sperm whales and all baleen whales.
- iv. The vessel must, to the maximum extent practicable, attempt to maintain a minimum separation distance of 50 m from all other marine mammals, with an understanding that at times this may not be possible (e.g., for animals that approach the vessel).
- v. When marine mammals are sighted while a vessel is underway, the vessel must take action as necessary to avoid violating the relevant separation distance (e.g., attempt to remain parallel to the animal's course, avoid excessive speed or abrupt changes in direction until the animal has left the area). If marine mammals are sighted within the relevant separation distance, the vessel must reduce speed and shift the engine to neutral, not engaging the engines until animals are clear of the area. This does not apply to any vessel towing gear or any vessel that is navigationally constrained.

5. Monitoring Requirements

- a. The operator must 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.
- b. Protected Species Observers Qualifications
- i. PSOs must have successfully completed an acceptable PSO training course.
  - ii. NMFS must review and approve PSO resumes.
  - iii. One visual PSO with experience as shown in 4(b) shall be designated as the lead for the PSO team. The lead must coordinate duty schedules and roles for the PSO team and serve as primary point of contact for the vessel operator. (Note that the responsibility of coordinating duty schedules and roles may instead be assigned to a shore-based, third-party monitoring coordinator.) To the maximum extent practicable, the lead PSO must devise the duty schedule such that experienced PSOs are on duty with those PSOs with appropriate training but who have not yet gained relevant experience.
  - iv. PSOs must successfully complete relevant training, including completion of all required coursework and passing (80 percent or greater) a written and/or oral examination developed for the training program.
  - v. PSOs must have successfully attained a bachelor's degree with a major in one of the natural sciences.
  - vi. The educational requirements may be waived if the PSO has acquired the relevant skills through alternate experience. Requests for such a waiver must be submitted to NMFS and must include written justification. Requests must be granted or denied (with justification) by NMFS within one week of receipt of submitted information. Alternate experience that may be considered includes, but is not limited to (1) secondary education and/or experience comparable to PSO duties; (2) previous work experience conducting academic, commercial, or government-sponsored marine mammal surveys; or (3) previous work experience as a PSO; the PSO should demonstrate good standing and consistently good performance of PSO duties.
- c. Data Collection
- i. PSOs must use standardized electronic data collection forms. PSOs must record detailed information about any implementation of mitigation requirements, including

the distance of animals to the airgun array and description of specific actions that ensued, the behavior of the animal(s), any observed changes in behavior before and after implementation of mitigation, and if shutdown was implemented, the length of time before any subsequent ramp-up of the airgun array. If required mitigation was not implemented, PSOs should record a description of the circumstances.

- ii. At a minimum, the following information must be recorded:
  1. Vessel name, vessel size and type, maximum speed capability of vessel;
  2. Dates (MM/DD/YYYY) of departures and returns to port with port name;
  3. PSO names and affiliations, PSO ID (initials or other identifier);
  4. Date (MM/DD/YYYY) and participants of PSO briefings (as discussed in General Requirement);
  5. Visual monitoring equipment used (description);
  6. PSO location on vessel and height (meters) of observation location above water surface;
  7. Watch status (description);
  8. Dates (MM/DD/YYYY) and times (Greenwich Mean Time/UTC) of survey on/off effort and times (GMC/UTC) corresponding with PSO on/off effort;
  9. Vessel location (decimal degrees) when survey effort began and ended and vessel location at beginning and end of visual PSO duty shifts;
  10. Vessel location (decimal degrees) at 30-second intervals if obtainable from data collection software, otherwise at a practical regular interval;
  11. Vessel heading (compass heading) and speed (knots) at beginning and end of visual PSO duty shifts and upon any change;
  12. Water depths (meters) (if obtainable from data collection software);
  13. Environmental conditions while on visual survey (at beginning and end of PSO shift and whenever conditions changed significantly), including BSS and any other relevant weather conditions including cloud cover, fog, sun glare, and overall visibility to the horizon;
  14. Factors that may have contributed to impaired observations during each PSO shift change or as needed as environmental conditions changed (description) (e.g., vessel traffic, equipment malfunctions); and

15. Vessel/survey activity information (and changes thereof) (description), such as airgun array power output while in operation, number and volume of airguns operating in the array, tow depth of the array, and any other notes of significance (i.e., pre-start clearance, ramp-up, shutdown, testing, shooting, ramp-up completion, end of operations, streamers, etc.).
- iii. Upon visual observation of any marine mammals, the following information must be recorded:
1. Sighting ID (numeric);
  2. Watch status (sighting made by PSO on/off effort, opportunistic, crew, alternate vessel/platform);
  3. Location of PSO/observer (description);
  4. Vessel activity at the time of the sighting (*e.g.*, deploying, recovering, testing, shooting, data acquisition, other);
  5. PSO who sighted the animal/ID;
  6. Time/date of sighting (GMT/UTC, MM/DD/YYYY);
  7. Initial detection method (description);
  8. Sighting cue (description);
  9. Vessel location at time of sighting (decimal degrees);
  10. Water depth (meters);
  11. Direction of vessel's travel (compass direction);
  12. Speed (knots) of the vessel from which the observation was made;
  13. Direction of animal's travel relative to the vessel (description, compass heading);
  14. Bearing to sighting (degrees);
  15. Identification of the animal (*e.g.*, genus/species, lowest possible taxonomic level, or unidentified) and the composition of the group if there is a mix of species;
  16. Species reliability (an indicator of confidence in identification)  
(1=unsure/possible, 2=probable, 3=definite/sure, 9=unknown/not recorded);
  17. Estimated distance to the animal (meters) and method of estimating distance;

18. Estimated number of animals (high/low/best) (numeric);
19. Estimated number of animals by cohort (adults, yearlings, juveniles, calves, group composition, etc.);
20. Description (as many distinguishing features as possible of each individual seen, including length, shape, color, pattern, scars or markings, shape and size of dorsal fin, shape of head, and blow characteristics);
21. Detailed behavior observations (*e.g.*, number of blows/breaths, number of surfaces, breaching, spyhopping, diving, feeding, traveling; as explicit and detailed as possible; note any observed changes in behavior);
22. Animal's closest point of approach (CPA) (meters) and/or closest distance from any element of the airgun array;
23. Description of any actions implemented in response to the sighting (*e.g.*, delays, shutdown, ramp-up) and time and location of the action.
24. Photos (Yes/No);
25. Photo Frame Numbers (list of numbers); and
26. Conditions at a time of sighting (*e.g.*, visibility, BSS)

## 6. Reporting

- (a) SIO must submit a draft comprehensive report to NMFS ([PR.ITP.MonitoringReports@noaa.gov](mailto:PR.ITP.MonitoringReports@noaa.gov) and [ITP.Fleming@noaa.gov](mailto:ITP.Fleming@noaa.gov)) on all activities and monitoring results within 90 days of the completion of the survey or expiration of the IHA, whichever comes sooner. A final report must be submitted within 30 days following resolution of any comments on the draft report. If no comments are received from NMFS within 30 calendar days of receipt of the draft report, the report shall be considered final. The draft report must include the following:
  - (i) Summary of all activities conducted and sightings of marine mammals near the activities;
  - (ii) Summary of all data required to be collected (see condition 5(c));
  - (iii) Full documentation of methods, results, and interpretation pertaining to all monitoring;
  - (iv) Summary of dates and locations of survey operations (including (1) the number of days on which the airgun array was active and (2) the percentage of time and total time the array was active during daylight vs. nighttime hours (including dawn and

dusk)) and all marine mammal sightings (dates, times, locations, activities, associated survey activities);

- (v) Geo-referenced time-stamped vessel tracklines for all time periods during which airguns were operating. Tracklines should include points recording any change in airgun status (e.g., when the airguns began operating, when they were turned off, or when they changed from full array to single gun or vice versa);
  - (vi) GIS files in ESRI shapefile format and UTC date and time, latitude in decimal degrees, and longitude in decimal degrees. All coordinates must be referenced to the WGS84 geographic coordinate system; and
  - (vii) Raw observational data.
- (b) Reporting Injured or Dead Marine Mammals
- (i) Discovery of Injured or Dead Marine Mammal – In the event that personnel involved in the survey activities covered by the authorization discover an injured or dead marine mammal, SIO must report the incident to the Office of Protected Resources (OPR) ([PR.ITP.MonitoringReports@noaa.gov](mailto:PR.ITP.MonitoringReports@noaa.gov) and [ITP.Fleming@noaa.gov](mailto:ITP.Fleming@noaa.gov)) as soon as feasible. The report must include the following information:
    1. Time, date, and location (latitude/longitude) of the first discovery (and updated location information if known and applicable);
    2. Species identification (if known) or description of the animal(s) involved;
    3. Condition of the animal(s) (including carcass condition if the animal is dead);
    4. Observed behaviors of the animal(s), if alive;
    5. If available, photographs or video footage of the animal(s); and
    6. General circumstances under which the animal was discovered.
  - (ii) Vessel Strike – In the event of a ship strike of a marine mammal by any vessel involved in the activities covered by the authorization, SIO must report the incident to OPR as soon as feasible. The report must include the following information:
    1. Time, date, and location (latitude/longitude) of the incident;
    2. Species identification (if known) or description of the animal(s) involved;
    3. Vessel's speed during and leading up to the incident;

4. Vessel's course/heading and what operations were being conducted (if applicable);
  5. Status of all sound sources in use;
  6. Description of avoidance measures/requirements that were in place at the time of the strike and what additional measures were taken, if any, to avoid strike;
  7. Environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover, visibility) immediately preceding the strike;
  8. Estimated size and length of animal that was struck;
  9. Description of the behavior of the marine mammal immediately preceding and following the strike;
  10. If available, description of the presence and behavior of any other marine mammals immediately preceding the strike;
  11. Estimated fate of the animal (e.g., dead, injured but alive, injured and moving, blood or tissue observed in the water, status unknown, disappeared); and
  12. To the extent practicable, photographs or video footage of the animal(s).
7. This Authorization may be modified, suspended or revoked if the holder fails to abide by the conditions prescribed herein (including, but not limited to, failure to comply with monitoring or reporting requirements), or if NMFS determines: (1) the authorized taking is likely to have or is having more than a negligible impact on the species or stocks of affected marine mammals, or (2) the prescribed measures are likely not or are not effecting the least practicable adverse impact on the affected species or stocks and their habitat.

#### 8. Renewals

On a case-by-case basis, NMFS may issue a one-time, one-year Renewal IHA following notice to the public providing an additional 15 days for public comments when (1) up to another year of identical, or nearly identical, activities are planned or (2) the specified activities would not be completed by the time this IHA expires and a Renewal would allow for completion of the activities, provided all of the following conditions are met:

- (a) A request for renewal is received no later than 60 days prior to the needed Renewal IHA effective date (the Renewal IHA expiration date cannot extend beyond one year from expiration of this IHA).
- (b) The request for renewal must include the following:

- (i) An explanation that the activities to be conducted under the requested Renewal IHA are identical to the activities analyzed for this IHA, are a subset of the activities, or include changes so minor that the changes do not affect the previous analyses, mitigation and monitoring requirements, or take estimates (with the exception of reducing the type or amount of take).
- (ii) A preliminary monitoring report showing the results of the required monitoring to date and an explanation showing that the monitoring results do not indicate impacts of a scale or nature not previously analyzed or authorized.
- (c) Upon review of the request for Renewal, the status of the affected species or stocks, and any other pertinent information, NMFS determines that there are no more than minor changes in the activities, the mitigation and monitoring measures will remain the same and appropriate, and the findings made in support of this IHA remain valid.

---

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

**Table 1. Authorized take numbers, by species**

Species	Stock	Authorized Level B take
Blue whale	Eastern N. Pacific	2
Fin whale	CA/OR/WA	2
Humpback whale	Central America/Southern Mexico – CA/OR/WA	2
	Mainland Mexico – CA/OR/WA	
	Hawai'i	
Minke whale	CA/OR/WA	1
Sei whale	Eastern N. Pacific	2
Sperm whale	CA/OR/WA	7
Baird's beaked whale	CA/OR/WA	7
Mesoplodont and goose-beaked whale <sup>1</sup>	CA/OR/WA	2
Killer whale	Eastern N. Pacific Offshore	7
Northern right whale dolphin	CA/OR/WA	64
Pacific white-sided dolphin	CA/OR/WA	55
Risso's dolphin	CA/OR/WA	19
Short beaked common dolphin	CA/OR/WA	156
Dwarf sperm whale	CA/OR/WA	1
Pygmy sperm whale		
Dall's porpoise	CA/OR/WA	26
California sea lion	U.S.	39
Guadalupe fur seal	Mexico	18
Northern fur seal	Eastern Pacific	6
	California	
Steller sea lion	Eastern	2
Northern elephant seal	California breeding	17

<sup>1</sup> Includes Blaineville's, Hubbs', and Stejneger's beaked whale

**Table 2. Level B Harassment Zones**

Airgun configuration	Water Depth (m)	Level B harassment zone (m)
Two 45in <sup>3</sup> GI airguns	>1,000	505

## **Appendix B: Biological Opinion**

National Marine Fisheries Service  
Endangered Species Act Section 7  
Biological Opinion

Title: Conference and Biological Opinion on the National Science Foundation's Funding of a Low-Energy Marine Geophysical Survey at the Cascadia Subduction Zone, Pacific Ocean, September 2025 and the 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

Action Agencies: U.S. National Science Foundation  
Permits and Conservation Division, Office of Protected Resources,  
National Marine Fisheries Service, National Oceanic and  
Atmospheric Administration, U.S. Department of Commerce

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

Publisher: Office of Protected Resources, National Marine Fisheries Service,  
National Oceanic and Atmospheric Administration, U.S.  
Department of Commerce

Approved:

---

Kimberly Damon-Randall  
Director, Office of Protected Resources

Date: 8/26/25

ECO Number: OPR-2025-01094

Digital Object Identifier: <https://doi.org/10.25923/0b33-bb39>

**TABLE OF CONTENTS**

1.	Introduction	1
1.1	Background	3
1.2	Consultation History	3
1.3	Analytical Approach	4
2.	Proposed Federal Action	5
2.1	Description of the Action	5
2.2	Conservation Measures	7
2.3	Stressors Resulting from the Components of the Proposed Action	9
3.	Action Area	9
4.	Species and Critical Habitat that May be Affected by the Proposed Action	11
4.1	May Affect, Not Likely to Adversely Affect	17
4.1.1	Stressors Not Likely to Adversely Affect Species or Critical Habitat	18
4.1.1.1	Pollution	18
4.1.1.2	Vessel Strike	19
4.1.1.3	Disturbance from the Research Vessel	19
4.1.1.4	Acoustic Instruments (Multibeam Echosounder, Sub-bottom Profiler, and Acoustic Doppler Current Profiler)	20
4.1.1.5	Entanglement/Interaction with In-water Equipment	20
4.1.2	Species Not Likely to be Adversely Affected	21
4.1.2.1	ESA-Listed Marine Mammals	21
4.1.2.2	ESA-Listed Sea Turtles	22
4.1.2.3	ESA-Listed Fishes	23
4.1.2.4	Proposed Sunflower Sea Star	25
4.1.3	Critical Habitat Not Likely to be Adversely Affected	25
4.2	Status of the Species Likely to be Adversely Affected	26
4.2.1	Life History Common to Blue, Fin, Humpback, Sei, and Sperm Whales	27
4.2.2	Threats Common to Blue, Fin, Humpback, Sei, and Sperm Whales	27
4.2.3	Blue Whale	28
4.2.4	Fin Whale	29
4.2.5	Humpback Whale – Central America DPS and Mexico DPS	31
4.2.6	Sei Whale	33
4.2.7	Sperm Whale	35
4.2.8	Guadalupe Fur Seal	37

5.	Environmental Baseline	39
5.1	Environmental Change	39
5.2	Unusual Mortality Events	41
5.3	Sound	41
5.4	Fisheries Interactions	46
5.5	Oil and Gas	48
5.6	Vessel Interactions	49
5.7	Research Permits	52
5.8	Aquaculture	53
5.9	Invasive Species	54
5.10	Marine Debris	55
5.11	Other Marine Pollution	56
5.12	Impact of the Baseline on ESA-Listed Species	57
6.	Analysis of Effects	58
6.1	Exposure	58
6.1.1	ESA-Listed Marine Mammal Exposure	58
6.2	Response	61
6.2.1	ESA-Listed Marine Mammal Responses	61
6.2.2	Marine Mammal Prey Responses	69
6.3	Summary of Effects	72
6.3.1	Blue Whale	72
6.3.2	Fin Whale	73
6.3.3	Humpback Whale – Central America DPS and Mexico DPS	73
6.3.4	Sei Whale	73
6.3.5	Sperm Whale	73
6.3.6	Guadalupe Fur Seal	73
7.	Cumulative Effects	74
8.	Integration and Synthesis	74
8.1	Jeopardy Analysis	75
8.1.1	Blue Whale	75
8.1.2	Fin Whale	76
8.1.3	Humpback Whale – Central America DPS and Mexico DPS	77
8.1.4	Sei Whale	78
8.1.5	Sperm Whale	78

8.1.6	Guadalupe Fur Seal	79
9.	Conclusion	80
10.	Incidental Take Statement	81
10.1	Amount or Extent of Take	81
10.2	Reasonable and Prudent Measures	82
10.3	Terms and Conditions	82
11.	Conservation Recommendations	83
12.	Reinitiation of Consultation	84
13.	Literature Cited	85

List of Figures

Figure 1.	Map of the survey location .....	10
-----------	----------------------------------	----

List of Tables

Table 1.	Predicted distances to marine mammal and sea turtle behavioral disturbance thresholds, 160 dB re 1 $\mu$ Pa <sub>rms</sub> and 175 dB re 1 $\mu$ Pa <sub>rms</sub> , respectively .....	7
Table 2.	Species and critical habitat present in the action area .....	11
Table 3.	Physical or Biological Features of designated or proposed critical habitat present in the action area that may be affected by the proposed action .....	16
Table 4.	Mean annual mortalities and serious injuries related to fisheries interactions for ESA-listed marine mammals within the action area.....	47
Table 5.	Mean annual mortalities and serious injuries related to vessel strikes for ESA-listed marine mammals for stocks in the Pacific Ocean within the action area. ....	50
Table 6.	Exposure estimates for ESA-listed marine mammals during NSF’s seismic survey .....	59
Table 7.	Estimated probability a humpback whale off the U.S. West Coast would belong to the Central America, Mexico, or Hawaii (non-listed) DPS.....	60
Table 8.	Anticipated number and type of ESA takes of marine mammals due to the proposed action.....	82

## 1. INTRODUCTION

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

Section 7(a)(4) of the ESA requires Federal agencies to confer with the Secretary on any action that is likely to jeopardize the continued existence of proposed species or result in the destruction or adverse modification of proposed critical habitat. For actions that are not likely to jeopardize the continued existence of a proposed species or adversely modify critical habitat, a conference can be requested by the action agency, though it is not required. If requested by the Federal action agency and deemed appropriate, the conference may be conducted in accordance with the procedures for formal consultation in 50 CFR §402.14. An opinion issued at the conclusion of the conference may be adopted as the biological opinion when the species is listed or critical habitat is designated.

Section 7(b)(3) of the ESA requires that, at the conclusion of consultation, the National Marine Fisheries Service (NMFS) provide an opinion stating whether the Federal agency's action is likely to jeopardize ESA-listed species or destroy or adversely modify their critical habitat. Similarly, when conferring on proposed species or proposed critical habitat, we also reach a conclusion as to whether the action will satisfy 7(a)(2) for those entities as proposed. If NMFS determines that the action is likely to jeopardize ESA-listed or proposed species or destroy or adversely modify designated critical habitat, NMFS provides a reasonable and prudent alternative that allows the action to proceed in compliance with section 7(a)(2) of the ESA. If the action (or reasonable and prudent alternative) is expected to cause incidental take without violating section 7(a)(2), section 7(b)(4), as implemented by 50 CFR §402.14(i), requires NMFS to provide an incidental take statement (ITS) that specifies the amount or extent of incidental taking. Blue whale (*Balaenoptera musculus*), fin whale (*Balaenoptera physalus*), gray whale (*Eschrichtius robustus*) – Western North Pacific DPS, humpback whale (*Megaptera novaeangliae*) – Mexico DPS and Central America DPS, killer whale (*Orcinus orca*) – Southern Resident DPS, North Pacific right whale (*Eubalaena japonica*), sei whale (*Balaenoptera borealis*), sperm whale (*Physeter macrocephalus*), and Guadalupe fur seal (*Arctocephalus townsendi*) in this consultation are regulated under the Marine Mammal Protection Act (MMPA) and the ESA. Each statute has defined the meaning of take independently. The MMPA defines take as to harass, hunt, capture, collect, or kill, or attempt to harass, hunt, capture, collect, or kill any marine mammal. Take under the ESA is to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct (16 U.S.C. §1532(19)). Actions considered 'take' under one statute do not necessarily rise to the level of take under the other statute. The ITS includes reasonable and prudent measures, which are actions necessary or appropriate to minimize impacts of incidental taking, and terms and conditions to implement the reasonable and prudent measures.

The action agencies for this consultation are the National Science Foundation (NSF) and the NMFS Office of Protected Resources (OPR) Permits and Conservation Division. The NSF proposes to fund a low-energy marine geophysical (seismic) survey at the Cascadia Subduction Zone, in September 2025. The survey would quantify the thermal effects of fluid circulation in oceanic crust entering the Cascadia Subduction Zone, which contributes to understanding the thermal structure of oceanic lithosphere. The survey will be conducted by researchers from the New Mexico Institute of Mining and Technology and Oregon State University on the U.S. Navy-owned research vessel (R/V) *Sally Ride*, which will be operated by the Scripps Institution of Oceanography (SIO). The NMFS Permits and Conservation Division proposes to issue an incidental harassment authorization (IHA) to SIO, authorizing non-lethal takes of marine mammals by Level B harassment (pursuant to section 101(a)(5)(D) of the MMPA).

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

Consultation in accordance with section 7(a)(2) of the statute (16 U.S.C. §1536(a)(2)), associated implementing regulations (50 CFR Part 402), and agency policy and guidance (USFWS and NMFS 1998) was conducted by the NMFS OPR ESA Interagency Cooperation Division (hereafter referred to as 'we' or 'us'). We prepared this conference and biological opinion (opinion) and ITS in accordance with section 7(b) of the ESA and implementing regulations at 50 CFR Part 402. This document represents NMFS's opinion on the effects of the action on blue whale, fin whale, gray whale – Western North Pacific DPS, humpback whale – Mexico DPS and Central America DPS, killer whale – Southern Resident DPS, North Pacific right whale, sei whale, sperm whale, Guadalupe fur seal, green turtle (*Chelonia mydas*) – East Pacific DPS, leatherback turtle (*Dermochelys coriacea*), loggerhead turtle (*Caretta caretta*) – North Pacific Ocean DPS, olive ridley turtle (*Lepidochelys olivacea*) – Mexico's Pacific Coast breeding colonies, chinook salmon (*Oncorhynchus tshawytscha*) – California coastal Evolutionarily Significant Unit (ESU), Central Valley spring-run ESU, Lower Columbia River ESU, Puget Sound ESU, Sacramento River winter-run ESU, Snake River ESU, Snake River spring/summer run ESU, Upper Columbia River spring-run ESU, and Upper Willamette River ESU, chum salmon (*Oncorhynchus keta*) – Columbia River ESU and Hood Canal summer-run ESU, coho salmon (*Oncorhynchus kisutch*) – Central California coast ESU, Lower Columbia River ESU, Oregon coast ESU, and Southern Oregon and Northern California coasts ESU, eulachon (*Thaleichthys pacificus*) – Southern DPS, green sturgeon (*Acipenser medirostris*) – Southern DPS, sockeye salmon (*Oncorhynchus nerka*) – Ozette Lake ESU and Snake River ESU, steelhead trout (*Oncorhynchus mykiss*) – California Central Valley DPS, Central California Coast DPS, Lower Columbia River DPS, Middle Columbia River DPS, Northern California DPS, Puget Sound DPS, Snake River Basin DPS, South-Central California Coast DPS, Southern

California DPS, Upper Columbia River DPS, and Upper Willamette River DPS, and proposed sunflower sea star (*Pycnopodia helianthoides*).

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

## 1.1 Background

The NSF, established by Congress with the *National Science Foundation Act* of 1950 (Public Law 810507, as amended), is dedicated to the support of fundamental research and education in all scientific and engineering disciplines. The funding of a low-energy seismic survey at the Cascadia Subduction Zone is a NSF program priority that helps fulfill NSF's mission to "promote the progress of science, advance the national health, prosperity, and welfare, and secure the national defense."

In conjunction with NSF's action, the NMFS Permits and Conservation Division proposes to issue an IHA to SIO for incidental takes of marine mammals that could occur during the low-energy seismic survey at the Cascadia Subduction Zone. Take of marine mammals is prohibited under the MMPA, with certain exceptions: under section 101(a)(5)(D) of the MMPA, NMFS may issue incidental take authorizations, which allow for the unintentional take, by harassment, of small numbers of marine mammals of a species or population stock, incidental but not intentional to specified activities.

This opinion supersedes OPR-2021-03468.

## 1.2 Consultation History

- **February 18, 2025:** We received NSF's request for consultation and Draft Environmental Assessment of Marine Geophysical Surveys by R/V *Sally Ride* at the Cascadia Subduction Zone, northeast Pacific Ocean, September 2025 (LGL 2025).
- **April 23, 2025:** We participated in the NMFS Permits and Conservation Division's Early Review Team meeting to discuss the NSF and SIO's low-energy seismic survey. On the same day, we requested additional information, via email to NSF, on NSF's take calculations for marine mammals, protected fish ensonified areas, and clarifications on the action area. Between April 23 and May 14, 2025, we and the NMFS Permits and Conservation Division exchanged emails and met to discuss NSF and SIO's take analysis.
- **April 29, 2025:** NSF provided responses to most of our requests for additional information. On April 30, 2025, NSF provided responses to the remainder of our requests for additional information. On the same day, we determined there was sufficient information to initiate consultation with NSF.

- **May 14, 2025:** The NMFS Permits and Conservation Division’s Early Review Team determined SIO’s IHA application adequate and complete.
- **July 17, 2025:** We received NMFS Permits and Conservation Division’s request for consultation, draft *Federal Register* notice for the proposed IHA and request for public comment, and draft proposed IHA. On July 21, 2025, the notice and request for public comment published in the *Federal Register*.
- **July 28, 2025:** We determined there was sufficient information to initiate consultation with NMFS Permits and Conservation Division.
- **August 20, 2025:** The public comment period for the proposed IHA closed. NMFS Permits and Conservation Division notified us on August 21, 2025 that they did not receive any public comments on the proposed IHA and possible renewal.

### 1.3 Analytical Approach

This opinion includes a jeopardy analysis. Prior to 2016, the designation of critical habitat for the leatherback turtle, Southern DPS green sturgeon, and Oregon coast ESU coho salmon used the term primary constituent element (PCE), essential features, or generally identified aspects of critical habitat that were essential to the conservation of the species. The 2016 critical habitat regulations (50 CFR §424.12) replaced these terms with physical or biological features (PBFs). 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 PCEs, PBFs, or essential features. In this opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

We use the following approach to determine whether an action agency is able to insure its proposed action is not likely to jeopardize listed species:

- Identify all aspects of the proposed action (as defined in 50 CFR §402.02), including activities that rely on the action for their occurrence.
- Identify the physical, chemical, and biological modifications to land, water, and air (stressors) that result from those actions and subsequent activities.
- Establish the spatial extent of those stressors, which is the action area (50 CFR §402.02).
- Identify the listed and proposed species (as defined at 16 U.S.C. §1532(16)) and designated critical habitat (as defined at 16 U.S.C. §1532(5)) in the action area.
- Identify the species and critical habitats that are not likely to be adversely affected by the action.
- Evaluate the range-wide status of the species and critical habitat expected to be adversely affected by the proposed action.
- Evaluate the environmental baseline (as defined in 50 CFR §402.02) as it pertains to the species and critical habitat.
- Evaluate the effects of the proposed action on listed or proposed species and their designated critical habitat using a stressor-exposure-response approach. When complete, this section anticipates the amount or extent, as well as the forms (harass, harm, etc.), of take of listed species (or a surrogate) that is reasonably certain to occur as a result of the action, as well as the extent of effects to critical habitat. Because take is categorized

differently under ESA and MMPA, the initiation documents provided by NSF, NMFS's Permits and Conservation Division, and the analysis in this opinion may discuss take differently and identify different numbers of takes as the reasonably certain outcomes of this action.

- Evaluate cumulative effects (as defined at 50 CFR §402.02).
- Produce an integration and synthesis, where we add the effects of the action and cumulative effects to the environmental baseline, and, in light of the status of the species and critical habitat, analyze whether the proposed action is likely to jeopardize the continued existence of listed species or destroy or adversely modify critical habitat.
- Compile our jeopardy and destruction or adverse modification analysis relying on the justification in the integration and synthesis.
- If the opinion determines the action agencies failed to insure their action is not likely to jeopardize the continued existence of listed species or destroy or adversely modify critical habitat, we suggest a reasonable and prudent alternative to the proposed action and assess the effects of that alternative action.
- For actions that do not violate section 7(a)(2) of the ESA or an alternative action is identified that does not violate section 7(a)(2) of the ESA and when take of marine mammals is permitted under section 101(a)(5) of the MMPA, after we conclude our opinion, we provide an incidental take statement that specifies the impact of the take on listed species (amount or extent), reasonable and prudent measures, and terms and conditions to implement those measures.

In each of the steps above, we rely on the best scientific and commercial data available. In order to ensure we reach supportable conclusions, we used information from NSF including the Draft Environmental Assessment of Marine Geophysical Surveys by R/V *Sally Ride* at the Cascadia Subduction Zone, northeast Pacific Ocean, September 2025 (LGL 2025), NMFS Permits and Conservation Division's proposed IHA, our and NMFS Permits and Conservation Division's meetings, NSF's responses to our requests for additional information, open-source scientific databases, peer-reviewed scientific literature, government reports, and commercial studies.

## 2. PROPOSED FEDERAL ACTION

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

### 2.1 Description of the Action

#### National Science Foundation's Proposed Action

The following provides a brief summary of NSF's proposed action. The NSF proposes to fund a low-energy seismic survey (hereafter referred to as "survey") at the Cascadia Subduction Zone in the Northeast Pacific Ocean (Figure 1) on the R/V *Sally Ride*, which will be operated by SIO. The R/V *Sally Ride* is approximately 238 feet (ft; 72.5 meters [m]) long, 49.2 ft (15 m) wide,

with a draft of approximately 15 ft (4.6 m). The R/V *Sally Ride* will transit at a speed of approximately five knots (9.3 kilometers per hour [km/hr]) during seismic operations. The survey will take place more than 62 miles (mi) or 100 km from the Oregon and Washington coasts, in water depths between approximately 6,560 and 11,483 ft (2,000 to 3,500 m). The survey will use two Generator-Injector (GI) airguns, with a maximum discharge volume of approximately 90 cubic inches (in<sup>3</sup>; or approximately 1,475 cubic centimeters [cm<sup>3</sup>]), 6.6 ft (2 m) separation distance, and towed approximately 82 ft (25 m) behind the R/V *Sally Ride* at a depth of approximately 13 ft (4 m). The receiving system is an approximately 0.62 mi (1 km) solid flexible polymer hydrophone streamer. In addition to the airguns, multibeam echosounders (MBES), sub-bottom profiler (SBP), and Acoustic Doppler Current Profiler (ADCP) will be operated during the survey. The survey will take place over three days in September 2025: two survey days covering approximately 276 mi (444 km) of seismic acquisition (see Figure 1 for tracklines) and one day of transit to/from Newport, Oregon.

For further details on NSF's proposed action, including specifications on the R/V *Sally Ride*, airguns, and other acoustic instruments, see the Draft Environmental Assessment of Marine Geophysical Surveys by R/V *Sally Ride* at the Cascadia Subduction Zone, northeast Pacific Ocean, September 2025 on NSF's Environmental Compliance webpage, under the subheading "Current environmental reviews" at <https://www.nsf.gov/funding/environmental-compliance>.

### **NMFS Permits and Conservation Division's Proposed Action**

The following provides a brief summary of the NMFS Permits and Conservation Division proposed action. The NMFS Permits and Conservation Division proposes to issue an IHA and potential renewal authorizing non-lethal takes of marine mammals by Level B harassment (pursuant to section 101(a)(5)(D) of the MMPA) incidental to conducting the survey. The IHA will be effective from September 2, 2025 to September 1, 2026.

The IHA will authorize the following takes for threatened and endangered species: two blue whales, two fin whales, two humpback whales (Central America/Southern Mexico – CA/OR/WA, Mainland Mexico – CA/OR/WA, and Hawaii stocks; the ESA equivalent of these MMPA stocks are the Central America DPS and Mexico DPS), two sei whales, seven sperm whales, and 18 Guadalupe fur seals. A notice of the proposed IHA and request for public comments published in the *Federal Register* on July 21, 2025 (90 Fed. Reg. 34212). The public comment period closed on August 20, 2025. The NMFS Permits and Conservation Division did not receive any public comments. No revisions were made to the proposed IHA since the notice was published.

In order to issue an IHA, the NMFS Permits and Conservation 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. To satisfy the least practicable impact standard, the NMFS Permits and Conservation Division reviewed seismic mitigation protocols required or recommended elsewhere (see 90 Fed. Reg. 34212) and will require SIO to implement those protocols, including vessel-based visual mitigation monitoring, establish shutdown and pre-start clearance zones, pre-start clearance and ramp-up, shutdown procedures, and vessel strike avoidance mitigation measures. These protocols are nearly identical to the mitigation

proposed by NSF, and are required. Thus, they are discussed in the following section together (Section 2.2).

For further details on the NMFS Permits and Conservation Division’s proposed action, including background on the IHA, circumstances for renewal, mitigation, and reporting, see the proposed IHA at 90 Fed. Reg. 34212.

**2.2 Conservation Measures**

Conservation measures include measures that avoid or reduce the severity of the effects of the action on ESA-listed species and their critical habitats, and monitoring, which 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 and their critical habitats are successful.

NSF considered mitigation requirements of previous IHAs and best practices (Acosta et al. 2017; Chou et al. 2021; Nowacek et al. 2013; Pierson et al. 1998; Weir and Dolman 2007; Wright 2014; Wright and Cosentino 2015) when developing conservation measures. Mitigation protocols detailed in NMFS Permits and Conservation Division’s proposed IHA are required. The following provides a brief summary of NSF’s and the NMFS Permits and Conservation Division’s conservation measures for this survey.

During the planning phase, NSF determined that the use of two GI airguns is the smallest sound source necessary to meet the research objectives. NSF also determined mitigation zones, within which a shutdown of the airguns would be implemented if a marine mammal or sea turtle were observed within the respective distances. Mitigation zones were derived from the predicted distances to sound levels associated with the NMFS marine mammal behavioral disturbance threshold (160 decibels referenced to a root-mean-square pressure of one micro Pascal [dB re 1  $\mu\text{Pa}_{\text{rms}}$ ]) and the NMFS sea turtle behavioral disturbance threshold (175 dB re 1  $\mu\text{Pa}_{\text{rms}}$ ), as modeled by the Lamont-Doherty Earth Observatory of Columbia University. The predicted distances are 1,567 ft (505 m) and 292 ft (89 m), to the 160 dB re 1  $\mu\text{Pa}_{\text{rms}}$  and 175 dB re 1  $\mu\text{Pa}_{\text{rms}}$  thresholds, respectively (Table 1). A shutdown zone of 492 ft (150 m) for sea turtles, which encompasses the modeled mitigation zone, will be implemented. However, for marine mammals, NSF will implement the IHA-required 328 ft (100 m) shutdown zone instead of the 1,567 ft (505 m) modeled mitigation zone.

**Table 1. Predicted distances to marine mammal and sea turtle behavioral disturbance thresholds, 160 dB re 1  $\mu\text{Pa}_{\text{rms}}$  and 175 dB re 1  $\mu\text{Pa}_{\text{rms}}$ , respectively**

<b>Airgun Source and Volume</b>	<b>Tow Depth (m)</b>	<b>Water Depth (m)</b>	<b>Distance (m) to 160 dB re 1 <math>\mu\text{Pa}_{\text{rms}}</math></b>	<b>Distance (m) to 175 dB re 1 <math>\mu\text{Pa}_{\text{rms}}</math></b>
Two 45 in <sup>3</sup> (737.4 cm <sup>3</sup> ) GI airguns; 6.6 ft (2 m) separation	4	>1,000	505	89

The following is a summary of the conservation measures proposed by NSF and the NMFS Permits and Conservation Division. During the survey, NSF will use two Protected Species Observers (PSOs) during all daytime seismic operations beginning 30 minutes prior to ramp up of the airguns. Pre-start clearance visual monitoring will occur prior to ramp up (i.e., gradual activation) of the airguns. Pre-start clearance monitoring will begin no less than 30 minutes prior to ramp up and must continue until one hour after use of the airguns ceases or 30 minutes past sunset. It consists of PSOs ensuring a 656.2 ft (200 m) pre-start clearance zone (which consist of a 328 ft or 100 m shutdown zone and additional 328 ft or 100 m buffer zone) from the edges of the airgun array is clear of marine mammals, or a 492 ft (150 m) zone is clear of sea turtles, prior to ramp up. If the pre-start clearance zone is clear of marine mammals and sea turtles, ramp up may begin and consists of activating a single airgun, then activating the second airgun at minimum five minutes later (so long as the zone is still clear of marine mammals and sea turtles). Ramp up would also be implemented after a specified time without airgun operations. Once ramp up has begun, observations of marine mammals within the buffer zone do not require shutdown (i.e., immediate deactivation of all airgun elements). The PSOs will monitor the shutdown zones (328 ft or 100 m for marine mammals, 492 ft or 150 m for sea turtles, and 1,640 ft or 500 m for a large whale with a calf, and groups of six or more large whales) for protected species. The airguns will be shut down prior to a marine mammal or sea turtle entering the respective shutdown zone, or immediately if a marine mammal or sea turtle is first observed within the respective shutdown zone. Seismic operations will not resume until the animal has left the shutdown zone, or until the PSO is confident the animals have left the vicinity of the R/V. PSOs will also monitor any impacts of the airguns on protected fishes. To minimize the risk of vessel strike, and as required by the IHA, the R/V will slow down, stop, and/or alter course when in the vicinity of protected species (to the extent allowed by the safety of the vessel and crew). Visual observers will also monitor a vessel strike avoidance zone around the R/V, which is 328 ft or 100 m from listed whales, and will implement a speed restriction for certain circumstances (e.g., when mother/calf pairs are observed near the R/V).

For further details on conservation measures that will be implemented during the survey, see NSF's Draft Environmental Assessment of Marine Geophysical Surveys by R/V *Sally Ride* at the Cascadia Subduction Zone, northeast Pacific Ocean, September 2025 on NSF's Environmental Compliance webpage, under the subheading "Current environmental reviews" at <https://www.nsf.gov/funding/environmental-compliance> and the NMFS Permits and Conservation Division's proposed IHA at 90 Fed. Reg. 34212.

### **Reporting to NMFS**

In order to issue an IHA, the NMFS Permits and Conservation Division must also set forth requirements related to monitoring and reporting of incidental take. Monitoring and reporting requirements should contribute to the improved understanding of marine mammal occurrence, exposure and response to stressors, impacts to individual and population-level fitness and survival, impacts to habitat, and effectiveness of mitigation. NSF and SIO, to us and the NMFS Permits and Conservation Division respectively, will submit a draft comprehensive report on all activities and monitoring results within 90 days of completion of the survey. For further details, see the proposed IHA (90 Fed. Reg. 34212) and ITS reporting in Section 10.

### **2.3 Stressors Resulting from the Components of the Proposed Action**

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

1. Pollution (e.g., R/V emissions, fuel);
2. Vessel strike;
3. Disturbance from the R/V (i.e., presence, visual, acoustic);
4. Acoustic instruments (MBES, SBP, ADCP);
5. Entanglement/interaction with in-water equipment; and
6. Airguns (underwater acoustic).

### **3. ACTION AREA**

*Action area* means “all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action” (50 CFR §402.02). The action area is defined by the extent of the environmental changes the stressors cause on the physical environment (e.g., land, air, or water, detailed in the previous section). The action area includes a portion of the Northeast Pacific Ocean, off Oregon and Washington, where the survey will take place, and waters where the survey raises sound levels above ambient levels. Because ambient underwater sound measurements are lacking where the survey will occur, we use the survey area determined by NSF (Figure 1) to delineate the extent of the area affected by the survey. The action area also includes waters between the survey area and Newport, Oregon, and Yaquina Bay where the Port of Newport is located and from where the R/V will depart and return.

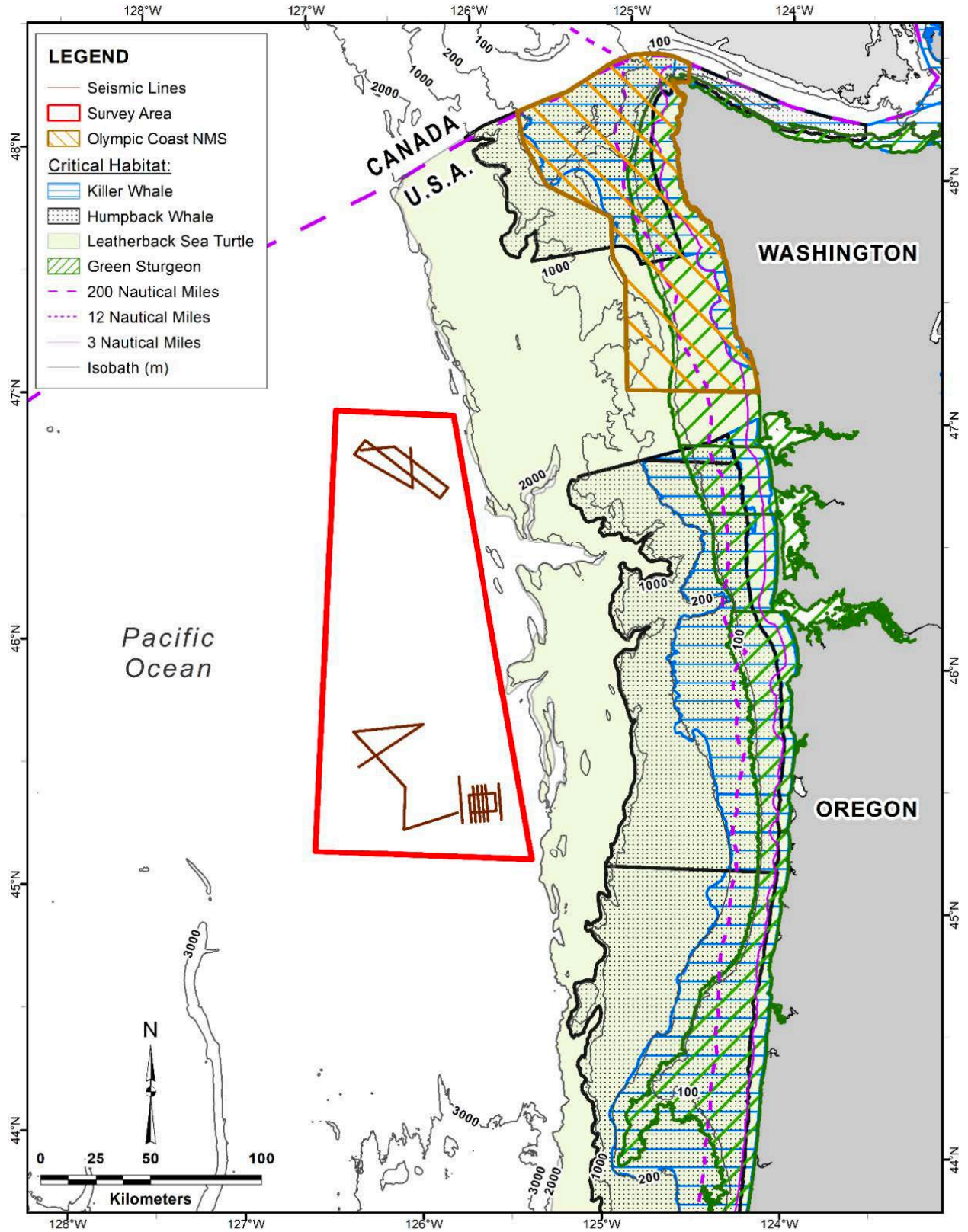


Figure 1. Map of the survey location

#### 4. SPECIES AND CRITICAL HABITAT THAT MAY BE AFFECTED BY THE PROPOSED ACTION

The ESA allows for three general determinations for listed species and critical habitat: 1) no effect, 2) may affect, not likely to adversely affect (NLAA), and 3) may affect, likely to adversely affect (LAA). Action agencies, prior to requesting ESA consultation, determine whether their proposed action may affect ESA-listed or proposed species or their designated critical habitat. Generally, a “no effect” determination means there is no plausible exposure or response to stressors generated by the proposed action for any ESA-listed or proposed species or designated critical habitat. A “no effect” determination does not require consultation. Any scenario where there is a plausible exposure to stressors generated by the action, no matter how unlikely, is considered “may affect.” For any action that “may affect” an ESA-listed species or its designated critical habitat, the action agency shall consult with the Services under section 7(a)(2) of the ESA. An action agency is also required to confer with the Services on any effects to proposed species or proposed critical habitat if those effects are likely to jeopardize the continued existence of the species, or destroy or adversely modify the proposed critical habitat. However, action agencies may voluntarily confer with the Services for all proposed species or proposed critical habitat in the action area when the action may affect those proposed entities without rising to a level requiring us to confer.

**Table 2. Species and critical habitat present in the action area**

Species	ESA Status	Critical Habitat	Recovery Plan
Blue Whale ( <i>Balaenoptera musculus</i> )	<a href="#">E – 35 Fed. Reg. 18319</a>	-- --	<a href="#">11/2020</a>
Fin Whale ( <i>Balaenoptera physalus</i> )	<a href="#">E – 35 Fed. Reg. 18319</a>	-- --	<a href="#">07/2010</a>
Gray Whale ( <i>Eschrichtius robustus</i> ) – Western North Pacific DPS	<a href="#">E – 35 Fed. Reg. 18319</a>	-- --	-- --
Humpback Whale ( <i>Megaptera novaeangliae</i> ) – Central America DPS	<a href="#">E – 81 Fed. Reg. 62259</a>	<a href="#">86 Fed. Reg. 21082</a>	<a href="#">11/1991</a> <a href="#">06/2022</a> (Outline)
Humpback Whale ( <i>Megaptera novaeangliae</i> ) – Mexico DPS	<a href="#">T – 81 Fed. Reg. 62259</a>	<a href="#">86 Fed. Reg. 21082</a>	<a href="#">11/1991</a> <a href="#">06/2022</a> (Outline)
Killer Whale ( <i>Orcinus orca</i> ) – Southern Resident DPS	<a href="#">E – 70 Fed. Reg. 69903</a> <a href="#">Amendment 80 Fed. Reg. 7380</a>	<a href="#">86 Fed. Reg. 41668</a>	<a href="#">01/2008</a>

<b>Species</b>	<b>ESA Status</b>	<b>Critical Habitat</b>	<b>Recovery Plan</b>
North Pacific Right Whale ( <i>Eubalaena japonica</i> )	<a href="#">E – 73 Fed. Reg. 12024</a>	<a href="#">73 Fed. Reg. 19000*</a>	<a href="#">06/2013</a>
Sei Whale ( <i>Balaenoptera borealis</i> )	<a href="#">E – 35 Fed. Reg. 18319</a>	---	<a href="#">12/2011</a>
Sperm Whale ( <i>Physeter macrocephalus</i> )	<a href="#">E – 35 Fed. Reg. 18319</a>	---	<a href="#">12/2010</a>
Guadalupe Fur Seal ( <i>Arctocephalus townsendi</i> )	<a href="#">T – 50 Fed. Reg. 51252</a>	---	---
Green Turtle ( <i>Chelonia mydas</i> ) – East Pacific DPS	<a href="#">T – 81 Fed. Reg. 20057</a>	<a href="#">88 Fed. Reg. 46572*</a> (Proposed)	<a href="#">01/1998</a>
Leatherback Turtle ( <i>Dermochelys coriacea</i> )	<a href="#">E – 35 Fed. Reg. 8491</a>	<a href="#">44 Fed. Reg. 17710*</a> <a href="#">77 Fed. Reg. 4170</a>	<a href="#">01/1998</a> – U.S. Pacific
Loggerhead Turtle ( <i>Caretta caretta</i> ) – North Pacific Ocean DPS	<a href="#">E – 76 Fed. Reg. 58868</a>	---	<a href="#">01/1998</a> – U.S. Pacific
Olive Ridley Turtle ( <i>Lepidochelys olivacea</i> ) – Mexico's Pacific Coast Breeding Colonies	<a href="#">E – 43 Fed. Reg. 32800</a>	---	<a href="#">01/1998</a>
Chinook Salmon ( <i>Oncorhynchus tshawytscha</i> ) – California Coastal ESU	<a href="#">T – 70 Fed. Reg. 37160</a>	<a href="#">70 Fed. Reg. 52488*</a>	<a href="#">10/2016</a>
Chinook Salmon ( <i>Oncorhynchus tshawytscha</i> ) – Central Valley Spring-Run ESU	<a href="#">T – 70 Fed. Reg. 37160</a>	<a href="#">70 Fed. Reg. 52488*</a>	<a href="#">07/2014</a>
Chinook Salmon ( <i>Oncorhynchus tshawytscha</i> ) – Lower Columbia River ESU	<a href="#">T – 70 Fed. Reg. 37160</a>	<a href="#">70 Fed. Reg. 52629*</a>	<a href="#">06/2013</a>
Chinook Salmon ( <i>Oncorhynchus tshawytscha</i> ) – Puget Sound ESU	<a href="#">T – 70 Fed. Reg. 37160</a>	<a href="#">70 Fed. Reg. 52629*</a>	<a href="#">01/2007</a>

<b>Species</b>	<b>ESA Status</b>	<b>Critical Habitat</b>	<b>Recovery Plan</b>
Chinook Salmon ( <i>Oncorhynchus tshawytscha</i> ) – Sacramento River Winter-Run ESU	<a href="#">E – 70 Fed. Reg. 37160</a>	<a href="#">58 Fed. Reg. 33212*</a>	<a href="#">07/2014</a>
Chinook Salmon ( <i>Oncorhynchus tshawytscha</i> ) – Snake River Fall-Run ESU	<a href="#">T – 70 Fed. Reg. 37160</a>	<a href="#">58 Fed. Reg. 68543*</a>	<a href="#">11/2017</a>
Chinook Salmon ( <i>Oncorhynchus tshawytscha</i> ) – Snake River Spring/Summer-Run ESU	<a href="#">T – 70 Fed. Reg. 37160</a>	<a href="#">64 Fed. Reg. 57399*</a>	<a href="#">11/2017</a>
Chinook Salmon ( <i>Oncorhynchus tshawytscha</i> ) – Upper Columbia River Spring-Run ESU	<a href="#">E – 70 Fed. Reg. 37160</a>	<a href="#">70 Fed. Reg. 52629*</a>	<a href="#">08/2007</a>
Chinook Salmon ( <i>Oncorhynchus tshawytscha</i> ) – Upper Willamette River ESU	<a href="#">T – 70 Fed. Reg. 37160</a>	<a href="#">70 Fed. Reg. 52629*</a>	<a href="#">08/2011</a>
Chum Salmon ( <i>Oncorhynchus keta</i> ) – Columbia River ESU	<a href="#">T – 70 Fed. Reg. 37160</a>	<a href="#">70 Fed. Reg. 52629*</a>	<a href="#">06/2013</a>
Chum Salmon ( <i>Oncorhynchus keta</i> ) – Hood Canal Summer-Run ESU	<a href="#">T – 70 Fed. Reg. 37160</a>	<a href="#">70 Fed. Reg. 52629*</a>	<a href="#">11/2005</a>
Coho Salmon ( <i>Oncorhynchus kisutch</i> ) – Central California Coast ESU	<a href="#">E – 70 Fed. Reg. 37160</a>	<a href="#">64 Fed. Reg. 24049*</a>	<a href="#">09/2012</a>
Coho Salmon ( <i>Oncorhynchus kisutch</i> ) – Lower Columbia River ESU	<a href="#">T – 70 Fed. Reg. 37160</a>	<a href="#">81 Fed. Reg. 9251*</a>	<a href="#">06/2013</a>
Coho Salmon ( <i>Oncorhynchus kisutch</i> ) – Oregon Coast ESU	<a href="#">T – 73 Fed. Reg. 7816</a>	<a href="#">73 Fed. Reg. 7816</a>	<a href="#">12/2016</a>

<b>Species</b>	<b>ESA Status</b>	<b>Critical Habitat</b>	<b>Recovery Plan</b>
Coho Salmon ( <i>Oncorhynchus kisutch</i> ) – Southern Oregon and Northern California Coasts ESU	<a href="#">T – 70 Fed. Reg. 37160</a>	<a href="#">64 Fed. Reg. 24049*</a>	<a href="#">09/2014</a>
Eulachon ( <i>Thaleichthys pacificus</i> ) – Southern DPS	<a href="#">T – 75 Fed. Reg. 13012</a>	<a href="#">76 Fed. Reg. 65323*</a>	<a href="#">09/2017</a>
Green Sturgeon ( <i>Acipenser medirostris</i> ) – Southern DPS	<a href="#">T – 71 Fed. Reg. 17757</a>	<a href="#">74 Fed. Reg. 52300</a>	<a href="#">8/2018</a>
Steelhead Trout ( <i>Oncorhynchus mykiss</i> ) – California Central Valley DPS	<a href="#">T – 71 Fed. Reg. 834</a>	<a href="#">70 Fed. Reg. 52487*</a>	<a href="#">07/2014</a>
Steelhead Trout ( <i>Oncorhynchus mykiss</i> ) – Central California Coast DPS	<a href="#">T – 71 Fed. Reg. 834</a>	<a href="#">70 Fed. Reg. 52487*</a>	<a href="#">10/2016</a>
Steelhead Trout ( <i>Oncorhynchus mykiss</i> ) – Lower Columbia River DPS	<a href="#">T – 71 Fed. Reg. 834</a>	<a href="#">70 Fed. Reg. 52629*</a>	<a href="#">06/2013</a>
Steelhead Trout ( <i>Oncorhynchus mykiss</i> ) – Middle Columbia River DPS	<a href="#">T – 71 Fed. Reg. 834</a>	<a href="#">70 Fed. Reg. 52629*</a>	<a href="#">11/2009</a>
Steelhead Trout ( <i>Oncorhynchus mykiss</i> ) – Northern California DPS	<a href="#">T – 71 Fed. Reg. 834</a>	<a href="#">70 Fed. Reg. 52487*</a>	<a href="#">10/2016</a>
Steelhead Trout ( <i>Oncorhynchus mykiss</i> ) – Puget Sound DPS	<a href="#">T – 72 Fed. Reg. 26722</a>	<a href="#">81 Fed. Reg. 9251*</a>	<a href="#">12/2019</a>
Steelhead Trout ( <i>Oncorhynchus mykiss</i> ) – Snake River Basin DPS	<a href="#">T – 71 Fed. Reg. 834</a>	<a href="#">70 Fed. Reg. 52629*</a>	<a href="#">11/2017</a>
Steelhead Trout ( <i>Oncorhynchus mykiss</i> ) – South-	<a href="#">T – 71 Fed. Reg. 834</a>	<a href="#">70 Fed. Reg. 52487*</a>	<a href="#">12/2013</a>

Species	ESA Status	Critical Habitat	Recovery Plan
Central California Coast DPS			
Steelhead Trout ( <i>Oncorhynchus mykiss</i> ) – Southern California DPS	<a href="#">E – 71 Fed. Reg. 834</a>	<a href="#">70 Fed. Reg. 52487*</a>	<a href="#">01/2012</a>
Steelhead Trout ( <i>Oncorhynchus mykiss</i> ) – Upper Columbia River DPS	<a href="#">T – 71 Fed. Reg. 834</a>	<a href="#">70 Fed. Reg. 52629*</a>	<a href="#">08/2007</a>
Steelhead Trout ( <i>Oncorhynchus mykiss</i> ) – Upper Willamette River DPS	<a href="#">T – 71 Fed. Reg. 834</a>	<a href="#">70 Fed. Reg. 52629*</a>	<a href="#">08/2011</a>
Sunflower Sea Star ( <i>Pycnopodia helanthoides</i> )	<a href="#">T – 88 Fed. Reg. 16212 (Proposed)</a>	--- --	--- --

Fed. Reg. = *Federal Register*; E = Endangered; T = Threatened; DPS = Distinct Population Segment; ESU = Evolutionarily Significant Unit

\* Designated critical habitat does not overlap with the action area

**Table 3. Physical or Biological Features of designated or proposed critical habitat present in the action area that may be affected by the proposed action**

<b>Designated or Proposed Critical Habitat</b>	<b>PBFs</b>
Killer Whale – Southern Resident DPS	<p>Currently Designated CH: U.S. West Coast – marine waters between the 20-ft (6.1-m) depth contour and the 656.2-ft (200-m) depth contour, from the U.S.-Canada border to Point Sur, California (excluding the Quinault Range Site)</p> <p>Designated CH PBFs:</p> <ol style="list-style-type: none"> <li>1. Water quality to support growth and development;</li> <li>2. Prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth; and</li> <li>3. Passage conditions to allow for migration, resting, and foraging.</li> </ol>
Humpback Whale – Central America DPS	<p>Currently Designated CH: California – marine habitat within portions of the California Coastal Ecosystem</p> <p>Designated CH PBFs: Prey species, primarily euphausiids and small pelagic schooling fishes, of sufficient quality, abundance, and accessibility within humpback whale feeding areas to support feeding and population growth.</p>
Humpback Whale – Mexico DPS	<p>Currently Designated CH: California – marine habitat within portions of the California Coastal Ecosystem</p> <p>Designated CH PBFs: Prey species, primarily euphausiids and small pelagic schooling fishes, of sufficient quality, abundance, and accessibility within humpback whale feeding areas to support feeding and population growth.</p>
Leatherback Turtle	<p>Currently Designated CH: California coast – Point Arena to Point Arguello east of the 3,000-m depth contour</p> <p>Designated CH PBFs: Occurrence of prey species, primarily scyphomedusae (i.e., jellyfish) of the order Semaestomeae, of sufficient condition, distribution, diversity, abundance and density necessary to support individual as well as population growth, reproduction, and development of leatherbacks</p>

<b>Designated or Proposed Critical Habitat</b>	<b>PBFs</b>
Coho Salmon – Oregon Coast ESU	<p>Currently Designated CH: Oregon coast – south of the Columbia River and north of Cape Blanco</p> <p>Designated CH PBFs:</p> <ol style="list-style-type: none"> <li>1. Estuarine areas free of obstruction with water quality conditions supporting juvenile and adult physiological transitions between fresh- and saltwater, including juvenile and adult forage;</li> <li>2. Nearshore marine areas free of obstruction with water quality conditions and forage supporting growth and maturation; and</li> <li>3. Offshore marine areas with water quality conditions and forage supporting growth and maturation.</li> </ol>
Green Sturgeon – Southern DPS	<p>Currently Designated CH: Coastal U.S. marine waters – from Monterey Bay, California to Cape Flattery, Washington, including various rivers, bays, and estuaries such as Yaquina Bay, Oregon</p> <p>Designated CH PBFs (for estuarine and marine areas):</p> <ol style="list-style-type: none"> <li>1. Food resources: abundant prey items for juvenile, subadult, and adult life stages; and</li> <li>2. Water quality: including chemical characteristics necessary for normal behavior, growth, and viability of all life stages and acceptably low levels of contaminants that may disrupt normal behavior, growth, and viability of subadult and adult green sturgeon</li> </ol>

CH = critical habitat; PBFs = physical or biological features; DPS = distinct population segment; ESU = Evolutionarily Significant Unit

#### 4.1 May Affect, Not Likely to Adversely Affect

Once we have determined the action may affect ESA-listed or proposed species or their designated critical habitat, the next step is differentiating between stressors that are NLAA and LAA for each listed species and critical habitat in the action area. An action warrants a NLAA finding when its effects are completely beneficial, discountable, or insignificant. Completely beneficial effects have an immediate positive effect without any adverse effects to the species or habitat. Completely beneficial effects are usually discussed when the project has a clear link to the ESA-listed species or its specific habitat needs and consultation is required because the species may be affected, albeit positively. Discountable effects are those that could occur while an ESA-listed species is in the action area but, because of the intensity, magnitude, frequency, duration, or timing of the stressor, exposure to the stressor is extremely unlikely to occur. Insignificant effects relate to the response of exposed individuals where the response, in terms of an individual’s growth, survival, or reproduction, would be immeasurable or undetectable, or an impact to the conservation value of a PBF would be immeasurable or undetectable. For stressors

that meet these criteria for completely beneficial, discountable, or insignificant, the appropriate conclusion is NLAA.

To assist in reaching a determination, we perform a two-step assessment that considers all of the stressors identified in Section 2.3 of this opinion, all of the species in Table 2, and critical habitats identified in Table 3, to understand the likelihood of the stressors having an effect on the ESA-listed or proposed species or their designated critical habitat. First, we consider whether it is likely that a listed species or critical habitat is exposed to a stressor or there is a reasonable expectation of the stressor and an individual or habitat co-occurring. If we conclude that exposure of a species or critical habitat to a stressor caused by the proposed action or activity is discountable, we must also conclude it is NLAA. However, if exposure is probable, the second step is to evaluate the probability of a response to the stressor. When all stressors of an action are found to be NLAA for a listed species or a critical habitat, we conclude informal consultation for that species or critical habitat. Likewise, if a stressor associated with this action is found to be NLAA for all listed species and all critical habitats, there is no need to continue analyzing the consequences of that stressor in the Analysis of Effects. Where the negative effects to any species or critical habitat or from any stressor to those species or critical habitat are found to exceed the standards of insignificant or discountable, we must analyze those consequences in the Analysis of Effects.

#### **4.1.1 Stressors Not Likely to Adversely Affect Species or Critical Habitat**

This section identifies the stressors that are NLAA for every ESA-listed or proposed species and their designated critical habitat in the action area and will not be analyzed further in this opinion.

##### **4.1.1.1 Pollution**

Pollutants emitted by the R/V *Sally Ride* during the survey can include exhaust (carbon dioxide, nitrogen oxides, and sulfur oxides), fuel or oil spills, or leaks. Exhaust may affect air-breathing ESA-listed species such as marine mammals and sea turtles considered in this consultation (Table 1). Although the R/V will transit through areas where ESA-listed marine mammals and sea turtles are expected to occur in higher numbers or densities (e.g., close to shore, critical habitat), it is unlikely that pollutants in the air would have a measurable impact on ESA-listed marine mammals or sea turtles given the relatively short duration of the survey (three days), dispersion of pollutants in the air, and the brief amount of time that marine mammals and sea turtles spend at the water's surface to breathe. Thus, the effects of pollutants in the air on ESA-listed species due to the proposed action will be so small as to be immeasurable, and, thus, insignificant. Fuel or oil spills, or leaks may affect ESA-listed or proposed marine mammals, sea turtles, fishes, and invertebrates considered in this consultation (Table 1). However, a fuel or oil leakage is extremely unlikely and R/Vs used for NSF-funded marine seismic surveys have spill prevention plans on preventing a fuel or oil spill. Additionally, no plastics or toxic materials will be disposed of at sea in accordance with waste management practices on the R/V and all project-related waste will be disposed of in accordance with international and U.S. Federal requirements. Thus, the effects of pollutants in the water on ESA-listed species due to the proposed action will be extremely unlikely to occur, and discountable.

In summary, the potential effects to ESA-listed or proposed species from pollution are insignificant or discountable. We conclude that impacts from pollution to ESA-listed or proposed species in the action area because of activities covered under this consultation may affect, but are not likely to adversely affect, ESA-listed species.

#### **4.1.1.2 Vessel Strike**

Vessel strikes are known to affect marine mammals, sea turtles, and fishes and may injure or even kill the struck animal. The potential for a vessel striking an ESA-listed or proposed species at or near the ocean's surface during the proposed survey is extremely unlikely because of minimal vessel operations and conservation measures that will be implemented during the survey. The survey consists of only three days of vessel use. Additionally, the R/V *Sally Ride* will transit at relatively slow speeds (approximately 10 knots or 18.5 km/hr during transit, and 5 knots or 9.3 km/hr during airgun operations), minimizing the risk of striking an animal (Rockwood et al. 2021; Vanderlaan and Taggart 2007b). Conservation measures including visual monitoring by PSOs and vessel strike avoidance measures (see Section 2.2) further reduce the potential for a vessel strike. Vessel strike of species that generally occur at the seafloor (e.g., Southern DPS of green sturgeon, and proposed sunflower sea star) is also unlikely. Transit of the R/V in shallow waters, where vessel strike of these species would be possible, would risk grounding of the vessel. Additionally, the draft (vertical distance between the waterline and the deepest point of the vessel) of the R/V *Sally Ride* (approximately 15.1 ft or 4.6 m) is less than the water depths that the R/V is expected to travel through (e.g., Yaquina Bay is an estuary categorized as a deep-draft development by the [State of Oregon](#), and is maintained at more than 22 ft or 6.7 m deep; the main vessel transit channel into the [Port of Newport](#) is at least 40 ft or 12.2 m deep). Thus, the R/V *Sally Ride* would not reach the seafloor. Therefore, ESA-listed and proposed species' exposure to vessel strike is discountable. We conclude that impacts from vessel strike to ESA-listed or proposed species in the action area because of activities covered under this consultation may affect, but are not likely to adversely affect ESA-listed or proposed species.

#### **4.1.1.3 Disturbance from the Research Vessel**

The R/V may visually disturb animals and vessel noise may cause disturbance because of elevated sound levels. The duration of R/V operations lasts three days, and is limited especially compared to the amount of recreational and commercial vessel traffic across the action area. Given the relatively small contribution of the R/V associated with the proposed survey to the overall vessel activity, effects from vessel presence are expected to be so minor that they cannot be meaningfully evaluated and are thus insignificant.

Noise from the R/V may produce an acoustic disturbance or otherwise affect the behavior of ESA-listed species that spend time near the surface, such as marine mammals, sea turtles, and fishes. Studies have shown that vessel operation 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). However, vessel noise will not exceed that of larger commercial shipping vessels and will only be temporary (three days) compared to the constant presence of commercial vessels.

Additionally, while not specifically designed to do so, several aspects of the conservation measures will minimize effects associated with vessel acoustic disturbance to ESA-listed species (e.g., maintaining separation distances from protected species, slowing to 10 knots or less around certain species and in specific areas; see Section 2.2). Given the aforementioned conservation measures and the relatively small contribution of the R/V to the overall soundscape, effects from vessel noise are expected to be so minor that they cannot be meaningfully evaluated and are thus insignificant.

In summary, the potential effects to ESA-listed species from R/V disturbance are insignificant. We conclude that impacts from R/V disturbance to ESA-listed species in the action area because of activities covered under this consultation may affect, but are not likely to adversely affect, ESA-listed species.

#### **4.1.1.4 Acoustic Instruments (Multibeam Echosounder, Sub-bottom Profiler, and Acoustic Doppler Current Profiler)**

Acoustic instruments other than the airguns will be operating during the survey, including MBESs, SBP, and ADCP (see NSF's Draft Environmental Assessment of Marine Geophysical Surveys by R/V *Sally Ride* at the Cascadia Subduction Zone, northeast Pacific Ocean, September 2025 on NSF's Environmental Compliance webpage, under the subheading "Current environmental reviews" at <https://www.nsf.gov/funding/environmental-compliance> for specifications on these instruments). These instruments (MBES, SBP, ADCP) have a limited beamwidth and are highly directional, unlike the airguns. If an ESA-listed marine mammal, sea turtle, or fish transits into the beam, the period of time the individual would be within the beam and exposed to the sound source would be very brief. Analyses that include the duration of exposure to the ensonified area created by the EM 122 and 124 indicate that the exposure would be brief, on the order of a few seconds or under a minute (Ruppel et al. 2022; Denes et al. 2021). However, it is extremely unlikely that an ESA-listed species will occur directly in the beam of these acoustic instruments because of the limited beamwidth, simultaneous movement of the R/V and the animals, and conservation measures implemented during the survey (e.g., visual monitoring, vessel strike avoidance measures). Therefore, ESA-listed species' exposure to acoustic instruments (MBES, SBP, ADCP) is discountable.

In summary, the potential effects to ESA-listed species from acoustic instruments (MBES, SBP, ADCP) are discountable. We conclude that impacts from acoustic instruments (MBES, SBP, ADCP) to ESA-listed species in the action area because of activities covered under this consultation may affect, but are not likely to adversely affect, ESA-listed species.

#### **4.1.1.5 Entanglement/Interaction with In-water Equipment**

Towed seismic equipment (the airgun array and towed hydrophone streamer) could risk entanglement of ESA-listed marine mammals, sea turtles, and fishes; however, entanglement is extremely unlikely. The airgun array and towed hydrophone streamer are rigid, and thus, is not expected to encircle, wrap around, or in any other way entangle ESA-listed species. Furthermore, there have been no reported entanglements or interactions with the towed equipment over numerous NSF-funded marine geophysical surveys. Therefore, ESA-listed species' exposure to

entanglement and interaction with equipment is discountable. We conclude that impacts from entanglement and interaction with equipment to ESA-listed species in the action area because of activities covered under this consultation may affect, but are not likely to adversely affect ESA-listed species.

#### **4.1.2 Species Not Likely to be Adversely Affected**

In addition to the potential stressors that are not likely to adversely affect ESA-listed or proposed species discussed above in Section 4.1.1, other stressors (i.e., airguns) resulting from the proposed action, may affect, but are not likely to adversely affect a majority of ESA-listed and proposed species that may be present in the action area. This section identifies the ESA-listed or proposed species for which the underwater acoustic effects from the airguns are NLAA and are not analyzed further in this opinion.

##### **4.1.2.1 ESA-Listed Marine Mammals**

The ESA-listed marine mammal species that are not likely to be adversely affected by the underwater acoustic effects from the airguns are: Western North Pacific DPS gray whale, Southern Resident DPS killer whale, and North Pacific right whale.

Western North Pacific DPS gray whales are mainly found in eastern Asia, but some individuals migrate to coastal waters off Canada, the U.S. West Coast, and Mexico (Lang et al. 2014; Mate et al. 2015; Urbán et al. 2019b; Weller et al. 2013; Weller et al. 2012). In the summer and fall, Western North Pacific DPS gray whales feed in the Okhotsk Sea off Sakhalin Island, Russia, and off southeastern Kamchatka in the Bering Sea (Burdin et al. 2017; Tyurneva et al. 2010; Vertyankin et al. 2004; Weller et al. 2002). In the spring and fall months off the west coast of North America (Alaska, Canada, Washington, Oregon, and California), only 1.2% of gray whales are expected to belong to the Western North Pacific DPS (Cooke 2018a; Cooke et al. 2019; Cooke et al. 2017; Eguchi et al. 2023; Lang et al. 2022; Martínez-Aguilar et al. 2022; Mate et al. 2015; Urbán et al. 2019a; Weller et al. 2012). Due to the rarity of Western North Pacific DPS gray whale in the action area and seasonal migration patterns, it is extremely unlikely that Western North Pacific DPS gray whale will be exposed to sound from the airguns. Therefore, the effects are discountable.

The Southern Resident DPS killer whale mainly occurs in the Salish Sea (Strait of Georgia, Strait of Juan de Fuca, and Puget Sound) during late spring, summer, and fall, and in coastal waters off Washington and Vancouver Island particularly between Grays Harbor and the Columbia River (Carretta et al. 2024a). Based on the intracoastal and coastal distribution of Southern Resident DPS killer whale, it is extremely unlikely that Southern Resident DPS killer whale will be exposed to sound from the airguns, which will occur much further offshore. Therefore, the effects are discountable.

North Pacific right whales are rare, though individuals have been sighted off the U.S. West Coast (Crance and Kennedy 2024). From 2006 to 2023, there are only six records (all individuals except one group of two) of North Pacific right whale off British Columbia, Canada, to the north of the action area, and only five records (all individuals) off California, to the south of the action

area (Crance and Kennedy 2024). There were no sighting records of North Pacific right whale off Oregon or Washington; however, two North Pacific right whale calls were acoustically detected off Washington in June 2013 (Širović et al. 2015). Although migration patterns are unknown, North Pacific right whales appear to migrate from high-latitude summer feeding grounds to low-latitude breeding grounds, similar to other baleen whale species. North Pacific right whales are thought to spend late spring to early fall in the Bering Sea (e.g., Munger et al. 2008). Due to the rarity of North Pacific right whale in the action area and probable seasonal migration patterns, it is extremely unlikely that North Pacific right whale will be exposed to sound from the airguns. Therefore, the effects are discountable.

In summary, the potential effects to ESA-listed Western North Pacific DPS gray whale, Southern Resident DPS killer whale, and North Pacific right whale from underwater acoustic effects from airguns are discountable. Therefore, we conclude that impacts from the airguns to Western North Pacific DPS gray whale, Southern Resident DPS killer whale, and North Pacific right whale in the action area because of activities covered under this consultation may affect, but are not likely to adversely affect, Western North Pacific DPS gray whale, Southern Resident DPS killer whale, and North Pacific right whale.

#### 4.1.2.2 ESA-Listed Sea Turtles

The ESA-listed sea turtle species that are not likely to be adversely affected by the underwater acoustic effects from the airguns are: East Pacific DPS green turtle, leatherback turtle, North Pacific Ocean DPS loggerhead turtle, and Mexico's Pacific Coast breeding colonies olive ridley turtle.

The East Pacific DPS green turtle occurs from the California/Oregon border (the north-most boundary of green turtle DPSs in the Pacific) to central Chile, and generally occurs in tropical, subtropical, or coastal temperate waters (Seminoff et al. 2015). North Pacific Ocean DPS loggerhead turtles are loggerhead turtles originating from the North Pacific Ocean, north of the Equator and south of 60 degrees (°) latitude (Conant et al. 2009). Green and loggerhead turtle sightings are rare in Oregon and Washington, and a majority of occurrences are strandings (Sato 2017b). Mexico's Pacific Coast breeding colonies olive ridley turtles typically occur in tropical and subtropical waters, and generally do not occur further north than California. However, they were historically documented as far north as Alaska (Hodge and Wing 2000) and in December 2014 and January 2015, two olive ridley turtles stranded in Washington (<https://komonews.com/news/local/2nd-endangered-sea-turtle-washes-up-on-wash-state-beach?photo=1>; accessed May 30, 2025). Between December 2024 and June 2025, there have been two strandings of olive ridley turtles (dead) and two strandings of loggerhead turtles (alive) in Oregon (see the [Oregon Marine Mammal Stranding Network Map](#)). Nesting of these three species does not occur in the action area. Given the rarity of East Pacific DPS green turtle, North Pacific Ocean DPS loggerhead turtle, and Mexico's Pacific Coast breeding colonies olive ridley turtle in the action area, it is extremely unlikely that these species will be exposed to sound from the airguns. Therefore, the effects are discountable.

Leatherback turtle distribution is global and they can occur as far as approximately 71°N to 47°S in the southern hemisphere. In the Pacific Ocean, leatherback turtles occur off British Columbia,

in the Gulf of Alaska to Chile and New Zealand's South Island in the Pacific (NMFS and USFWS 2013). Nesting does not occur in the action area. Leatherbacks have been sighted and satellite tracked within the action area (see Benson et al. 2011 and Bailey et al. 2012). Individuals that occur within the action area most likely migrated from nesting beaches in the western Pacific (i.e., Indonesia), and forage off of Washington, Oregon, and California in the summer and fall (Sato 2017a). DON (2019), which informs marine species densities for the U.S. Navy's Phase III Northwest Training and Testing Study Area, provides the best available information on leatherback turtle densities in the action area because the offshore portion of the Northwest Training and Testing Study Area encompasses the action area. However, because of a lack of survey data in the Northwest Training and Testing Offshore Study Area, DON (2019) used leatherback turtle data from the California Current Ecosystem. The resulting density is very low, 0.000114 leatherback turtles per square kilometer (km<sup>2</sup>), which, in addition to the short duration of the survey (three days), makes it extremely unlikely that leatherback turtles will be exposed to sound from the airguns. Therefore, the effects are discountable.

In summary, the potential effects to East Pacific PDS green turtle, leatherback turtle, North Pacific Ocean DPS loggerhead turtle, and Mexico's Pacific Coast breeding colonies olive ridley turtle from underwater acoustic effects from airguns are discountable. Therefore, we conclude that impacts from the airguns to East Pacific PDS green turtle, leatherback turtle, North Pacific Ocean DPS loggerhead turtle, and Mexico's Pacific Coast breeding colonies olive ridley turtle in the action area because of activities covered under this consultation may affect, but are not likely to adversely affect, East Pacific PDS green turtle, leatherback turtle, North Pacific Ocean DPS loggerhead turtle, and Mexico's Pacific Coast breeding colonies olive ridley turtle.

#### **4.1.2.3 ESA-Listed Fishes**

The ESA-listed fish species that are not likely to be adversely affected by the underwater acoustic effects from the airguns are: the California coastal ESU, Central Valley spring-run ESU, Lower Columbia River ESU, Puget Sound ESU, Sacramento River winter-run ESU, Snake River ESU, Snake River spring/summer run ESU, Upper Columbia River spring-run ESU, and Upper Willamette River ESU of chinook salmon, the Columbia River ESU and Hood Canal summer-run ESU of chum salmon, the Central California coast ESU, Lower Columbia River ESU, Oregon coast ESU, and Southern Oregon and Northern California coasts ESU of coho salmon, the Southern DPS of eulachon, the Southern DPS of green sturgeon, the Ozette Lake ESU and Snake River ESU of sockeye salmon, the California Central Valley DPS, Central California Coast DPS, Lower Columbia River DPS, Middle Columbia River DPS, Northern California DPS, Puget Sound DPS, Snake River Basin DPS, South-Central California Coast DPS, Southern California DPS, Upper Columbia River DPS, and Upper Willamette River DPS of steelhead trout.

Salmonids (chinook salmon, chum salmon, coho salmon, sockeye salmon, and steelhead trout) are generally anadromous, meaning they migrate from freshwater streams and rivers to marine waters and back to spawn in their natal stream/river. There is limited information on salmonids' distribution and movements in the open ocean. A handful of studies off Oregon and Washington observed chinook salmon at depths up to approximately 577 ft (176 m), with highest catch probability at depths up to 328 ft (100 m), and a majority were observed within approximately

14.9–17.4 mi (24–28 km) from shore (Bi et al. 2007; Foley et al. 2005; Freshwater et al. 2024; Roni et al. 1999; Watters et al. 2005). While most of these studies observed yearling or subadult salmon, Freshwater et al. (2024) studied depth distributions of adult chinook salmon, which occurred in waters 1,312.3 ft (400 m) or less. Coho were also observed within 34.2 mi (55 km) from shore and in depths less than 656 ft (200 m) for yearlings or 328 ft (100 m) for subadults (Bi et al. 2007; Freshwater et al. 2024). In the eastern Bering Sea, chum and sockeye salmon were captured at depths averaging 52.5 ft (16 m) and 9.8 ft (3 m), and maximum depths of 830 ft (253 m) and 272.3 ft (83 m), respectively (Walker et al. 2007). Steelhead may be distributed further from shore than other salmonids and have been observed 40 km from shore (Daly et al. 2014); however, densities are not expected to be high offshore because steelhead do not aggregate in those areas. The areas that salmonids are expected to occupy are much closer to shore than the survey area (more than 62 mi or 100 km from shore, in water depths between 6,560–11,483 ft or 2,000–3,500 m). Thus, it is extremely unlikely that salmonids will be exposed to sound from the airguns, and the effects are discountable.

The range of the Southern DPS of eulachon is also limited to more nearshore waters than the survey area. The Southern DPS of eulachon occurs in water depths 164–656.2 ft (50–200m) off the U.S. West Coast (Gustafson et al. 2022). Thus, it is extremely unlikely that the Southern DPS of eulachon will be exposed to sound from the airguns and the effects are discountable.

The Southern DPS of green sturgeon is also an anadromous fish, spawning in their natal stream from April to July and migrating to marine waters from November to January. Spawning for the Southern DPS of green sturgeon is only known to occur in the Sacramento River. Post-spawning fish and juveniles typically rear and feed in fresh and estuarine waters for one to four years before migrating to marine waters as subadults (Nakamoto et al. 1995). Subadults and adults generally occupy coastal waters between 66–230 ft (20–70 m) depth, but have been observed in water depths up to 360.9 ft (110 m; Erickson and Hightower 2007; Huff et al. 2011). Thus, it is extremely unlikely that the Southern DPS of eulachon will be exposed to sound from the airguns, and the effects are discountable.

In summary, the potential effects to ESA-listed fishes from underwater acoustic effects from airguns are discountable. Therefore, we conclude that impacts from the airguns to the California coastal ESU, Central Valley spring-run ESU, Lower Columbia River ESU, Puget Sound ESU, Sacramento River winter-run ESU, Snake River ESU, Snake River spring/summer run ESU, Upper Columbia River spring-run ESU, and Upper Willamette River ESU of chinook salmon, the Columbia River ESU and Hood Canal summer-run ESU of chum salmon, the Central California coast ESU, Lower Columbia River ESU, Oregon coast ESU, and Southern Oregon and Northern California coasts ESU of coho salmon, the Southern DPS of eulachon, the Southern DPS of green sturgeon, the Ozette Lake ESU and Snake River ESU of sockeye salmon, the California Central Valley DPS, Central California Coast DPS, Lower Columbia River DPS, Middle Columbia River DPS, Northern California DPS, Puget Sound DPS, Snake River Basin DPS, South-Central California Coast DPS, Southern California DPS, Upper Columbia River DPS, and Upper Willamette River DPS of steelhead trout in the action area because of activities covered under this consultation may affect, but are not likely to adversely affect these species.

#### **4.1.2.4 Proposed Sunflower Sea Star**

The proposed sunflower sea star occurs in coastal waters from the Aleutian Islands to Baja California, and is most commonly found in waters less than 82 ft (25 m) deep, and rare in waters deeper than 394 ft (120 m; (Lowry et al. 2022)). Because the proposed sunflower sea star does not occur where the survey will occur, it is extremely unlikely that proposed sunflower sea star will be exposed to underwater acoustic effects from the airguns. Thus, the effects are discountable. We conclude that the proposed action may affect, but is not likely to adversely affect the proposed sunflower sea star.

#### **4.1.3 Critical Habitat Not Likely to be Adversely Affected**

This section identifies the designated critical habitat for which effects are NLAA from stressors resulting from the proposed action and are not analyzed further in this opinion. Critical habitats that are not likely to be adversely affected by the proposed action include the designated critical habitats of the Southern Resident DPS of killer whale, Central America DPS and Mexico DPS of humpback whale, leatherback turtle, Oregon Coast ESU of coho salmon, and Southern DPS of green sturgeon.

Designated critical habitat for the Southern Resident DPS of killer whale may be affected, but is not likely to be adversely affected by the following stressors: pollution, disturbance from the R/V, and other acoustic instruments. Pollution may affect the PBF related to water quality. As previously discussed, it is extremely unlikely that a fuel or oil spill will occur, or that debris and waste will enter the marine environment. Thus, the effects of pollution on the water quality of the Southern Resident DPS killer whale critical habitat are discountable. The R/V may affect the PBF related to prey quantity, quality, and availability. The R/V may temporarily displace prey for the duration of transit through critical habitat. However, the limited time that the R/V is operational (three days) and the constant movement of the R/V will not measurably affect the quantity, quality, or availability of prey in Southern Resident DPS killer whale critical habitat, and, thus, effects are insignificant. Noise from the R/V and other acoustic instruments may affect the PBF related to passage conditions to allow for migration, resting, and foraging. In the final rule designating Southern Resident DPS killer whale critical habitat, “acoustic obstructions” (e.g., chronic noise introduced by acoustic harassment devices) was identified as an obstacle or deterrent to the whales’ use of an area. However, given the limited use and temporary duration of the survey overall (three days), the constant movement of the sound sources, the contribution of noise due to the proposed action compared to the overall soundscape will be so small as to be immeasurable, and thus, effects to critical habitat are insignificant.

Designated critical habitat for the Central America DPS and Mexico DPS of humpback whale may be affected, but is not likely to be affected by disturbance from the R/V. The R/V may affect prey of sufficient quality, abundance, and accessibility within humpback feeding areas. The R/V may temporarily displace prey for the duration of transit through critical habitat. However, the limited time that the R/V is operational (three days) and the constant movement of the R/V will not measurably affect the quality, abundance, and accessibility of prey within the Central America DPS and Mexico DPS humpback whale critical habitats. Thus, effects from the R/V on

Central America DPS and Mexico DPS humpback whale critical habitats will be too small to measure and thus insignificant.

Designated critical habitat for the leatherback turtle may be affected, but is not likely to be affected by disturbance from the R/V. The R/V may affect prey of sufficient condition, distribution, diversity, abundance, and density. The R/V may temporarily displace prey for the duration of transit through critical habitat. However, the limited time that the R/V is operational (three days) and the constant movement of the R/V will not measurably affect the condition, distribution, diversity, abundance, and density of prey. Thus, effects from the R/V on leatherback turtle critical habitat will be too small to measure and thus insignificant.

Designated critical habitat for the Oregon Coast ESU of coho salmon may be affected, but is not likely to be adversely affected by the following stressors: pollution and disturbance from the R/V. Pollution may affect the PBF related to water quality in estuarine, nearshore marine, and offshore marine areas. As previously discussed, it is extremely unlikely that a fuel or oil spill will occur, or that debris and waste will enter the marine environment. Thus, the effects of pollution on the water quality of the Oregon Coast ESU coho salmon critical habitat are discountable. The R/V may temporarily displace prey for the duration of transit through critical habitat. However, the limited time that the R/V is operational (three days) and the constant movement of the R/V will not measurably affect forage in estuarine, nearshore marine, or offshore marine areas. Thus, effects from the R/V on the Oregon Coast ESU coho salmon critical habitat will be too small to measure and thus insignificant.

Designated critical habitat for the Southern DPS of green sturgeon may be affected, but is not likely to be adversely affected by the following stressors: pollution and disturbance from the R/V. Pollution may affect the PBF related to water quality. As previously discussed, it is extremely unlikely that a fuel or oil spill will occur, or that debris and waste will enter the marine environment. Thus, the effects of pollution on the water quality of the Southern DPS green sturgeon critical habitat are discountable. The R/V may temporarily displace prey for the duration of transit through critical habitat. However, the limited time that the R/V is operational (three days) and the constant movement of the R/V will not measurably affect food resources for juvenile, subadult, and adult life stages. Thus, effects from the R/V on the Southern DPS green sturgeon critical habitat will be too small to measure and thus insignificant.

We conclude the proposed action may affect, but is not likely to adversely affect designated critical habitats of the Southern Resident DPS of killer whale, Central America DPS and Mexico DPS of humpback whale, leatherback turtle, Oregon Coast ESU of coho salmon, and Southern DPS of green sturgeon.

#### **4.2 Status of the Species Likely to be Adversely Affected**

The remainder of this opinion examines the status of each species that is likely to be adversely affected by the proposed actions: blue whale, fin whale, Central America DPS and Mexico DPS of humpback whale, sei whale, sperm whale, and Guadalupe fur seal. The status is an assessment of the abundance, recent trends in abundance, survival rates, life stages present, limiting factors, and sub-lethal or indirect changes in population trends such as inter-breeding period, shifts in

distribution or habitat use, and shifts in predator distribution that contribute to the extinction risk that the listed species face. The status of each species below is described in terms of life history, threats, population dynamics, critical habitat, and recovery planning.

The information used in each of these sections is based on parameters considered in documents such as status reviews, recovery plans, and listing decisions and based on the best available scientific and commercial information. This section informs the description of the species' likelihood of both survival and recovery in terms of their "reproduction, numbers, or distribution" as described in 50 CFR §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 the NMFS OPR web site (<https://www.fisheries.noaa.gov/species-directory/threatened-endangered>).

#### **4.2.1 Life History Common to Blue, Fin, Humpback, Sei, and Sperm Whales**

ESA-listed whales in the action area share the same general life history, migrating from low latitude winter breeding areas where they mate, calve and nurse, to high latitude summer feeding areas. These species are long-lived, with life spans of 50–90 years. Females give birth to a single calf and calve on average every two to three years, though sperm whales calve on average every four to six years. Sexual maturity is reached between five and 15 years of age (male sperm whales reach sexual maturity around 18 to 21 years of age), and gestation is approximately one year. Calves nurse for approximately six months up to one year. While sperm whales feed primarily on squid and blue whales on krill, baleen whales generally feed on small schooling fish, zooplankton, and euphausiids.

Baleen whales such as blue, fin, humpback, and sei whales generally hear low-frequency sounds, and are categorized in the low-frequency cetaceans hearing group, with a hearing range of seven Hertz (Hz) to 36 kiloHertz (kHz; NMFS 2024). There has only been one direct study on baleen whale hearing, which reported that wild minke whales were sensitive to frequencies as high as 45–90 kHz (Houser et al. 2024). Sperm whales, as toothed whales, are categorized in the high-frequency cetaceans hearing group, with a hearing range of 150 Hz to 160 kHz (NMFS 2024). All whales produce vocalizations, which can help determine population structure. Blue, fin, humpback, and sei whales produce calls and song (repeated patterns of calls, which are thought to be produced by males only), and sperm whales produce clicks (click sequences are called codas).

#### **4.2.2 Threats Common to Blue, Fin, Humpback, Sei, and Sperm Whales**

ESA-listed whales in the action area face numerous natural and human-induced threats that shape their status and affect their ability to recover. Many of these threats are either the same or similar in nature among the blue, fin, humpback, sei, and sperm whale.

Historically, all five species were harvested during the commercial whaling era, which reduced populations to a fraction of their historical abundance. Current threats to ESA-listed whales

include vessel strikes, entanglement in fishing gear, pollution (anthropogenic underwater noise and plastic debris), and changing environmental trends.

### 4.2.3 Blue Whale

The blue whale was first listed as endangered in 1970 (35 Fed. Reg. 18319). The Society of Marine Mammalogy's Taxonomy Committee currently recognizes five subspecies of blue whale: *B. m. musculus* (Northern blue whales in the North Atlantic and North Pacific), *B. m. intermedia* (Antarctic blue whales), and *B. m. indica*, *B. m. brevicauda*, and an unnamed subspecies off Chile (pygmy-type blue whales; Committee on Taxonomy 2016).

#### Life History

Blue whales produce the lowest frequency vocalizations of any baleen whale; most vocalizations are between 12–25 Hz, with a range of 12–400 Hz (Ketten 1998; McDonald et al. 2001; McDonald et al. 1995a; Mellinger and Clark 2003). In the Northeast Pacific, the main blue whale vocalizations include tonal and pulsed calls, the former of which is very low frequency (around 16 Hz) and long (about 20 seconds), and the latter of which is a downsweeping (from high to low frequency) call (Stafford et al. 2001). These are loud calls, with average source levels ranging from 179–199 decibels referenced to a pressure of one microPascal (dB re 1  $\mu$ Pa; McDonald et al. 2009; Samaran et al. 2010; Širović et al. 2007). There have been no direct studies on blue whale hearing, but it is assumed that they can hear in the same frequency ranges as the vocalizations they produce.

#### Population Dynamics

There are three stocks of blue whales designated in U.S. waters: the Eastern North Pacific Ocean (population estimate [N]=1,898 individuals; minimum population estimate [ $N_{\min}$ ]=1,767 individuals; Calambokidis and Barlow 2020), Central North Pacific Ocean (N=137 individuals; 95% confidence interval [CI]=23–796 individuals; Bradford et al. 2021), and Western North Atlantic Ocean (N=402 individuals;  $N_{\min}$ =402 individuals; Ramp and Sears 2013). In the Southern Hemisphere, the latest abundance estimate for Antarctic blue whales is 2,280 individuals in 1997/1998 (95% CI=1,160–4,500 individuals) with a population growth rate of 8.2% per year (95% CI=1.6–14.8%; Branch 2008). While no range-wide estimate for pygmy blue whales exists, the latest estimate for pygmy blue whales off the west coast of Australia is 662–1,559 individuals based on passive acoustic monitoring (McCauley and Jenner 2010), or 712–1,754 individuals based on photographic mark-recapture (Jenner 2008). A minimum estimate of the Chilean blue whale population is 303 individuals (95% CI=176–625; Williams et al. 2011). 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 Eastern North Pacific Stock of blue whales occurs in the Gulf of Alaska, along the U.S. West Coast (including the action area), and in the eastern tropical Pacific. The population abundance estimate for this population of blue whales is 1,878 individuals ( $N_{\min}$ =1,767; CV = 0.085), based on the most recent capture-recapture data (2015–2018; Calambokidis and Barlow 2020). Monnahan et al. (2014) estimated that 3,411 blue whales (95% range = 2,593–4,114 blue

whales) were removed from the population between 1905 and 1971 due to commercial whaling. While the population may have increased since the 1990's, the current population trend is unknown. Carretta et al. (2024b) cited a study by Monnahan et al. (2015) that estimated the eastern Pacific blue whale population was near carrying capacity in 2013, which may explain why population size increases have not been observed recently.

In general, blue whale distribution is driven largely by food requirements; blue whales are more likely to occur in waters with environmental conditions that support concentrations of their primary food source, krill. For example, off California, models showed that blue whales were more likely to use habitats with higher temperatures and higher chlorophyll-a concentration (proxies for prey density) and a northward shift in primary production from California to Oregon and Washington was also reflected in blue whale acoustic detections (Burtenshaw et al. 2004; Hazen et al. 2017; Irvine et al. 2014).

### **Critical Habitat**

Critical habitat has not been designated for this species.

### **Recovery Planning**

In response to the current threats facing the species, NMFS identified actions needed to recover blue whale populations. These threats will be discussed in further detail in the environmental baseline of this consultation. See the 2020 recovery plan for the blue whale for complete down-listing/delisting criteria for each of the following major actions (NMFS 2020). The recovery plan identifies two main objectives to recover blue whales:

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

#### **4.2.4 Fin Whale**

The fin whale was first listed as endangered in 1970 (35 Fed. Reg. 18319). The Society for Marine Mammalogy recognizes three subspecies: *B. p. physalus* in the North Atlantic and North Pacific, *B. p. quoyi* in the Southern Hemisphere, and *B. p. patachonica* the pygmy fin whale.

### **Life History**

Fin whale vocalizations are low-frequency, often between 10–200 Hz, and are most commonly 20-Hz (range 18–35 Hz) downsweeping pulses lasting 0.5–2 seconds (Thompson et al. 1992; Watkins et al. 1987). These pulses are loud, with source levels ranging from 184–195 dB re 1  $\mu$ Pa (Miksis-Olds et al. 2019; Širović et al. 2007; Weirathmueller et al. 2013b). There have been no direct studies on fin whale hearing, but it is assumed that they can hear in the same frequency ranges as the vocalizations they produce. Cranford and Krysl (2015) conducted a CT scan of a

stranded newborn male fin whale calf and predicted the audiogram. Because audiogram parameters have not been measured for baleen whales, Cranford and Krysl (2015) set the parameters to be similar to toothed whales, which produce and hear sounds at higher frequencies than baleen whales. They predicted sensitivity to a broad range of frequencies between 10 Hz and 12 kHz, with best sensitivity at 1.2 kHz.

## Population Dynamics

The pre-exploitation estimate for the fin whale population in the North Pacific Ocean was 42,000–45,000 individuals, which was reduced to 8,000–11,000 individuals in 1973 (Ohsumi and Wada 1974). In the North Atlantic Ocean, an estimated 56,000 individuals made up the population in the early 1990's (Bérubé and Aguilar 1998). Over 725,000 fin whales were killed in the Southern Hemisphere during 1905–1976 (Allison 2017 cited in Cooke 2018b). Leaper and Miller (2011) estimated a circumpolar estimate (south of 60°S) of 5,445 individuals (95% CI=2,000–14,500 individuals). No current population estimates exist for the entire North Pacific, North Atlantic, or Southern Hemisphere, though NMFS (2019) summarizes the regional population estimates. For U.S. stocks, the best population abundance estimate are as follows:

- Western North Atlantic: 6,802 individuals ( $N_{\min}$ =5,573 individuals; Hayes et al. 2024)
- Northeast Pacific: 3,168 individuals ( $N_{\min}$ =2,554 individuals; Rone et al. 2017)
- Hawaii: 203 individuals ( $N_{\min}$ =101 individuals; Bradford et al. 2021)
- California/Oregon/Washington: 11,065 individuals ( $N_{\min}$ =7,970 individuals; Becker et al. 2020)

Overall population growth rates for the Hawaii stock, western North Atlantic stock, and Southern Hemisphere fin whales are not available at this time. Current estimates indicate an annual growth rate of 4.8% (95% CI=4.1–5.4%) for the Northeast Pacific stock, although this estimate is based on data between 1987 and 2003 and in coastal waters south of the Alaska Peninsula (Zerbini et al. 2006). A population growth rate of 7.5% was estimated for the California/Oregon/Washington stock based on data between 1991 and 2014 (Nadeem et al. 2016). However, Carretta et al. (2024b) note that it is unknown how much of this growth is due to immigration versus birth and death processes.

Fin whales have been detected acoustically and visually year-round off Oregon and Washington (Derville et al. 2022; Moore et al. 1998). However, it is not known whether the year-round presence is due to individuals moving in and out of the area or if there is a subset of the population that is resident (Soule and Wilcock 2013).

## Threats

Vessel strike appears to be of particular concern for fin whales. Jensen and Silber (2003) found that approximately 26% of vessel strikes from 1975 to 2002 involved fin whales. Van Waerebeek and Leaper (2008) compiled data on vessel strikes and cetaceans between 1900 and 2000 for the International Whaling Commission Vessel Strike Data Standardisation Working Group. Out of 763 strikes, only 572 strikes had identifiable species. Of those 572 strikes, 220 (29.2%) were strikes of fin whales (Van Waerebeek and Leaper 2008).

## Critical Habitat

Critical habitat has not been designated for this species.

## Recovery Planning

In response to the current threats facing the species, NMFS identified actions needed to recover fin whale populations. These threats will be discussed in further detail in the environmental baseline of this consultation. See the 2010 recovery plan for the fin whale for complete down-listing/delisting criteria for each of the following major actions (NMFS 2010a). The recovery plan identifies two main objectives to recover fin whales:

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

### 4.2.5 Humpback Whale – Central America DPS and Mexico DPS

The humpback whale was first listed as endangered in 1970 (35 Fed. Reg. 18319). Since then, NMFS has divided the species into 14 DPSs – four are listed as endangered and one is listed as threatened. The Central America DPS is listed as endangered and the Mexico DPS is listed as threatened (81 Fed. Reg. 62260).

## Life History

Humpback whale vocalizations are among the most well-studied of all cetaceans. Humpback whale vocalizations are generally divided into song and non-song (or social) calls (Dunlop et al. 2008b; Mellinger and Clark 2003; Payne and McVay 1971). Different vocalizations correspond to different functions: feeding, breeding, and other social calls (Dunlop et al. 2008a). These vocalizations range from 20 Hz–12 kHz: humpback whale song, produced by males most commonly while in low-latitude breeding areas (although there have been studies documenting song on feeding grounds and on migration), generally occurs across a frequency range of 20 Hz–4 kHz with estimated source levels from 144–195 dB re 1  $\mu$ Pa (Au and Green 2000; Frazer and Mercado 2000; Richardson et al. 1995a; Winn et al. 1970). Males also produce sounds associated with aggression, which are generally characterized by frequencies between 50 Hz–10 kHz with most energy below 3 kHz (Silber 1986; Tyack 1983). Such sounds can be heard up to 5.6 mi (9 km) away (Tyack 1983). Other social sounds from 50 Hz–10 kHz (most energy below 3 kHz) are also produced in breeding areas (Richardson et al. 1995a; Tyack 1983). While in northern feeding areas, both sexes vocalize in grunts (25 Hz–1.9 kHz), pulses (25–89 Hz) and songs (ranging from 30 Hz–8 kHz but dominant frequencies of 120 Hz–4 kHz), which can be very loud with sound pressures of 175–192 decibels referenced to a pressure of one microPascal measured at one meter (dB re 1  $\mu$ Pa @ 1m; Au and Green 2000; Erbe 2002a; Payne 1985; Richardson et al. 1995a; Thompson et al. 1986). However, humpback whales tend to be less vocal in northern feeding areas than in southern breeding areas (Richardson et al. 1995a).

Humpback whale audiograms using a mathematical model based on the internal structure of the ear estimate sensitivity is from 700 Hz–10 kHz, with maximum relative sensitivity between 2

kHz and 6 kHz (Ketten and Mountain 2014). The ability of humpback whales to hear frequencies around 3 kHz 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 kHz at 219 dB re 1  $\mu$ Pa @ 1m or frequency sweep of 3.1–3.6 kHz. Tubelli et al. (2018) modeled the middle ear transfer function based on two models for how sound reaches the middle ear in humpback whales and predicted hearing ranges of 15 Hz to 3 kHz or 200 Hz to 9 kHz.

## Population Dynamics

About 15,000 humpback whales were taken from the North Pacific between 1919 and 1987 (Tønnessen and Johnsen 1982). There are five stocks designated in the North Pacific: Hawaii (Hawaii DPS), Mexico-North Pacific (Mexico DPS), Mainland Mexico-California/Oregon/Washington (Mexico DPS), Central America/Southern Mexico-California/Oregon/Washington (Central America DPS), and Western North Pacific (Western North Pacific DPS). The current population estimates and population trend (if known) for the stocks are as follows:

- Hawaii: 11,278 individuals ( $N_{\min}=7,265$  individuals; Becker et al. 2022); there is evidence that the population was increasing prior to the marine heatwave in 2014–2016 and Unusual Mortality Event in 2015–2016 (see Young et al. 2023); however, it is unknown if the population is currently increasing.
- Mexico-North Pacific: 2,352 individuals ( $CV=0.075$ ; Martínez-Aguilar 2011) or 918 individuals ( $CV=0.217$ ; Wade et al. 2021); there is evidence that the population along the mainland Mexican coast was increasing; however, it is currently unknown whether the stock in general is increasing because of the aforementioned marine heatwave and Unusual Mortality Event on feeding grounds (see Young et al. 2023).
- Mainland Mexico-California/Oregon/Washington: 3,477 individuals ( $CV=0.101$ ; Calambokidis and Barlow 2020; Curtis et al. 2022); Calambokidis and Barlow (2020) estimate an annual 8.2% increase in abundance of humpback whales in the California Current since 1989; however, it is unknown whether this is specific to the Mainland Mexico-California/Oregon/Washington stock.
- Central America/Southern Mexico-California/Oregon/Washington: 1,496 individuals ( $N_{\min}=1,284$  individuals; Curtis et al. 2022); Curtis et al. (2022) estimated an annual growth rate of 1.6% for Central America/Southern Mexico.
- Western North Pacific: 1,086 individuals ( $CV=0.088$ ) for the Asia study area (Wade et al. 2021); current population trends are unknown.

The Central America DPS spends winters off the coast of Central America from Panama to southern Mexico, as far north as Michoacán and Colima (Taylor et al. 2021). This DPS primarily spends summer off California and Oregon, with the highest density of whales in southern California, although some individuals feed off the coast of Washington and southern British Columbia (Barlow et al. 2011; Calambokidis et al. 2008; Wade et al. 2021). Movement and genetics data do not suggest further population structure within this DPS (Taylor et al. 2021). Curtis et al. (2022) estimated the abundance of this DPS to be 1,496 ( $CV=0.171$ ) whales with an estimated annual growth rate of 1.6% ( $SD=2.0\%$ ).

The Mexico DPS spends winters along the Pacific coast of mainland Mexico and in the Revillagigedo Archipelago, transits along the coast of Baja California, and spends summers feeding throughout the North Pacific from California to the Kamchatka Peninsula in Russia (Calambokidis et al. 2008; Titova et al. 2018; Wade et al. 2021). Movement and genetics data suggest the existence of further population structure within this DPS (Martien et al. 2021). There is currently no abundance estimate for this DPS, although an estimated 3,477 (CV=0.101) whales from the Mexico DPS feed off the U.S. West Coast (Calambokidis and Barlow 2020; Curtis et al. 2022). While the current trend is unknown, Calambokidis and Barlow (2020) reported an approximate 8.2% annual growth rate from 1989–2018 for humpback whales off California and Oregon waters, where whales from the Mexico and Central America DPSs overlap.

### **Critical Habitat**

Critical habitats for the Central America DPS and Mexico DPS of humpback whale were found to be NLAA (Section 4.1.3) and is not considered further in the opinion.

### **Recovery Planning**

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 of this consultation. See the 2022 recovery outline for Central America DPS, Mexico DPS, and Western North Pacific DPS of humpback whales (NMFS 2022) for interim guidance to direct recovery efforts. The interim recovery program will focus on:

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

#### **4.2.6 Sei Whale**

The sei whale was first listed as endangered in 1970 (35 Fed. Reg. 18319). Two subspecies of sei whale are recognized, *B. b. borealis* in the Northern Hemisphere and *B. b. schlegellii* in the Southern Hemisphere.

### **Life History**

Data on sei whale vocal behavior is limited, but includes records off the Antarctic Peninsula of broadband sounds in the 100–600 Hz range with 1.5 second duration and tonal and upsweep calls in the 200–600 Hz range of one to three second durations (McDonald et al. 2005). Vocalizations from the North Atlantic Ocean consisted of single, paired, or triplet downsweeps from 50–30 Hz and 82–34 Hz, and patterned combinations of downsweeps suggesting that sei whales may

produce songs (Tremblay et al. 2019). Source levels of  $189 \pm 5.8$  dB re  $1 \mu\text{Pa}$  @ 1m have been established for sei whales in the northeastern Pacific Ocean (Weirathmueller et al. 2013a).

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 1997b; Ketten 1997a; Richardson et al. 1995a; 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 1997a).

## **Population Dynamics**

There are no estimates of pre-exploitation abundance for the North Atlantic Ocean. Models indicate that total abundance declined from 42,000 individuals to 8,600 individuals between 1963 and 1974 in the North Pacific Ocean. More recently, the central and eastern North Pacific Ocean population was estimated to be 29,632 individuals (95% CI=18,576–47,267 individuals) between 2010 and 2012 (Hakamada et al. 2017). 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 stocks occur in U.S. waters: Nova Scotia, which covers waters from Halifax, Nova Scotia to Florida (N=6,292 individuals,  $N_{\min}$ =3,098 individuals; Palka et al. 2017), Hawaii (N=401 individuals; CV=0.84; Bradford et al. 2021), and Eastern North Pacific, which covers waters off California, Oregon, and Washington (N=864 individuals,  $N_{\min}$ =625 individuals; Barlow 2016), and are most likely to occur in the action area. 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.

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 in coastal waters.

## **Critical Habitat**

Critical habitat has not been designated for this species.

## **Recovery Planning**

In response to the current threats facing the species, NMFS identified actions needed to recover sei whale populations. These threats will be discussed in further detail in the environmental baseline of this consultation. See the 2011 recovery plan for the sei whale for complete down-listing/delisting criteria for each of the following major actions (NMFS 2011). The recovery plan identifies two main objectives to recover sei whales:

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

#### 4.2.7 Sperm Whale

The sperm whale was first listed as endangered in 1970 (35 Fed. Reg. 18319).

##### Life History

Recordings of sperm whale vocalizations reveal that they produce a variety of sounds, such as clicks, gunshots, chirps, creaks, short trumpets, pips, squeals, and clangs (Goold 1999). Sperm whales typically produce short duration repetitive broadband clicks with frequencies below 100 Hz to greater than 30 kHz (Watkins 1977) and dominant frequencies between 1–6 kHz and 10–16 kHz. Another class of sound, “squeals,” are produced with frequencies of 100 Hz to 20 kHz (e.g., Weir et al. 2007). The source levels of clicks can reach 236 dB re 1  $\mu$ Pa @ 1m, although lower source level energy has been suggested at around 171 dB re 1  $\mu$ Pa @ 1m (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). The clicks of neonate sperm whales are very different from typical clicks of adults in that they are of low directionality, long duration, and low frequency (between 300 Hz and 1.7 kHz) with estimated source levels between 140–162 dB re 1  $\mu$ Pa @ 1m (Madsen et al. 2003).

Long, repeated clicks are associated with feeding and echolocation (Goold and Jones 1995a; Goold and Jones 1995b; Miller et al. 2004b; Miller et al. 2004a; Weilgart and Whitehead 1993; Weilgart and Whitehead 1997b; Weilgart and Whitehead 1997a; Whitehead and Weilgart 1991a; Whitehead and Weilgart 1991b). 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. 2005b; Laplanche et al. 2005a; Miller et al. 2004b; Miller et al. 2004a). 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 2004a; Rendell and Whitehead 2004b; 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 auditory evoked potential tests were recorded (Carder and Ridgway 1990). From this whale, responses support a hearing range of 2.5–60 kHz and highest sensitivity to frequencies 5–20 kHz. Other hearing information consists of indirect data. For example, the anatomy of the sperm whale’s inner and middle ear indicates an ability to best hear high-frequency to ultrasonic hearing (Ketten

1992). The sperm whale may also possess better low-frequency hearing than other odontocetes, although not as low as many baleen whales (Ketten 1992). Reactions to anthropogenic sounds can provide indirect evidence of hearing capability, and several studies have made note of changes seen in sperm whale behavior in conjunction with these sounds. For example, sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders and submarine sonar (Watkins et al. 1985a; Watkins et al. 1985b; Watkins and Schevill 1975b; Watkins and Schevill 1975a). In the Caribbean Sea, Watkins et al. (1985b) observed that sperm whales exposed to 3.25–8.4 kHz pulses (presumed to be from submarine sonar) ceased activity 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 kHz pulsed signal did not ultimately exhibit any general avoidance reactions: when resting at the surface in a compact group, sperm whales initially reacted strongly, and then ignored the signal completely (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  $\mu\text{Pa}^2$ -second between 250 Hz and 1 kHz) interrupted sperm whale acoustic activity and resulted in the animals converging on the vessel. Sperm whales have also been observed to stop vocalizing for brief periods when codas are being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones 1995b).

### **Population Dynamics**

The most recent estimate indicated a global population of 300,000–450,000 individuals (Whitehead 2009). 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 1,180 individuals (CV=0.22;  $N_{\min}$ =983 individuals; Garrison et al. 2020) and the North Atlantic stock, underestimated to consist of 5,895 individuals (CV=0.29;  $N_{\min}$ =4,639 individuals; Dias et al. 2022). There are insufficient data to estimate abundance for the Puerto Rico and U.S. Virgin Islands stock. In the eastern tropical Pacific Ocean, the abundance of sperm whales was estimated to be 22,700 individuals (95% CI=14,800–34,600 individuals) based on surveys between 1986 and 1990 (Wade and Gerrodette 1993). Population estimates are also available for three U.S. stocks that occur in the Pacific Ocean: the California/Oregon/Washington stock, estimated to consist of 2,606 individuals (CV=0.135;  $N_{\min}$ =2,011 individuals; Becker et al. 2020), the Hawaii stock, estimated to consist of 5,707 individuals (CV=0.23;  $N_{\min}$ =4,486 individuals; Becker et al. 2022), and the North Pacific stock, estimated to consist of a minimum of 244 individuals (Rone et al. 2017). The  $N_{\min}$  for the North Pacific stock is considered an underestimate of the stock because it does not cover the stock's entire range, and there are no current population estimates. 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.

Sperm whales mostly inhabit areas with a water depth of 1,968 ft (600 m) or more, and are uncommon in waters less than 984 ft (300 m) deep. However, sperm whales may occur closer to shore when there are shelf breaks or submarine canyons. Sperm whales distribute widely throughout the North Pacific Ocean, with movements over 3,107 mi (5,000 km), likely driven by

changes in prey abundance. While both males and females may be found in latitudes less than 40°, only adult males venture into the higher latitudes near the poles. Thus, males appear to range more broadly than females (Mizroch and Rice 2013).

### **Critical Habitat**

Critical habitat has not been designated for this species.

### **Recovery Planning**

In response to the current threats facing the species, NMFS identified actions needed to recover sperm whale populations. These threats will be discussed in further detail in the environmental baseline of this consultation. See the 2010 recovery plan for the sperm whale for complete down-listing/delisting criteria for each of the following major actions (NMFS 2010b). The recovery plan identifies two main objectives to recover sperm whales:

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

#### **4.2.8 Guadalupe Fur Seal**

The Guadalupe fur seal was first listed as threatened in 1985 (50 Fed. Reg. 51252).

### **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 (Figueroa-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 (Auriolles-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 (Auriolles-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% of their time sea, and 25% at rest (Gallo-Reynoso et al. 1995).

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 2–40 kHz (Moore and Schusterman 1987). Guadalupe fur seals are categorized in the otariid hearing group, which has an estimated hearing range of 60 Hz to 68 kHz under water and 90 Hz to 40 kHz in air (NMFS 2024).

## Population Dynamics

Commercial sealing during the 19th century brought the Guadalupe fur seal to near extinction in 1894 (Townsend 1931). The species was presumed extinct, until 1949, when an adult male was observed at San Nicolas Island, CA (Bartholomew Jr. 1950) and a small number of individuals were found on Guadalupe Island, Mexico in 1954 (Hubbs 1956). 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 individuals in 2010 (García-Capitanachi et al. 2017), and 34,000–44,000 individuals 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). Based on a total population to pup ratio of 4:1, the best estimate of population abundance is 63,850 individuals (range 57,199–72,631 individuals; Juárez-Ruiz et al. 2022; DON 2019). Juárez-Ruiz et al. (2022) estimated an annual growth rate of 8.4% (range: 8–8.8%) from 1991 to 2019.

The Guadalupe fur seal is found in waters along the west coast of North America from central Mexico (Ortega-Ortiz et al. 2019) to southern British Columbia, Canada (Norris and Elorriaga-Verplancken 2019; Norris et al. 2017), with rare sightings in Alaska (Carretta et al. 2025; Lambourn et al. 2012). In the U.S., they haul out on the California Channel Islands and a small number of pups have been observed at San Miguel Island. Satellite-tagged Guadalupe fur seals in California traveled as far north as Graham Island and Vancouver Island, British Columbia, Canada and some traveled as far offshore as 805.5 mi (1,296.3 km) west of the California/Oregon border (Norris et al. 2015).

## Threats

Commercial sealers in the 19<sup>th</sup> century decimated the Guadalupe fur seal population, taking as many 8,300 Guadalupe fur seals from San Benito Island (Townsend 1924). The species was presumed extinct, until 1949, when an adult male was observed at San Nicolas Island, CA (Bartholomew Jr. 1950) and a small number of animals were found on Guadalupe Island in 1954 (Hubbs 1956). Although commercial hunting of Guadalupe fur seals does not occur at present, the effects persist today. Other human activities, such as entanglements from commercial fishing gear, are ongoing and continue to affect these species (Carretta et al. 2025). Other human impacts include entanglement in marine debris, shootings, and oil/tar.

## Critical Habitat

Critical habitat has not been designated for this species.

## Recovery Planning

There has been no recovery plan prepared for Guadalupe fur seals.

## 5. ENVIRONMENTAL BASELINE

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

### 5.1 Environmental Change

There is a large and growing body of literature on past, present, and future impacts of environmental change, exacerbated and accelerated by human activities. These changes include sea level rise, ocean acidification, increased frequency and magnitude of severe weather events, changes in air and water temperatures, and changes in precipitation patterns, all of which affect ESA resources.

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 are increasing the warming of the global climate system and altering the carbonate chemistry of the ocean (i.e., ocean acidification). 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 in the form of aragonite. Changes in pH outside the normal range can make it difficult for marine organisms with shells to maintain their shells (Fabry et al. 2008). Many of those creatures such as crustaceans, crabs, mollusks, and other calcium carbonate-dependent organisms such as pteropods (free-swimming pelagic sea snails and sea slugs), are important parts of the food web in the North Pacific Ocean. Reduction in these 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.

Elevated ocean temperatures have been documented and are projected to increase. Habitat loss, shifts in species' ranges and abundances, and altered marine food webs could have substantial consequences for ESA species. Warming ocean temperatures may make it more difficult for organisms to locate or capture prey (Roemmich and Mcgowan 1995; Zamon and Welch 2005), allow for the northward expansion of predator and competitor ranges (Mcfarlane et al. 2000; Phillips et al. 2007; Rexstad and Pikitch 1986), and create larger areas of hypoxia or anoxia because warmer water holds less dissolved oxygen. 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 given rising sea surface temperatures using a database of electronic tags and a global climate model. They predicted up to a 35% change in

some key marine predators' core habitat area in the Pacific Ocean, with some species predicted to experience gains in available core habitat and some predicted to experience losses. MacLeod (2009) estimated that, based on predicted shifts in water temperature, 88% of cetaceans will be affected by changing environmental conditions, with 47% predicted to experience unfavorable conditions (e.g., range contraction).

Changing environmental conditions will likely result in changes to the distribution and abundance of keystone prey species like krill and in cephalopod populations, which will likely affect marine mammal populations as they search for prey. For example, blue whales, which exclusively eat krill, are likely to shift their distribution in response to changes in the distribution of krill (Barlow et al. 2020). Pecl and Jackson (2008) predicted that changing environmental conditions will likely result in squid that hatch out smaller and earlier, undergo faster growth over shorter life-spans, and mature younger at a smaller size. This could have negative consequences for species such as sperm whales and Guadalupe fur seals, whose diets can be dominated by cephalopods. For ESA-listed species that undergo long migrations such as baleen whales, 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 Elliott 2009).

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

The Pacific decadal oscillation is the leading mode of variability in the North Pacific and operates over longer periods than either El Niño or La Niña/Southern Oscillation events. It 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 Ocean experiences above average sea surface temperatures while the central and western Pacific Ocean undergoes below-normal sea surface temperatures (Royer 2005). Warm Pacific decadal oscillation regimes, as occurs in El Niño events, tends to decrease productivity along the U.S. west coast, as upwelling typically diminishes (Childers et al. 2005; Hare et al. 1999).

Changing environmental conditions can also increase the frequency and intensity of marine heatwaves. During the 2014–2016 northeast Pacific marine heatwave, Steller sea lion adult, sub-adults, juvenile, and pup counts on rookeries in Alaska declined (Suryan et al. 2021). Humpback and killer whale abundance in the region also declined (Gabriele et al. 2022; Suryan et al. 2021). The effects were still noticeable five years after the onset of the heatwave, with low abundance of humpback whales, lower than average calf production, calf survival, and non-calf survival, and prey species such as Pacific herring, sand lance, and capelin (Gabriele et al. 2022; Suryan et al. 2021). Santora et al. (2020) observed habitat compression in foraging whales because of the marine heatwave, which they linked to a record number of whale entanglements in the central California Current crab fishery. Guadalupe fur seal pup mortality rates were also significantly higher during the heatwave compared to the years prior to the heatwave (Gálvez et al. 2023).

This review highlights evidence of significant changes in environmental conditions that may affect ESA-listed species and their habitats. While it is difficult to accurately predict the consequences of these changing environmental conditions 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. This is discussed further in the Integration and Synthesis (Section 8).

## 5.2 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.

An UME was declared for Guadalupe fur seals beginning January 1, 2015, and continuing through September 2, 2021 (<https://www.fisheries.noaa.gov/national/marine-life-distress/2015-2021-guadalupe-fur-seal-and-2015-northern-fur-seal-unusual>). 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). At the peak of the UME in 2019, the number of Guadalupe fur seal strandings off Oregon and Washington were nearly 18 times the number of strandings in the years prior to the declaration of the UME. 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.

## 5.3 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 produce 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 blue 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). 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. 2006; Parks 2003; Parks 2009b). 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 in establishing frameworks to consider such effects (NAS 2017).

### ***Vessels***

Individual vessels produce unique acoustic signatures, although these signatures may change with vessel speed, vessel load, and activities that may be taking place on the vessel. Sound levels are typically higher for the larger and faster vessels. Peak spectral levels for individual commercial vessels are in the frequency band of 10-50 Hz and range from 195 dB re 1  $\mu\text{Pa}^2$ -second @ 1m for fast-moving (greater than 20 knots [37 km/hr]) supertankers to 140 dB re 1  $\mu\text{Pa}^2$ -second @ 1m for smaller vessels (NRC 2003c). The low frequency sounds from large vessels overlap with many mysticetes predicted hearing ranges and may mask their vocalizations and cause stress (Rolland et al. 2012b). Although large vessels emit predominantly low frequency sound, studies report broadband sound from large cargo vessels to about 2 kHz, and small boats can produce sound in the mid-frequency (1–5 kHz) range and at moderate (150 to

180 dB re 1  $\mu$ Pa at 1 meter) sound source levels (Erbe 2002b; Gabriele et al. 2003; Kipple and Gabriele 2004), which may interfere with important biological functions of odontocetes such as sperm whales (Blair et al. 2016; Holt 2008). At frequencies below 300 Hz, ambient sound levels are elevated by 15–20 dB when exposed to sounds from vessels at a distance (McKenna et al. 2013).

Measurements made over the period 1950 through 1970 indicated low frequency (50 Hz) vessel traffic sound in the eastern North Pacific Ocean was increasing by 0.55 dB per year (Ross 1976; Ross 1993; Ross 2005). Most data indicate vessel sound is likely still increasing (Hildebrand 2009; Kaplan and Solomon 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***

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 below.

### ***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 0.6–1.9 mi (1–3 km) away, although the airplane noises ceased as soon as the airplanes left the area, which was relatively quickly compared to a cargo vessel. 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. Kuehne et al. (2020) found that sounds from military aircraft at Whidbey Island, Washington, were detectable 98.4 ft (30 m) below the water surface at levels of 134 dB re 1  $\mu$ Pa (root-mean-square [rms]).

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.

### ***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 ( $3.9 \times 10^{13}$  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 kHz (Goold and Coates 2006). Seismic airgun noise can propagate substantial distances at low frequencies (e.g., Nieu Kirk 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  $1 \mu\text{Pa}_{\text{rms}}$  at dominant frequencies of 5–300 Hz (NRC 2003a). Most of the sound energy is at frequencies below 500 Hz, 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, 2021, and 2022. 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.

### ***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.

### ***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 1–10 kHz, high-frequency for 10–100 kHz; and very high-frequency for greater than 100 kHz (Hildebrand 2004). Low-frequency systems are designed for long-range detection (Popper et al. 2014). The effective sound source level of a low-frequency airgun array, when viewed in the horizontal direction can be 235 dB re 1  $\mu$ Pa 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 approximately 200 kHz, with sound source levels ranging from 150–235 dB re 1  $\mu$ Pa 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.

### ***Military Operations***

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. 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.

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 auditory injury, temporary threshold shifts, 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 their 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

#### **5.4 Fisheries Interactions**

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 changes to environmental conditions. 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.

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 tissue, enable infection, and severely compromise an individual's health (Derraik 2002). Entanglements also make animals

more vulnerable to additional threats (e.g., predation, vessel strikes, loss of foraging opportunities) by restricting movement. 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% of entanglement is caused by derelict fishing gear (Baulch and Perry 2014a).

The number of confirmed whale entanglements per year detected off the West Coast of the U.S. has increased significantly from 2001 to 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 mean annual mortalities and serious injuries over the latest five-years related to commercial fisheries interactions for the ESA-listed marine mammals likely to be found in the action area within U.S. waters are given in Table 4 below (Carretta et al. 2024a; Carretta et al. 2025; Jannot et al. 2022). 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 4. Mean annual mortalities and serious injuries related to fisheries interactions for ESA-listed marine mammals within the action area.**

Species	Time Period	Mean Annual Mortality/Serious Injury
Blue Whale	2017–2021	Greater than or equal to 0.61
Fin Whale	2017–2021	Greater than or equal to 0.5
Humpback Whale – Multiple DPSs	2016–2020	19.5
Sei Whale	2017–2021	0
Sperm Whale	2017–2021	0.52
Guadalupe Fur Seal	2018–2022	Greater than or equal to 7.2

DPS=distinct population segment

There have been reports of Guadalupe fur seals stranding with evidence of entanglement in fishing gear or other marine debris (Carretta et al. 2025). There are several records of Guadalupe fur seals being hooked in the mouth by longline gear in the Hawai’i shallow set longline fishery (Carretta et al. 2025). Between 1990 and 2022, no Guadalupe fur seals were observed entangled in California gillnet fisheries (Carretta 2023; Julian and Beeson 1998). Other human-related mortalities and serious injuries between 2018 and 2022 include eight Guadalupe fur seals observed entangled in marine debris, three that were involved in shootings, two unidentified human interactions, and one oil/tar (Carretta et al. 2025).

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.

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.

## 5.5 Oil and Gas

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 spills 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 spills are generally small (less than 1,000 barrels), but larger spills occur as well.

There has not yet been a large-scale oil spill in the action area, but numerous small-scale spills are likely to 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. 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 because no information exists on the effects of small-scale oil spills within the action area.

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 92.6 mi (149 km) of shoreline was heavily oiled and 285.2 mi (459 km) 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. For example, as a result of the *Deepwater Horizon* oil spill, sperm whales were likely exposed to toxic oil components through inhalation, aspiration, ingestion, and dermal exposure. There were 19 observations of 33 sperm whales either swimming in *Deepwater Horizon* surface oil or with visible 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 includes 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 in the action area.

## 5.6 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.

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 188.6 ft (57.5 m) 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 1,200.8 ft (366 m), 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 dives than males when vessels were less than 1,200.8 ft away (366 m; Holt et al. 2021).

### *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 (Pirota 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, such as in the Santa Barbara Channel (Redfern 2013). As vessels 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 262.5 ft (80 m) or longer (Laist et al. 2001). For whales, studies show that the probability of fatal injuries from vessel strikes increases as vessels operate at speeds above 14 knots (26 km/hr; 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 observed. Most animals killed by vessel strike likely end up sinking rather than washing up on shore (Cassoff 2011). Kraus et al. (2005) estimated that only 17% of vessel strikes are actually detected. Therefore, it is likely that the number of documented cetacean mortalities related to vessel strikes is much lower than the actual number of mortalities associated with vessel strikes, especially for less buoyant species such as blue, humpback, and fin whales (Rockwood et al. 2017). Rockwood et al. (2017) modeled vessel strike mortalities of blue, humpback, and fin whales off California using carcass recovery rates of 5–17% 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 (Laist et al. 2001; Vanderlaan and Taggart 2007a). Vessel traffic within the action area can come from both private (e.g., commercial, recreational) and Federal (e.g., military, research) sources, but traffic that is most likely to result in vessel strikes comes from commercial shipping. The latest five-year annual 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 5 below (Carretta et al. 2024a; Carretta et al. 2025; Jannot et al. 2022). 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 5. Mean annual mortalities and serious injuries related to vessel strikes for ESA-listed marine mammals for stocks in the Pacific Ocean within the action area.**

Species	Time Period	Mean Annual Mortality/Serious Injury
Blue Whale	2017–2021	0.6
Fin Whale	2017–2021	1.6

Humpback Whale – Multiple DPSs	2016–2020	16.6
Sei Whale	2017–2021	0
Sperm Whale	2017–2021	0
Guadalupe Fur Seal	2018–2022	NA

DPS=distinct population segment, NA=not available

***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, and may 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 2005; Watkins 1986; Williams et al. 2002). A whale’s behavioral response to whale watching vessels may depend on the distance of the vessel from the whale, vessel speed, vessel direction, vessel sound, the number of vessels, and the animal’s behavior. 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 2006).

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 2006). 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. However, the survey will take place approximately 62 mi (100 km) from the Oregon/Washington coast, which is generally further from shore than whale watching vessels are expected to travel.

## **5.7 Research Permits**

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 many 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 survey.

## 5.8 Aquaculture

Marine aquaculture systems are diverse, ranging from highly controlled land-based systems to open water cages that release wastes directly to the environment. Species produced in the marine environment are also diverse, and include seaweeds, bivalve mollusks, echinoderms, crustaceans, and finfish (Langan 2004). Globally, aquaculture supplies more than 50% of all seafood produced for human consumption, and that percentage will likely continue to rise (NOAA Marine Aquaculture; <https://www.fisheries.noaa.gov/topic/aquaculture>). Marine aquaculture is expected to expand in the U. S. Exclusive Economic Zone (EEZ) due to increased demand for domestically grown seafood, coupled with improved technological capacity to farm in the open ocean. The National Offshore Aquaculture Act of 2005 (S. 1195) promotes offshore aquaculture development within the EEZ and established a permitting process that encourages private investment in aquaculture operations, demonstrations, and research. Additionally, Executive Order 13921, “Promoting American Seafood Competitiveness and Economic Growth”, highlights effective permitting related to offshore aquaculture and a renewed focus on aquaculture.

Aquaculture opportunity areas (AOA’s) have not yet been identified for Oregon and Washington; however, given the National Offshore Aquaculture Act of 2005 and Executive Order 13921, it is reasonable to conclude that aquaculture will continue to expand in the U.S. Pacific, and that aquaculture may introduce potential stress to native biota which may affect either the health or prey base of native fauna.

Potential impacts to ESA-listed species can occur at all stages of aquaculture development, operation, and decommissioning, and can include attraction to farms or displacement from important habitats, resulting in changes to distribution, behaviors, or social structures (Clement 2013; Price et al. 2017). Aquaculture has the potential to affect protected species via entanglement and/or other interaction with aquaculture gear (i.e., buoys, nets, and lines), introduction or transfer of pathogens, increased vessel traffic and noise, impacts to habitat and benthic organisms, and water quality (Clement 2013; Lloyd 2003; Price et al. 2017; Price and Morris 2013). Current data suggest that interactions and entanglements of ESA-listed marine mammals with aquaculture gear are rare (Price et al. 2017). This may be because worldwide the number and density of aquaculture farms are low, and thus there is a low probability of interactions, or because they pose little risk to ESA-listed marine mammals. It is not always possible to determine if the gear animals become entangled in originates from aquaculture or commercial fisheries (Price et al. 2017). Some aquaculture gear has the potential for behavioral effects on marine mammals. For example, aquaculture gear may act as a “fish aggregating device” which may attract marine mammals seeking prey for food, and subsequent marine mammal depredation may occur (Callier et al. 2018). Aquaculture gear may also block migration routes (MPI 2013) or at least cause animals to have to circumnavigate the aquaculture gear.

## 5.9 Invasive 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% of ESA-listed species (Czech and Krausman 1997). Currently, there is little information on the level of aquatic nuisance species and the impacts 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.

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% 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 saxatilis*] 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.

## 5.10 Marine Debris

Marine debris is an ecological threat introduced into the marine environment through ocean dumping, littering, or hydrological transport of these materials from land-based sources or weather events (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 (Werth et al. 2024).

Cetaceans are also impacted by marine debris, which includes: plastics, glass, metal, polystyrene foam, rubber, and derelict fishing gear (Baulch and Perry 2014b; Li et al. 2016). Over half of cetacean species (including blue, fin, humpback, sei, and sperm whales) are known to ingest marine debris (mostly plastic), with up to 31% of individuals in some populations containing marine debris in their guts and being the cause of death for up to 22% of individuals found stranded on shorelines (Baulch and Perry 2014a). A recent study showed that microplastics were present in nearly all fecal samples from Southern Resident DPS of killer whales (Harlacher 2020). 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.

### **5.11 Other Marine Pollution**

Exposure to pollution and contaminants has 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 sources 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). 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). 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).

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). In 2001, a male Guadalupe fur seal stranded and exhibited symptoms consistent with domoic acid toxicosis, and received treatment for seizures over the next 19 years prior to humane euthanasia (Schmitt et al. 2023).

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 studied, but it is possible that the effects could be sub-lethal and long-term in nature, and include impacting reproduction, immune function, and endocrine activity. These are effects that would become more apparent as time goes on. At present, however, the effects of persistent organic pollutants in ESA-listed species are not well known.

### **5.12 Impact of the Baseline on ESA-Listed Species**

Collectively, the environmental 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), whereas others result in more indirect (e.g., fishing that affects 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 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 blue, fin, humpback, sei, and sperm whales, and Guadalupe fur seals, to be the status and trends of those species. As noted in Section 4.2, some of the species considered in this consultation are experiencing increases in population abundance, some are declining, and, for others, their status remains unknown. Taken together, this indicates that the environmental baseline is affecting species in different ways. The species experiencing increasing population abundances are doing so despite the potential negative impacts of the environmental baseline. Therefore, while the environmental baseline may slow their recovery, recovery is not prevented. For the species that may be declining in abundance, it is possible the suite of conditions described in the environmental baseline section is preventing their recovery. However, it is also possible their populations are at such low levels (e.g., due to historical harvesting) 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.

## 6. ANALYSIS OF EFFECTS

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

### 6.1 Exposure

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

#### 6.1.1 ESA-Listed Marine Mammal Exposure

The ESA-listed marine mammals likely to be adversely affected by underwater acoustic effects from the airguns are blue whale, fin whale, Central America DPS humpback whale, Mexico DPS humpback whale, sei whale, sperm whale, and Guadalupe fur seal. As discussed in Section 4.2, these species' hearing ranges encompass the dominant frequencies of the airguns (0–188 Hz). To estimate the number of marine mammals exposed to underwater sound from the airguns, NSF used the level of exposure to sound above which species are reasonably certain to be affected, marine mammal density in the action area, and the duration of the survey. Given the characteristics of the sound source (non-explosive, impulsive), NSF used the 160 dB re 1  $\mu\text{Pa}_{\text{rms}}$  threshold, above which, if marine mammals are exposed, NMFS predicts that marine mammals are likely to be behaviorally “harassed” based on definitions provided in the MMPA (16 U.S.C. §1362(18)(a)). Using this threshold, NSF calculated the total marine area that would be ensonified to levels within this threshold during the survey. The total ensonified area was calculated as the product of the ensonified line length around the source (i.e., two times the radius, or distance from the sound source to the 160 dB re 1  $\mu\text{Pa}$  level), the distance surveyed in one day (approximately 137.9 mi or 222 km) including endcaps, and the number of survey days (two). The resulting ensonified area was then increased by 25% to account for any additional seismic operations associated with airgun testing or repeat surveying of areas where initial data quality is sub-standard. To estimate the number of individuals of each species that may be exposed, the total ensonified area was multiplied by the best available species density in the area. Species densities for blue, fin, and humpback whales were obtained from Becker et al. (2020). Densities for sei whales was obtained from DON (2019) and Marine Geospatial Ecology Lab

Duke University (2021). Sperm whale densities were obtained by NSF through a personal communication with the lead author of Becker et al. (2020). Exposures for whales were rounded to the nearest average group size for each species. Guadalupe fur seal densities were calculated using formulas in DON (2019) and the most recent population abundance estimate in Carretta et al. (2025).

For more details, see NSF’s Draft Environmental Assessment of Marine Geophysical Surveys by R/V *Sally Ride* at the Cascadia Subduction Zone, northeast Pacific Ocean, September 2025 on NSF’s Environmental Compliance webpage, under the subheading “Current environmental reviews” at <https://www.nsf.gov/funding/environmental-compliance> and the NMFS Permits and Conservation Division’s proposed IHA (90 Fed. Reg. 34212). Table 6 summarizes the total number of individuals exposed to underwater acoustic effects from the airguns by species.

**Table 6. Exposure estimates for ESA-listed marine mammals during NSF’s seismic survey**

Species	Hearing Group	Density (individuals per km <sup>2</sup> )	Daily Ensonified Area (km <sup>2</sup> )	Number of Survey Days	Estimated Exposures	Exposures
Blue whale	Low-frequency	0.000025	221	2	0.013906	2*
Fin whale	Low-frequency	0.004482	221	2	2.493113	2
Humpback whale	Low-frequency	0.00048	221	2	0.267	2
Sei whale	Low-frequency	0.0004	221	2	0.2225	2
Sperm whale	High-frequency	0.002731	221	2	1.519119	7
Guadalupe fur seal	Otariid	0.033027	221	2	18.37127	18

km<sup>2</sup> = square kilometers

\* Although the estimated exposure results in less than one, the NMFS Permits and Conservation Division proposed to authorize one group given observations reported during previous surveys in the project area in 2021 and 2022 (RPS 2022a; RPS 2022b; RPS 2023)

Blue, fin, Central America DPS and Mexico DPS humpback, sei, and sperm whales of all age classes are likely to be exposed during the proposed survey. Adult and juvenile Guadalupe fur seals are likely to be exposed during the proposed survey. Given that the proposed low-energy seismic survey will be conducted in late summer, we expect that most animals will be on or migrating to/from their feeding grounds. Blue, fin, Central America DPS and Mexico DPS humpback, sei, and sperm whales are expected to be feeding (for example, Central America DPS and Mexico DPS humpback whales feed off the U.S. West Coast; see Section 4.2.5), 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 bias between juvenile male and female sperm whale exposure. For sperm whales, exposure of adult males is expected to be 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 40–50° latitude). For blue whales, fin whales, Central America DPS and Mexico DPS humpback whales, sei whales, sperm whales, and Guadalupe fur seals, these individuals may be exposed to the proposed survey while they are feeding in or transiting through the action area. We assume that sex distribution is even for blue whales, fin whales, Central America DPS and Mexico DPS humpback whales, sei whales, and Guadalupe fur seals, and that sexes are exposed at a relatively equal level.

**Blue Whale** – The estimated exposure is two individuals. While there are no abundance estimates for the entire population, the estimated regional population abundance is 1,898 individuals (lower and upper 20<sup>th</sup> percentile values of 1,767 to 2,038 individuals) in the eastern North Pacific Ocean (Calambokidis and Barlow 2020). Given this population estimate, the estimated exposure of two individuals is approximately 0.1% of the population.

**Fin Whale** – The estimated exposure is two individuals. While there are no abundance estimates for the entire population, the estimated regional population abundance is 11,065 individuals (95% CI=5,156–23,747 individuals) for the California/Oregon/Washington stock (Becker et al. 2020). Given this population estimate, the estimated exposure of two individuals is approximately 0.02% of the population.

**Central America DPS and Mexico DPS Humpback Whale** – The estimated exposure of the population is two individuals. The estimated population abundances of the Central America DPS and Mexico DPS are 1,496 individuals (CV=0.171) and 3,477 individuals (CV=0.101), respectively (Calambokidis and Barlow 2020; Curtis et al. 2022).

Humpback whales off the coasts of California, Oregon, and Washington may belong to different DPSs. Calambokidis et al. (2017) and Wade et al. (2021) estimated the probability that a humpback whale off the U.S. West Coast would belong to the Central America, Mexico, or Hawaii (non-listed) DPS (Table 7).

**Table 7. Estimated probability a humpback whale off the U.S. West Coast would belong to the Central America, Mexico, or Hawaii (non-listed) DPS**

Area	Probability Belonging to Central America DPS	Probability Belonging to Mexico DPS	Probability Belonging to Hawaii (non-listed) DPS
California/Oregon	42%	58%	0%
Washington	6%	25%	69%

Humpback whales from the two listed DPSs (Central America DPS and Mexico DPS) are expected to be present in the action area; however, if a humpback whale is exposed to the underwater acoustic effects from the airguns, it is not possible to immediately identify whether an individual belongs to the Central America DPS or Mexico DPS (or the non-listed Hawaii DPS, if an individual is encountered off Washington). Therefore, the estimated exposure of two individuals could be from either the Central America DPS or Mexico DPS. Based on the

population estimates, the estimated exposure of two individuals is approximately 0.13% of the Central America DPS or approximately 0.06% of the Mexico DPS.

**Sei Whale** – The estimated exposure of the population is two individuals. While there are no abundance estimates for the entire population, the estimated regional population abundance is 864 individuals (CV=0.4) in the California Current based on ship-based line-transect surveys off California, Oregon, and Washington (Barlow 2016). Given this population estimate, the estimated exposure of two individuals is approximately 0.2% of the population.

**Sperm Whale** – The estimated exposure of the population is seven individuals. While there are no abundance estimates for the entire population, the estimated regional population abundance is 2,606 individuals (CV=0.135) for the California/Oregon/Washington stock (Becker et al. 2020). Given this population estimate, the estimated exposure of seven individuals is approximately 0.3% of the population.

**Guadalupe Fur Seal** – The estimated exposure of the population is 18 individuals. The best estimate of population abundance is 63,850 individuals (range 57,199–72,631 individuals; DON 2019; Juárez-Ruiz et al. 2022). Given this population estimate, the estimated exposure of 18 individuals is approximately 0.03% of the population.

## 6.2 Response

Given the potential for exposure to stressors associated with the proposed survey discussed above, in this section, we describe the range of responses ESA-listed species may display because of exposure to those stressors. Our assessment considers the potential lethal, sub-lethal (or physiological), or behavioral responses that might reduce the fitness of individuals.

### 6.2.1 ESA-Listed Marine Mammal Responses

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

Seismic airguns transmit acoustic energy into the water, which can affect ESA-listed blue whales, fin whales, Central America DPS and Mexico DPS humpback whales, sei whales, sperm whales, and Guadalupe fur seals considered in this opinion. Possible marine mammal responses include noise-induced hearing loss/noise-induced threshold shifts, behavioral responses, physiological stress or non-auditory injury, masking, and potential stranding. Where there is limited information on these species’ responses to airguns within the action area, we use the best available information on similar species in other marine areas.

### Hearing Loss and Threshold Shifts

Marine mammals are susceptible to noise-induced hearing loss, or noise-induced threshold shifts (i.e., a loss of hearing sensitivity), and auditory injury when exposed to high levels of sound

within their limited hearing range. Types of noise-induced threshold shifts include temporary threshold shift (TTS) and auditory injury, the latter of which includes, but is not limited to, permanent threshold shift (PTS). TTS is a temporary, reversible increase in hearing threshold at a specified frequency or portion of an animal's hearing range above a previously established reference level (ANSI 1995; Yost 2007). Auditory injury consists of damage to the inner ear that can result in the destruction of tissue, such as the loss of cochlear neuron synapses or auditory neuropathy (Finneran 2024; Houser 2021), which may or may not result in PTS. Studies on terrestrial mammals have reported recoverable noise-induced threshold shifts that still resulted in neuropathy; therefore, there could be cases where auditory injury occurs but PTS does not (Kujawa and Liberman 2009; Liberman et al. 2016). PTS is a permanent, irreversible increase in hearing threshold at a specified frequency of a portion of an animal's hearing range above an established reference level (ANSI 1995; Yost 2007). The most recent NMFS Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (NMFS 2024) replaced PTS with auditory injury.

Few data are available to precisely define each ESA-listed species hearing range, let alone its sensitivity and sound levels that result in the onset of TTS or auditory injury. Baleen whales (e.g., blue, fin, humpback, and sei whales) have an estimated functional hearing frequency range of 7 Hz to 36 kHz and sperm whales have an estimated functional hearing frequency range of 150 Hz to 160 kHz (NMFS 2024). For pinnipeds underwater, data were limited to measurements of TTS in harbor seals (*Phoca vitulina*), a northern elephant seal (*Mirounga angustirostris*), and California sea lions (*Zalophus californianus*; Kastak et al. 1999). Otariid pinnipeds, such as Guadalupe fur seals, have an estimated functional underwater hearing range of 60 Hz to 68 kHz (NMFS 2024). Thus, these species' hearing ranges overlap the dominant frequencies of the airguns (0–188 Hz).

For marine mammals, auditory injury is considered to be possible when sound exposures are sufficient to produce 40 dB of TTS measured after exposure (Southall et al. 2019). There have been no direct studies on auditory injury in marine mammals with the exception of a single study which unintentionally induced PTS in a harbor seal (*Phoca vitulina*; Reichmuth et al. 2019). However, based on the small anticipated isopleths MMPA Level A harassment (equated to auditory injury), auditory injury is not expected to occur and has not been proposed to be authorized by the NMFS Permits and Conservation Division.

The best available information supports the position that sound levels at a given frequency will need to be approximately 186 dB sound exposure level (SEL) or approximately 196–201 dB re 1  $\mu\text{Pa}_{\text{rms}}$  in order to produce a low-level TTS from a single pulse (Finneran et al. 2013; Southall et al. 2007b). PTS 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. 2007b). TTS was observed in harbor porpoise (*Phocoena phocoena*) after exposure to ten and 20 consecutive airgun pulses from two airguns simultaneously, with cumulative SELs of 188 and 191 dB re 1  $\mu\text{Pa}^2\text{-second}$  (Kastelein et al. 2017). Lucke et al. (2009) observed TTS at 4 kHz when harbor porpoise were exposed to SELs of 164.3 dB re 1  $\mu\text{Pa}^2\text{-second}$ . A small (9 dB) shift was observed in bottlenose dolphins (*Tursiops truncatus*) when exposed to ten airgun pulses of increasing peak sound pressure levels, from 196–210 dB re 1  $\mu\text{Pa}$  (Finneran et al. 2015).

Research on pinniped TTS responses to airguns are limited. Spotted (*Phoca largha*) and ringed seals (*Pusa hispida*) did not show evidence of TTS when exposed to single airgun pulses of between 165 and 181 dB re 1  $\mu\text{Pa}^2$ -second (Reichmuth et al. 2016). Bearded seals (*Erignathus barbatus*) showed TTS when exposed to four to ten consecutive airgun pulses of a cumulative SEL 191–195 dB re 1  $\mu\text{Pa}^2$ -second at 400 Hz, but not to single pulses at 185 dB re 1  $\mu\text{Pa}^2$ -second SEL and 207 dB re 1  $\mu\text{Pa}$  peak-to-peak sound pressure level (Sills et al. 2020).

## Behavioral Responses

We expect the greatest response of marine mammals to airgun array sounds in terms of the 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 that address responses of ESA-listed marine mammals considered in this consultation directly, additional studies on 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 is 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 NSF's Draft Environmental Assessment of Marine Geophysical Surveys by R/V *Sally Ride* at the Cascadia Subduction Zone, northeast Pacific Ocean, September 2025 on NSF's Environmental Compliance webpage, under the subheading "Current environmental reviews" at <https://www.nsf.gov/funding/environmental-compliance> and the NMFS Permits and Conservation Division's *Federal Register* notice of the proposed IHA and request for public comment (90 Fed. Reg. 34212).

There are numerous studies on the responses of some baleen whale species to airgun arrays. Activity of individuals at the time of exposure to the sound appears 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. 1984b; Miller et al. 1999; Miller et al. 2005; Richardson et al. 1995a; Richardson et al. 1995b; Richardson et al. 1999). Migrating bowhead whales showed strong avoidance reactions to received levels of 120–130 dB re 1  $\mu\text{Pa}_{\text{rms}}$  at distances of 12.4–18.6 mi (20–30 km), and changed dive and respiratory patterns while feeding at received levels of 152–178 dB re 1  $\mu\text{Pa}$  (rms; Harris et al. 2007; Ljungblad et al. 1988; Miller et al. 1999; Miller et al. 2005; Richardson et al. 1995a; 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, the available data indicate that most 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. 2007c; Stone et al. 2017; Stone and Tasker 2006).

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  $\mu\text{Pa}_{\text{rms}}$  (Bain and Williams 2006; Gailey et al. 2007; Johnson et al. 2007a; Malme and Miles 1985; Malme et al. 1984b; Malme et al. 1987; Malme et al. 1986; Meier et al. 2007; Würsig et al. 1999; Yazvenko et al. 2007). Migrating gray whales changed their swimming patterns at approximately 160 dB re 1  $\mu\text{Pa}_{\text{rms}}$  and exhibited slight behavioral changes at 140–160 re 1  $\mu\text{Pa}_{\text{rms}}$  (Malme and Miles 1985; Malme et al. 1984a; 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.

Humpback whales exhibit a pattern of lower threshold responses when not feeding. Migrating humpbacks altered their travel path (at least locally) along Western Australia at received levels as low as 140 dB re 1  $\mu\text{Pa}_{\text{rms}}$  when females with calves were present, or 4.3–7.5 mi (7–12 km) from the acoustic source (McCauley et al. 2000a; McCauley et al. 1998). A startle response occurred as low as 112 dB re 1  $\mu\text{Pa}_{\text{rms}}$ . Closest approaches were generally limited to 1.9–2.5 mi (3–4 km), although some individuals (mainly males) approached to within 0.06 mi (100 m) on occasion where sound levels were 179 dB re 1  $\mu\text{Pa}_{\text{rms}}$ . Changes in course and speed generally occurred at estimated received levels of 157–164 dB re 1  $\mu\text{Pa}_{\text{rms}}$ . Migrating humpback whales exhibited no abnormal behaviors in response to an active 3,130 in<sup>3</sup> (51,291.5 cm<sup>3</sup>) airgun array (Dunlop et al. 2017). Some humpback whales reduced their speed and changed course along their migratory route within 2.5 mi (4 km) from the array at received level over 135 dB re 1  $\mu\text{Pa}^2\text{-second}$  (Dunlop et al. 2017). Feeding humpback whales appear to be somewhat more tolerant. Humpback whales off the coast of Alaska startled at 150–169 dB re 1  $\mu\text{Pa}_{\text{rms}}$  and no clear evidence of avoidance was apparent at received levels up to 172 dB re 1  $\mu\text{Pa}_{\text{rms}}$  (Malme et al. 1984b; Malme et al. 1985). Potter et al. (2007) found that humpback whales on feeding grounds in the Atlantic Ocean exhibited 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). 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 during periods of seismic activity (Stone 2003; Stone et al. 2017; Stone and Tasker 2006). Other studies have

also observed small differences in sighting rates (lower) and avoidance behavior during seismic survey activities (Moulton and Miller 2005).

Several studies have aided in assessing the various levels at which whales may modify or stop their calls in response to sounds from airguns. Whales 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. 1995b; 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. 1995b). Fin whales, presumably adult males because the animals were singing (see Section 4.2), 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 38,610 mi<sup>2</sup> or 100,000 km<sup>2</sup> (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 or any anomalous behavior that could be directly ascribed to the use of airguns at sound levels of approximately less than 145 dB re 1  $\mu\text{Pa}_{\text{rms}}$ . 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). Bowhead whale calling rates decreased when exposed to seismic airguns at estimated received levels of 116 to 129 dB re 1  $\mu\text{Pa}_{\text{rms}}$ , but did not change at received levels of 99 to 108 dB re 1  $\mu\text{Pa}$  (rms; Blackwell et al. 2013). A different study observed 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  $\mu\text{Pa}^2$ -second over the course of ten minutes (Blackwell et al. 2015). Once sound levels exceeded approximately 127 dB re 1  $\mu\text{Pa}^2$ -second over ten minutes, call rates began to decline and at approximately 160 dB re 1  $\mu\text{Pa}^2$ -second over ten minutes, bowhead whales appeared ceased calling all together (Blackwell et al. 2015).

Sperm whales, at least under some conditions, may be particularly sensitive to airgun sounds, as they have been documented to cease calling in association with airguns being fired tens to hundreds of miles 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  $\mu\text{Pa}$  (peak-to-peak; Madsen et al. 2002a; McCall Howard 1999a; McCall Howard 1999b). However, some studies also found sperm whales in the Atlantic Ocean showed little or no response to seismic activity (Davis et al. 2000; Madsen et al. 2006; Miller et al. 2009; Moulton and Miller 2005; Stone 2003; Stone et al. 2017; Stone and Tasker 2006; Weir 2008a; Weir 2008b). A study of sperm whales in the Gulf of America (formerly Gulf of Mexico) suggested some alteration in foraging from less than 130–162 dB re 1  $\mu\text{Pa}$  peak-to-peak, and avoidance reactions by sperm whales in response to seismic ensonification (Jochens and Biggs 2004; Jochens 2003; Mate et al. 1994). Although other behavioral reactions were not noted by other studies (Gordon et al. 2006; Gordon et al. 2004; Jochens et al. 2006; Madsen et al. 2006; Winsor and Mate 2006). Miller et al. (2009) found sperm whales were not displaced from the area due to airgun exposure in the Gulf of America, although foraging behavior may have been affected based on changes in echolocation rate and slight changes in dive behavior. Responses of sperm whales to impulse noise likely varies

depending on the activity/behavior at the time of exposure. For example, in the presence of abundant food or during breeding encounters, toothed whales sometimes are extremely tolerant of impulsive sound (NMFS 2010c).

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 or behavior they are engaged in at the time of exposure. 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 560–1,500 in<sup>3</sup> (9,176.8–24,580.6 cm<sup>3</sup>). 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 328.1 ft (100 m) to a few hundred of meters, and many seals remained within 328.1–656.2 ft (100–200 m) of the trackline as the operating airgun array passed by the animals.

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; Kvasdheim et al. 2010). Significant behavioral reactions would not be expected in most cases, and long-term consequences for individuals or the population are unlikely.

### **Physiological Stress**

Individual whales exposed to airguns 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. 2007c; 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 changes have generally been associated with explosives and/or mid-frequency tactical sonar, and not seismic airguns. Therefore, we do not expect ESA-listed marine mammals to experience these non-auditory injuries as a result of the proposed seismic survey activities.

The primary distinction between stress and distress is the cost of the response. 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 release 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; Mancía 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; Herraéz 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 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  $\mu$ Pa at 1 m [peak-to-peak]) and single pure tones (up to 201 dB re 1  $\mu$ Pa) had increases in stress chemicals, including catecholamines, which could affect an individual's ability to fight off disease. During the period 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. 2012b; Rolland et al. 2012a). These levels returned to baseline after 24 hours of vessel traffic resuming.

Given exposure to airguns are expected to be temporary, we expect any 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. 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.

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). Seismic survey activities can potentially lead to habituation, which may lead to additional energetic costs or reductions in foraging success (Nowacek et al. 2015).

## Masking

Interference, or masking, occurs when a sound is of a similar frequency and similar amplitude 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 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).

As previously discussed, the operating frequencies of the airguns overlap with the assumed hearing range and vocalizations of ESA-listed marine mammals. Thus, the proposed low-energy seismic survey could mask baleen whale, sperm whale, and pinniped calls. Given the larger disparity between sperm whale and pinniped vocalizations and hearing ranges with the dominant frequencies of the airguns, 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 source of background noise levels. 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 likely other marine mammals as well, have additional capabilities besides directional hearing that can facilitate detection of sounds in the presence of background sound (for example, see discussion on Behavioral Responses above). 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 2009a; Parks 2009b; Parks et al. 2007; Parks 2007; Terhune 1999).

## Stranding

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 (Iage 2004; IWC 2007). 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 (8,490 in<sup>3</sup> or 139,126.2 cm<sup>3</sup>) approximately 13.7 mi (22 km) 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.

### **6.2.2 Marine Mammal Prey Responses**

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 study by Day et al.

(2017) in a more controlled setting did find significant differences in mortality between scallops exposed to a single airgun and a control group that received no exposure. However, the increased mortality documented by Day et al. (2017) was not significantly different from the expected natural mortality. All available data on echinoderms suggests they exhibit no physical or physiological response to exposure to seismic survey activities. Based on the available data, we assume that some fishes and invertebrates that serve as prey 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.

Research suggests that seismic airgun arrays may lead to a significant reduction in zooplankton, including copepods. McCauley et al. (2017) found that the use of a single airgun (approximately 150 in<sup>3</sup> [2,458.1 cm<sup>3</sup>]) led to a decrease in zooplankton abundance by over 50% and a two- to three-fold increase in dead adult and larval zooplankton when compared to control scenarios. In addition, effects were observed 0.75 mi (1.2 km) away, which was 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).

However, Fields et al. (2019) has demonstrated different results through a series of control experiments using seismic shots from two airguns (260 in<sup>3</sup> or 4,260.6 cm<sup>3</sup>) 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 32.8 ft (10 m) of the seismic airguns, but there was no measurable impact at greater distances. The study also found significantly higher immediate mortality at distances greater than 16.4 ft (5 m) from the airgun and a higher cumulative mortality (seven days after exposure) at a distance somewhere between 32.8–65.6 ft (10–20 m) from the airgun, and observed 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).

Some documented fish or invertebrate mortality resulting from exposure to airguns was 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, were expected within a few meters of the airgun array (Buchanan et al. 2004; Dalen and Knutsen 1986). 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) reported that caged *Pelates* spp., pink snapper, and trevally (*Caranx ignobilis*) 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). 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 that 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 active airgun activity (Davidsen et al. 2019).

There are also reports showing sub-lethal effects to some fish species from airguns. Several species at various life stages exposed to high-intensity sound sources (220 to 242 dB re 1  $\mu$ Pa) at close distances, caused 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  $\mu$ Pa<sup>2</sup>-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  $\mu$ Pa 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  $\mu$ Pa (Falk and Lawrence 1973).

Startle responses were observed in rockfish at received airgun levels of 200 dB re 1  $\mu$ Pa 0-to-peak and alarm responses at greater than 177 dB re 1  $\mu$ Pa 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  $\mu$ Pa 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 1.6 mi (2.5 km) 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  $\mu$ Pa 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  $\mu$ Pa) despite continued 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  $\mu$ Pa<sub>rms</sub>, 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  $\mu$ Pa 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 65.6–164 ft (20–50 m) deeper in response to airgun ensonification and a shift away from the seismic survey area was also found (Slotte et al. 2004). Startle responses were infrequently observed from salmonids receiving 142 to 186 dB re 1  $\mu$ Pa 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  $\mu$ Pa 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).

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  $\mu$ Pa<sub>rms</sub> 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  $\mu$ Pa<sub>rms</sub>. 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 246–252 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 50–400 Hz at  $157 \pm 5$  dB re 1  $\mu$ Pa. 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  $157 \pm 5$  dB re 1  $\mu$ Pa, with peak levels at 175 dB re 1  $\mu$ Pa. 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).

## 6.3 Summary of Effects

In this section, we combine the exposure analysis and response analysis to produce estimates of the amount and extent of take anticipated because of the stressors caused by this action. This summary of the anticipated effects of the action considers all consequences caused by the action and its activities. The following subsections state the anticipated effects of the action for each species that will be adversely affected by the proposed action.

### 6.3.1 Blue Whale

We expect two blue whales to be exposed to underwater sound from the airguns within the 160 dB re 1  $\mu$ Pa ensonified area within the action area and exhibit a response in the form of TTS or behavioral and physiological stress. This may affect blue whales' normal behavioral patterns but

is not expected to result in a long-term reduction in individual fitness, decrease in survivorship or reproduction, or have population-level effects.

### **6.3.2 Fin Whale**

We expect two fin whales to be exposed to underwater sound from the airguns within the 160 dB re 1  $\mu$ Pa ensonified area within the action area and exhibit a response in the form of TTS or behavioral and physiological stress. This may affect fin whales' normal behavioral patterns but is not expected to result in a long-term reduction in individual fitness, decrease in survivorship or reproduction, or have population-level effects.

### **6.3.3 Humpback Whale – Central America DPS and Mexico DPS**

We expect two humpback whales from either the Central America DPS or Mexico DPS to be exposed to underwater sound from the airguns within the 160 dB re 1  $\mu$ Pa ensonified area within the action area and exhibit a response in the form of TTS or behavioral and physiological stress. This may affect humpback whales' normal behavioral patterns but is not expected to result in a long-term reduction in individual fitness, decrease in survivorship or reproduction, or have population-level effects.

### **6.3.4 Sei Whale**

We expect two sei whales to be exposed to underwater sound from the airguns within the 160 dB re 1  $\mu$ Pa ensonified area within the action area and exhibit a response in the form of TTS or behavioral and physiological stress. This may affect sei whales' normal behavioral patterns but is not expected to result in a long-term reduction in individual fitness, decrease in survivorship or reproduction, or have population-level effects.

### **6.3.5 Sperm Whale**

We expect seven sperm whales to be exposed to underwater sound from the airguns within the 160 dB re 1  $\mu$ Pa ensonified area within the action area and exhibit a response in the form of TTS or behavioral and physiological stress. This may affect sperm whales' normal behavioral patterns but is not expected to result in a long-term reduction in individual fitness, decrease in survivorship or reproduction, or have population-level effects.

### **6.3.6 Guadalupe Fur Seal**

We expect 18 Guadalupe fur seals to be exposed to underwater sound from the airguns within the 160 dB re 1  $\mu$ Pa ensonified area within the action area and exhibit a response in the form of TTS or behavioral and physiological stress. This may affect Guadalupe fur seals' normal behavioral patterns but is not expected to result in a long-term reduction in individual fitness, decrease in survivorship or reproduction, or have population-level effects.

## 7. CUMULATIVE EFFECTS

*Cumulative effects* are defined in regulations as “those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation” (50 CFR §402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7(a)(2) of the ESA.

We assessed the action area of this consultation for any non-Federal activities that are reasonably certain to occur. The past and ongoing impact of existing actions was described in the environmental baseline (Section 5). During this consultation, we searched for information on future state, tribal, local, or private (non-Federal) actions reasonably certain to occur in the action area. We did not find any information about non-Federal actions other than the activities described in the environmental baseline.

An increase in non-Federal activities described in the environmental baseline (Section 5) could increase their effect on ESA-listed resources, and, for some, a future increase is considered reasonably certain to occur. Given current trends in global population growth, threats associated with changing environmental trends, sound, fisheries, vessel interactions, debris, and pollution are likely to continue to increase in the future, although any increase in effects may be somewhat countered by an increase in conservation and management, should these occur.

## 8. INTEGRATION AND SYNTHESIS

This opinion includes a jeopardy analysis for the ESA-listed threatened and endangered species that are likely to be adversely affected by the action. Section 7(a)(2) of the ESA and its implementing regulations require every federal agency, in consultation with and with the assistance of the Secretary (16 U.S.C. §1532(15)), to insure that any action it authorizes, funds, or carries out, in whole or in part, in the United States or upon the high seas, is not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat. The jeopardy analysis, therefore, relies upon the regulatory definitions of *jeopardize the continued existence of* and *destruction or adverse modification*.

*Jeopardize the continued existence of* means “to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species” (50 CFR §402.02). *Recovery*, used in that definition, means “improvement in the status of listed species to the point at which listing is no longer appropriate under the criteria set out in section 4(a)(1) of the Act” (50 CFR §402.02).

The Integration and Synthesis is the final step in our jeopardy analyses. In this section, we add the effects of the action (Section 6) to the environmental baseline (Section 5) and the cumulative effects (Section 7), taking into account the status of the species (Section 4), to formulate the agency’s biological opinion as to whether the action agency can insure its proposed action is not likely to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution.

## 8.1 Jeopardy Analysis

The jeopardy analysis assesses the proposed action's effects on ESA-listed blue whale, fin whale, Central America DPS and Mexico DPS humpback whale, sei whale, sperm whale, and Guadalupe fur seal survival and recovery. The following sections summarize the relevant information in this opinion for each individual species considered.

### 8.1.1 Blue Whale

The blue whale is endangered because of past commercial whaling. While commercial whaling no longer occurs, current threats such as vessel strikes, entanglement in fishing gear, pollution, and changing environmental patterns still threaten the blue whale. While there are no abundance estimates for the entire population, estimated regional population abundances are as follows: 1,898 individuals ( $N_{\min}=1,767$  individuals) in the Eastern North Pacific Ocean stock (Calambokidis and Barlow 2020), 137 individuals (95% CI=23–796 individuals) in the Central North Pacific Ocean stock (Bradford et al. 2021), 402 individuals in the Western North Atlantic Ocean stock (Ramp and Sears 2013), 2,280 individuals in 1997/1998 (95% CI=1,160–4,500 individuals) and a population growth rate of 8.2% per year (95% CI=1.6–14.8) in the Southern Hemisphere (Branch 2008), and 303 individuals (95% CI=176–625 individuals) in the Chilean blue whale population (Williams et al. 2011). The best population estimate is 1,898 individuals (lower and upper 20<sup>th</sup> percentile values of 1,767 to 2,038 individuals) in the eastern North Pacific Ocean (Calambokidis and Barlow 2020).

Blue whales will experience TTS or behavioral and physiological stress responses in the action area from underwater sound from the airguns. We anticipate two instances of TTS or behavioral and physiological stress is reasonably certain to occur over the proposed survey.

As discussed in Section 6.2.1, TTS and behavioral and physiological stress is temporary. As such, we do not anticipate that TTS or behavioral and physiological stress exposure would result in a reduction in numbers and will not have a measurable impact on the reproduction of the species. The anticipated effects leading to TTS or behavioral and physiological stress in one individual will not affect the distribution of this species. Therefore, two TTS or behavioral and physiological stress exposures will not have measurable impacts to the population to which that individual belongs, and the effects of the stressors resulting from the airguns as part of the proposed action will not affect the survival of blue whales in the wild.

The 2020 recovery plan for the blue whale identified the major actions needed to recover this species (NMFS 2020). There are no recovery actions that are directly relevant to the proposed action, although the recovery plan acknowledges that seismic surveys (as it relates to oil and gas exploration and development) can affect blue whales and cause negative impacts including, but not limited to, injury. While we anticipate blue whales will be harassed by underwater sound from airguns, this will not impede the potential for recovery of blue whales. Therefore, the effects of the stressors resulting from the airguns as part of the proposed action will not appreciably diminish the ability of blue whales to recover in the wild.

In summary, based on the evidence available, including the status of the species, environmental baseline, analysis of effects, and cumulative effects, we determine that the proposed action would not appreciably reduce the likelihood of both survival and recovery of blue whales in the wild.

### 8.1.2 Fin Whale

The fin whale is endangered because of past commercial whaling. While commercial whaling no longer occurs, current threats such as vessel strikes, entanglement in fishing gear, pollution, and changing environmental patterns still threaten the fin whale. While there are no abundance estimates for the entire population, estimated regional population abundances are as follows: 5,445 (95% CI=2,000–14,500) individuals south of 60°S (Leaper and Miller 2011), 6,802 individuals ( $N_{\min}=5,573$  individuals) in the Western North Atlantic stock (Hayes et al. 2024), 3,168 individuals ( $N_{\min}=2,554$  individuals) and an annual growth rate of 4.8% (95% CI=4.1–5.4%) in the Northeast Pacific stock (Rone et al. 2017; Zerbini et al. 2006), 203 individuals ( $N_{\min}=101$  individuals) in the Hawaii stock (Bradford et al. 2021), and 11,065 individuals ( $N_{\min}=7,970$  individuals) and a population growth rate of 7.5% between 1991 and 2014 for the California/Oregon/Washington stock (Becker et al. 2020; Nadeem et al. 2016).

Fin whales will experience TTS or behavioral and physiological stress responses in the action area from underwater sound from the airguns. We anticipate two instances of TTS or behavioral and physiological stress is reasonably certain to occur over the proposed survey.

As discussed in Section 6.2.1, TTS and behavioral and physiological stress is temporary. As such, we do not anticipate that TTS or behavioral and physiological stress exposure would result in a reduction in numbers and will not have a measurable impact on the reproduction of the species. The anticipated effects leading to TTS or behavioral and physiological stress in one individual will not affect the distribution of this species. Therefore, two TTS or behavioral and physiological stress exposures will not have measurable impacts to the population to which that individual belongs, and the effects of the stressors resulting from the airguns as part of the proposed action will not affect the survival of fin whales in the wild.

The 2010 recovery plan for the fin whale identified the major actions needed to recover this species (NMFS 2010a). There are no recovery actions that are directly relevant to the proposed action, although the recovery plan acknowledges that seismic surveys (as it relates to oil and gas exploration and development) can affect fin whales and cause negative impacts including, but not limited to, injury. While we anticipate fin whales will be harassed by underwater sound from airguns, this will not impede the potential for recovery of fin whales. Therefore, the effects of the stressors resulting from the airguns as part of the proposed action will not appreciably diminish the ability of fin whales to recover in the wild.

In summary, based on the evidence available, including the status of the species, environmental baseline, analysis of effects, and cumulative effects, we determine that the proposed action would not appreciably reduce the likelihood of both survival and recovery of fin whales in the wild.

### 8.1.3 Humpback Whale – Central America DPS and Mexico DPS

The Central America DPS humpback whale is endangered, and Mexico DPS humpback whale is threatened, because of past commercial whaling. While commercial whaling no longer occurs, current threats such as vessel strikes, entanglement in fishing gear, pollution, and changing environmental patterns still threaten both DPSs of humpback whale. Curtis et al. (2022) estimated the abundance of the Central America DPS to be 1,496 (CV=0.171) whales with an estimated annual growth rate of 1.6% (SD=2.0%). While no abundance estimate currently exists for the Mexico DPS, an estimated 3,477 (CV=0.101) whales from the Mexico DPS feed off the U.S. West Coast (Calambokidis and Barlow 2020; Curtis et al. 2022). While the current trend is unknown, Calambokidis and Barlow (2020) reported an approximate 8.2% annual growth rate from 1989–2018 for humpback whales off California and Oregon waters, where whales from the Mexico and Central America DPSs overlap.

Humpback whales from either DPS will experience TTS or behavioral and physiological stress responses in the action area from underwater sound from the airguns. We anticipate two instances of TTS or behavioral and physiological stress is reasonably certain to occur over the proposed survey.

As discussed in Section 6.2.1, TTS and behavioral and physiological stress is temporary. As such, we do not anticipate that TTS or behavioral and physiological stress exposure would result in a reduction in numbers and will not have a measurable impact on the reproduction of the species. The anticipated effects leading to TTS or behavioral and physiological stress in one individual will not affect the distribution of this species. Therefore, two TTS or behavioral and physiological stress exposures will not have measurable impacts to the population to which that individual belongs, and the effects of the stressors resulting from the airguns as part of the proposed action will not affect the survival of the Central America DPS or Mexico DPS humpback whale in the wild.

The 2022 recovery outline for Central America DPS, Mexico DPS, and Western North Pacific DPS of humpback whales identified the major actions needed to recover this species (NMFS 2022). There are no recovery actions that are directly relevant to the proposed action, although the recovery plan acknowledges that chronic exposure to anthropogenic sound may affect humpback whales. While we anticipate humpback whales will be harassed by underwater sound from airguns, this will not impede the potential for recovery of the Central America DPS or Mexico DPS of humpback whale. Therefore, the effects of the stressors resulting from the airguns as part of the proposed action will not appreciably diminish the ability of the Central America DPS or Mexico DPS of humpback whale to recover in the wild.

In summary, based on the evidence available, including the status of the species, environmental baseline, analysis of effects, and cumulative effects, we determine that the proposed action would not appreciably reduce the likelihood of both survival and recovery of the Central America DPS or Mexico DPS of humpback whale in the wild.

#### 8.1.4 Sei Whale

The sei whale is endangered because of past commercial whaling. While commercial whaling no longer occurs, current threats such as vessel strikes, entanglement in fishing gear, pollution, and changing environmental patterns still threaten the sei whale. While there are no abundance estimates for the entire population, estimated regional population abundances are as follows: 29,632 individuals (95% CI=18,576–47,267 individuals) in the central and eastern North Pacific Ocean population between 2010 and 2012 (Hakamada et al. 2017), 6,292 individuals ( $N_{\min}=3,098$  individuals) in the Nova Scotia stock, 401 individuals ( $CV=0.84$ ) in the Hawaii stock (Bradford et al. 2021), and 864 individuals ( $N_{\min}=625$  individuals) in the Eastern North Pacific stock (Barlow 2016).

Sei whales will experience TTS or behavioral and physiological stress responses in the action area from underwater sound from the airguns. We anticipate two instances of TTS or behavioral and physiological stress is reasonably certain to occur over the proposed survey.

As discussed in Section 6.2.1, TTS and behavioral and physiological stress is temporary. As such, we do not anticipate that TTS or behavioral and physiological stress exposure would result in a reduction in numbers and will not have a measurable impact on the reproduction of the species. The anticipated effects leading to TTS or behavioral and physiological stress in one individual will not affect the distribution of this species. Therefore, two TTS or behavioral and physiological stress exposures will not have measurable impacts to the population to which that individual belongs, and the effects of the stressors resulting from the airguns as part of the proposed action will not affect the survival of sei whales in the wild.

The 2011 recovery plan for the sei whale identified the major actions needed to recover this species (NMFS 2011). There are no recovery actions that are directly relevant to the proposed action, although the recovery plan acknowledges that seismic surveys (as it relates to oil and gas exploration and development) and anthropogenic noise can affect sei whales and cause negative impacts including, but not limited to, injury. While we anticipate sei whales will be harassed by underwater sound from airguns, this will not impede the potential for recovery of sei whales. Therefore, the effects of the stressors resulting from the airguns as part of the proposed action will not appreciably diminish the ability of sei whales to recover in the wild.

In summary, based on the evidence available, including the status of the species, environmental baseline, analysis of effects, and cumulative effects, we determine that the proposed action would not appreciably reduce the likelihood of both survival and recovery of sei whales in the wild.

#### 8.1.5 Sperm Whale

The sperm whale is endangered because of past commercial whaling. While commercial whaling no longer occurs, current threats such as vessel strikes, entanglement in fishing gear, pollution, and changing environmental patterns still threaten the sperm whale. While there are no abundance estimates for the entire population, estimated regional population abundances are as follows: 1,180 individuals ( $CV =0.22$ ;  $N_{\min}=983$  individuals) in the Northern Gulf of Mexico

stock (Garrison et al. 2020), 5,895 individuals (CV=0.29;  $N_{\min}$ =4,639 individuals) in the North Atlantic stock (Dias et al. 2022), 2,606 individuals (CV=0.135;  $N_{\min}$ =2,011 individuals) in the California/Oregon/Washington stock (Becker et al. 2020), 5,707 individuals (CV=0.23;  $N_{\min}$ =4,486 individuals) in the Hawaii stock (Becker et al. 2022), and a minimum of 244 individuals in the North Pacific stock (Rone et al. 2017).

Sperm whales will experience TTS or behavioral and physiological stress responses in the action area from underwater sound from the airguns. We anticipate seven instances of TTS or behavioral and physiological stress is reasonably certain to occur over the proposed survey.

As discussed in Section 6.2.1, TTS and behavioral and physiological stress is temporary. As such, we do not anticipate that TTS or behavioral and physiological stress exposure would result in a reduction in numbers and will not have a measurable impact on the reproduction of the species. The anticipated effects leading to TTS or behavioral and physiological stress in one individual will not affect the distribution of this species. Therefore, seven TTS or behavioral and physiological stress exposures will not have measurable impacts to the population to which that individual belongs, and the effects of the stressors resulting from the airguns as part of the proposed action will not affect the survival of sperm whales in the wild.

The 2010 recovery plan for the sperm whale identified the major actions needed to recover this species (NMFS 2010b). There are no recovery actions that are directly relevant to the proposed action, although the recovery plan acknowledges that seismic surveys (as it relates to oil and gas exploration and development) and anthropogenic noise can affect sperm whales and cause negative impacts, including, but not limited to, injury. While we anticipate sperm whales will be harassed by underwater sound from airguns, this will not impede the potential for recovery of sperm whales. Therefore, the effects of the stressors resulting from the airguns as part of the proposed action will not appreciably diminish the ability of sperm whales to recover in the wild.

In summary, based on the evidence available, including the status of the species, environmental baseline, analysis of effects, and cumulative effects, we determine that the proposed action would not appreciably reduce the likelihood of both survival and recovery of sperm whales in the wild.

### **8.1.6 Guadalupe Fur Seal**

The Guadalupe fur seal is threatened because of past commercial sealing. While commercial sealing no longer occurs, current threats such as entanglement in fishing gear, pollution, and changing environmental patterns still threaten the Guadalupe fur seal. The best estimate of population abundance for Guadalupe fur seals is 63,850 individuals (range 57,199–72,631 individuals; Juárez-Ruiz et al. 2022; DON 2019). Juárez-Ruiz et al. (2022) estimated an annual growth rate of 8.4% (range: 8–8.8%) from 1991 to 2019.

Guadalupe fur seals will experience TTS or behavioral and physiological stress responses in the action area from underwater sound from the airguns. We anticipate 18 instances of TTS or behavioral and physiological stress is reasonably certain to occur over the proposed survey.

As discussed in Section 6.2.1, TTS and behavioral and physiological stress is temporary. As such, we do not anticipate that TTS or behavioral and physiological stress exposure would result in a reduction in numbers and will not have a measurable impact on the reproduction of the species. The anticipated effects leading to TTS or behavioral and physiological stress in one individual will not affect the distribution of this species. Therefore, 18 TTS or behavioral and physiological stress exposures will not have measurable impacts to the population to which that individual belongs, and the effects of the stressors resulting from the airguns as part of the proposed action will not affect the survival of Guadalupe fur seals in the wild.

A recovery plan has not been prepared for the Guadalupe fur seal. While we anticipate Guadalupe fur seals will be harassed by underwater sound from airguns, this will not impede the potential for recovery of Guadalupe fur seals. Therefore, the effects of the stressors resulting from the airguns as part of the proposed action will not appreciably diminish the ability of Guadalupe fur seals to recover in the wild.

In summary, based on the evidence available, including the status of the species, environmental baseline, analysis of effects, and cumulative effects, we determine that the proposed action would not appreciably reduce the likelihood of both survival and recovery of Guadalupe fur seals in the wild.

## **9. CONCLUSION**

After reviewing and analyzing the current status of the listed species, the environmental baseline within the action area, the consequences of the proposed action and associated activities, and the cumulative effects, it is NMFS's biological opinion that the proposed action is not likely to jeopardize the continued existence of the blue whale, fin whale, Central America DPS humpback whale, Mexico DPS humpback whale, sei whale, sperm whale, or Guadalupe fur seal.

NMFS also determined the proposed action may affect, but is not likely to adversely affect the Western North Pacific DPS of gray whale, Southern Resident DPS of killer whale, North Pacific right whale, East Pacific DPS of green turtle, leatherback turtle, North Pacific Ocean DPS of loggerhead turtle, Mexico's Pacific Coast breeding colonies of olive ridley turtle, California coastal, Central Valley spring-run, Lower Columbia River, Puget Sound, Sacramento River winter-run, Snake River, Snake River spring/summer run, Upper Columbia River spring-run, and Upper Willamette River ESUs of chinook salmon, Columbia River and Hood Canal summer-run ESUs of chum salmon, Central California coast, Lower Columbia River, Oregon coast, and Southern Oregon and Northern California coasts ESUs of coho salmon, Southern DPS of eulachon, Southern DPS of green sturgeon, Ozette Lake and Snake River ESUs of sockeye salmon, California Central Valley, Central California coast, Lower Columbia River, Middle Columbia River, Northern California, Puget Sound, Snake River Basin, South-Central California coast, Southern California, Upper Columbia River, and Upper Willamette River DPSs of steelhead trout, and sunflower sea star and designated critical habitats of the Southern Resident DPS killer whale, Central America DPS humpback whale, Mexico DPS humpback whale, leatherback turtle, Oregon Coast ESU coho salmon, and Southern DPS green sturgeon.

## 10. INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. “Take” is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. NMFS defines the term “harass” in Policy Directive 02-110-19 as to create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding or sheltering. “Incidental take” is defined by regulation as takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or applicant (50 CFR §402.02). Section 7(b)(4) and section 7(o)(2) of the ESA, as well as in regulation at 50 CFR §402.14(i)(5) 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 ITS.

When an action is reasonably certain to result in incidental take of ESA-listed marine mammals, section 7(b)(4) of the ESA requires that such taking be authorized under section 101(a)(5) of the MMPA in order for the Secretary to issue an ITS for ESA-listed marine mammals and that the ITS specify the measures identified as necessary to comply with section 101(a)(5) of the MMPA. As part of the proposed action, the NMFS Permits and Conservation Division proposes to issue an IHA. Accordingly, the terms of this ITS and the exemption from Section 9 of the ESA become effective only upon the issuance of the 101(a)(5) authorization. The marine mammal portion of this ITS is a preliminary statement. It will become final and effective upon the issuance of the authorization under section 101(a)(5) of the MMPA and NMFS’s written confirmation to the Federal agency, for the duration of the authorization and with relevant revisions per the final authorization.

### 10.1 Amount or Extent of Take

Section 7(b)(4) and its implementing regulations require NMFS to specify the impact of any incidental take of endangered or threatened species; that is, the amount or extent, of such incidental taking on the species (50 CFR §402.14(i)(1)(i)). The amount of take represents the number of individuals that are expected to be taken by actions while the extent of take specifies the impact, i.e., the amount or extent of such incidental taking on the species, which may be used if we cannot assign numerical limits for animals that could be incidentally taken during the course of an action (see 80 Fed. Reg. 26832).

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

We anticipate the low-energy seismic survey in the North Pacific Ocean off Oregon and Washington is likely to result in the incidental take of ESA-listed marine mammals by harassment. TTS and/or significant behavioral response is expected to occur at received levels at

or above 160 dB re 1  $\mu\text{Pa}_{\text{rms}}$  for airgun array operations for ESA-listed marine mammals. In the opinion, NMFS determined that incidental take is reasonably certain to occur as follows:

**Table 8. Anticipated number and type of ESA takes of marine mammals due to the proposed action**

Species	Harassment: TTS / Significant Behavioral Response
Blue Whale	2
Fin Whale	2
Humpback Whale – Central America DPS or Mexico DPS	2
Sei Whale	2
Sperm Whale	7
Guadalupe Fur Seal	18

### 10.2 Reasonable and Prudent Measures

“Reasonable and prudent measures” are measures that are necessary or appropriate to minimize the impact of incidental take on the species (50 CFR §402.02). These measures “cannot alter the basic design, location, scope, duration, or timing of the action and may involve only minor changes” (50 CFR §402.14(i)(2)). NMFS believes the following reasonable and prudent measures are necessary and appropriate:

1. The NMFS Permits and Conservation Division must ensure that the NSF 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 for the incidental taking of blue whales, fin whales, humpback whales (Central America DPS and Mexico DPS), sei whales, sperm whales, and Guadalupe fur seals pursuant to section 101(a)(5)(D) of the MMPA. In addition, the NMFS Permits and Conservation Division must ensure that the provisions of the IHA are carried out, and inform the NMFS ESA Interagency Cooperation Division if take is exceeded.
2. The NSF must implement a program to mitigate and report the potential effects of seismic survey activities as well as the effectiveness of conservation measures for endangered and threatened marine mammals.

### 10.3 Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the ESA, the NMFS Permits and Conservation Division and NSF must comply with the following (or must ensure that any applicant complies) with the following terms and conditions. The NMFS Permits and Conservation Division, NSF, or any applicant has a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this ITS (50 CFR §402.14(i)(3)).

The following terms and conditions implement the above reasonable and prudent measures:

1. A copy of the draft comprehensive report on all seismic survey activities and monitoring results must be provided to the NMFS ESA Interagency Cooperation Division within 90 days of the completion of the seismic survey, or expiration of the IHA, whichever occurs first. Send the report to [nmfs.hq.esa.consultations@noaa.gov](mailto:nmfs.hq.esa.consultations@noaa.gov), with the subject line, “OPR-2025-01094 NSF Cascadia 2025 Seismic Survey Draft Report.”
2. Any reports of injured or dead ESA-listed species must be provided by the NMFS Permits and Conservation Division or NSF to the NMFS ESA Interagency Cooperation Division within 24 hours to Tanya Dobrzynski, Chief, ESA Interagency Cooperation Division by email at [Tanya.Dobrzynski@noaa.gov](mailto:Tanya.Dobrzynski@noaa.gov) and [nmfs.hq.esa.consultations@noaa.gov](mailto:nmfs.hq.esa.consultations@noaa.gov), with the subject line, “OPR-2025-01094 NSF Cascadia 2025 Seismic Survey: Dead/Injured ESA-listed Species Report.”

## 11. CONSERVATION RECOMMENDATIONS

Conservation recommendations are “suggestions ... regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information” (50 CFR §402.02).

The following conservation recommendations should be considered by the NMFS Permits and Conservation Division and NSF to minimize or avoid effects to threatened and endangered species associated with this action:

1. We recommend that the NSF promote and fund research examining the potential effects of seismic surveys on prey species for ESA-listed marine mammals and sea turtles.
2. We recommend that the NSF develop a more robust propagation model that incorporates environmental variables into estimates of how far sound levels reach from airgun arrays.
3. We recommend that the NSF conduct a sound source verification in the study area (and future locations) to validate predicted and modeled isopleth distances to NMFS acoustic thresholds and incorporate the results of that study into buffer and exclusion/shutdown zones prior to starting seismic survey activities.
4. We recommend the NSF use (and NMFS Permits and Conservation Division require in MMPA incidental take authorizations) thermal imaging cameras, in addition to binoculars (Big-Eye and handheld) and the naked eye, for use during daytime and nighttime visual observations and test their effectiveness at detecting ESA-listed species.
5. We recommend the NSF and NMFS Permits and Conservation 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.

6. We recommend the NSF use real-time cetacean sighting services such as the WhaleAlert application (<http://www.whalealert.org/>). We recognize that the research vessel may not have reliable internet access during operations offshore, but nearshore, where many of the cetaceans considered in this opinion are likely found in greater numbers, we anticipate internet access may be better. Monitoring such systems will help plan seismic survey activities and transits to avoid locations with recent ESA-listed cetacean sightings, and may also be valuable during other activities to alert others of ESA-listed cetaceans within the area, which they can then avoid.
7. We recommend the NSF submit their monitoring data (i.e., visual sightings) by PSOs to the Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations online database so that it can be added to the aggregate marine mammal, seabird, sea turtle, and fish observation data from around the world.
8. We recommend the vessel operator and other relevant vessel personnel (e.g., crewmembers) on the R/V *Sally Ride* take the U.S. Navy's marine species awareness training available online at: <https://www.youtube.com/watch?v=KKo3rlyVBBA> in order to detect ESA-listed species and relay information to PSOs.

In order for NMFS Office of Protected Resources Interagency Cooperation Division to be kept informed of actions minimizing or avoiding adverse effects on ESA-listed species or their critical habitat, the NSF and NMFS Permits and Conservation Division should notify the ESA Interagency Cooperation Division of any conservation recommendations implemented in the final action. Notice can be provided to [nmfs.hq.esa.consultations@noaa.gov](mailto:nmfs.hq.esa.consultations@noaa.gov) with the Environmental Consultation Organizer (ECO) number for this consultation (OPR-2025-01094) in the subject line.

## 12. REINITIATION OF CONSULTATION

This concludes formal consultation on NSF and NMFS Permits and Conservation Division's proposed actions. Consistent with 50 CFR §402.16(a), reinitiation of consultation is required and shall be requested by the Federal agency, where discretionary Federal agency involvement or control over the action has been retained or is authorized by law and:

1. If the amount or extent of incidental taking specified in the ITS is exceeded;
2. If new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not previously considered;
3. If the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the opinion; or
4. If a new species is listed or critical habitat designated that may be affected by the identified action.

### 13.LITERATURE CITED

- Aaron, T., Straley, J., Tiemann, C. O., Folkert, K., & O'connell, V. (2007). Observations of potential acoustic cues that attract sperm whales to longline fishing in the Gulf of Alaska. *Journal of the Acoustical Society of America* 122(2):1265–1277.
- Acosta, A., Niño-Rodríguez, N., Yepes, M. C., & Boisseau, O. (2017). Mitigation provisions to be implemented for marine seismic surveying in Latin America: a review based on fish and cetaceans. *Aquatic Biology* 26:199-216.
- Addison, R. F. & Brodie, P. F. (1987). Transfer of organochlorine residues from blubber through the circulatory system to milk in the lactating grey seal *Halichoerus grypus*. *Canadian Journal of Fisheries and Aquatic Sciences* 44:782-786.
- Aguirre, A. A., Keefe, T. J., Reif, J. S., Kashinsky, L., Yochem, P. K., Saliki, J. T., Stott, J. L., Goldstein, T., Dubey, J., & Braun, R. (2007). Infectious disease monitoring of the endangered Hawaiian monk seal. *Journal of Wildlife Diseases* 43(2):229-241.
- André, M., Terada, M., & Watanabe, Y. (1997). *Sperm whale (Physeter macrocephalus) behavioural responses after the playback of artificial sounds*. International Whaling Commission, SC/48/NA13.
- Andre, M. L. F. L. J. (1997). Sperm whale (*Physeter macrocephalus*) behavioural response after the playback of artificial sounds. Pages 92 in Tenth Annual Conference of the European Cetacean Society, Lisbon, Portugal.
- André, M. T., M.; Watanabe, Y. (1997). Sperm whale (*Physeter macrocephalus*) behavioural responses after the playback of artificial sounds. *Report of the International Whaling Commission* 47:499-504.
- ANSI, A. N. S. I. (1995). *Bioacoustical Terminology (ANSI S3.20-1995)*, Acoustical Society of America, New York.
- Arias-del-Razo, A., Heckel, G., Schramm, Y., & Pardo, M. A. (2016). Terrestrial habitat preferences and segregation of four pinniped species on the islands off the western coast of the Baja California Peninsula, Mexico. *Marine Mammal Science* 32(4):1416-1432. <https://doi.org/10.1111/mms.12339>
- Atkinson, S., Demaster, D. P., & Calkins, D. G. (2008). Anthropogenic causes of the western Steller sea lion *Eumetopias jubatus* population decline and their threat to recovery. *Mammal Review* 38(1):1-18.
- Au, W. W. L. (1975). Propagation of dolphin echolocation signals. Pages 23 in Conference on the Biology and Conservation of Marine Mammals, University of California, Santa Cruz.
- Au, W. W. L. (1993). *The Sonar of Dolphins*, Springer-Verlag, New York, New York.
- Au, W. W. L., Floyd, R. W., Penner, R. H., & Murchison, A. E. (1974). Measurement of echolocation signals of the Atlantic bottlenose dolphin, *Tursiops truncatus* Montagu in open waters. *Journal of the Acoustical Society of America* 56(4):1280-1290.
- Au, W. W. L. & Green, M. (2000). Acoustic interaction of humpback whales and whale-watching boats. *Marine Environmental Research* 49(5):469-481.
- Au, W. W. L. R. W. F. R. H. P. A. E. M. (1974). Measurement of echolocation signals of the Atlantic bottlenose dolphin, *Tursiops truncatus* Montagu in open waters. *Journal of the Acoustical Society of America* 56(4):1280-1290.
- Aurioles-Gamboa, D., Elorriaga-Verplancken, F., & Hernandez-Camacho, C. J. (2010). The current population status of Guadalupe fur seal (*Arctocephalus townsendi*) on the San Benito Islands, Mexico. *Marine Mammal Science* 26(2):402-408.

- Aurioles-Gamboa, D. & Szteren, D. (2019). Lifetime coastal and oceanic foraging patterns of male Guadalupe fur seals and California sea lions. *Marine Mammal Science* n/a(n/a). <https://doi.org/10.1111/mms.12649>
- Bailey, H., Benson, S. R., Shillinger, G. L., Bograd, S. J., Dutton, P. H., Eckert, S. A., Morreale, S. J., Paladino, F. V., Eguchi, T., Foley, D. G., Block, B. A., Piedra, R., Hitipeuw, C., Tapilatu, R. F., & Spotila, J. R. (2012). Identification of distinct movement patterns in Pacific leatherback turtle populations influenced by ocean conditions. *Ecological Applications* 22(3):735-747. <https://doi.org/10.1890/11-0633>
- Bain, D. E. & Dahlheim, M. E. (1994). Effects of masking noise on detection thresholds of killer whales. Pages 243-256 in T. R. Loughlin, editor. *Marine Mammals and the Exxon Valdez*. Academic Press, San Diego.
- Bain, D. E., Kriete, B., & Dahlheim, M. E. (1993). Hearing abilities of killer whales (*Orcinus orca*). *Journal of the Acoustical Society of America* 94(3 part 2):1829.
- Bain, D. E. & Williams, R. (2006). Long-range effects of airgun noise on marine mammals: responses as a function of received sound level and distance. *International Whaling Commission Working Paper SC/58/E35*.
- Bain, D. E. B. K. M. E. D. (1993). Hearing abilities of killer whales (*Orcinus orca*). *Journal of the Acoustical Society of America* 94(3 part 2):1829.
- Bain, D. E. M. E. D. (1994). Effects of masking noise on detection thresholds of killer whales. Pages 243-256 in T. R. Loughlin, editor. *Marine Mammals and the Exxon Valdez*. Academic Press, San Diego.
- Baird, R. W., Mahaffy, S. D., Gorgone, A. M., Cullins, T., Mcsweeney, D. J., Oleson, E. M., Bradford, A. L., Barlow, J., & Webster, D. L. (2015). False killer whales and fisheries interactions in Hawaiian waters: Evidence for sex bias and variation among populations and social groups. *Marine Mammal Science* 31(2):579-590.
- Barber, J. R., Crooks, K. R., & Fristrup, K. M. (2010). The costs of chronic noise exposure for terrestrial organisms. *Trends in Ecology and Evolution* 25(3):180–189. <https://doi.org/10.1016/j.tree.2009.08.002>
- Barkaszi, M. J., Butler, M., Compton, R., Unietis, A., & Bennet, B. (2012). *Seismic Survey Mitigation Measures and Marine Mammal Observer Reports*. U.S. Department of the Interior, Bureau of Ocean Energy Management, Gulf of Mexico OCS Region, OCS Study BOEM 2012-015, New Orleans, LA.
- Barlow, D. R., Bernard, K. S., Escobar-Flores, P., Palacios, D. M., & Torres, L. G. (2020). Links in the trophic chain: modeling functional relationships between in situ oceanography, krill, and blue whale distribution under different oceanographic regimes. *Marine Ecology Progress Series* 642:207-225.
- Barlow, J. (2016). *Cetacean abundance in the California current estimated from ship-based line-transect surveys in 1991-2014*. Southwest Fisheries Science Center, Administrative Report, LJ-2016-01.
- Barlow, J., Calambokidis, J., Falcone, E. A., Baker, C. S., Burdin, A. M., Clapham, P. J., Ford, J. K. B., Gabriele, C. M., LeDuc, R., Mattila, D. K., Quinn II, T. J., Rojas-Bracho, L., Straley, J. M., Taylor, B. L., Urbán R., J., Wade, P., Weller, D., Witteveen, B. H., & Yamaguchi, M. (2011). Humpback whale abundance in the North Pacific estimated by photographic capture-recapture with bias correction from simulation studies. *Marine Mammal Science* 27(4):793-818. <https://doi.org/10.1111/j.1748-7692.2010.00444.x>

- Bartholomew Jr., G. A. (1950). A male Guadalupe fur seal on San Nicholas Island, California. *Journal of Mammalogy* 31(2):175-180.
- Baulch, S. & Perry, C. (2014a). Evaluating the impacts of marine debris on cetaceans. *Marine Pollution Bulletin* 80(1-2):210-221.
- Baulch, S. & Perry, C. (2014b). Evaluating the impacts of marine debris on cetaceans. *Mar Pollut Bull* 80(1-2):210-21. <https://doi.org/10.1016/j.marpolbul.2013.12.050>
- Beamish, R. J. (1993). Climate and exceptional fish production off the west coast of North American. *Canadian Journal of Fisheries and Aquatic Sciences* 50(10):2270-2291.
- Becker, E. A., Forney, K. A., Miller, D. L., Fiedler, P. C., Barlow, J., & Moore, J. E. (2020). Habitat-based density estimates for cetaceans in the California Current Ecosystem based on 1991-2018 survey data.
- Becker, E. A., Forney, K. A., Oleson, E. M., Bradford, A. L., Hoopes, R., Moore, J. E., & Barlow, J. (2022). Abundance, distribution, and seasonality of cetaceans within the U.S. Exclusive Economic Zone around the Hawaiian Archipelago based on species distribution models. <https://doi.org/https://doi.org/10.25923/9e50-d280>
- Benson, A. & Trites, A. W. (2002). Ecological effects of regime shifts in the Bering Sea and eastern North Pacific Ocean. *Fish and Fisheries* 3(2):95-113.
- Benson, S. R., Eguchi, T., Foley, D. G., Forney, K. A., Bailey, H., Hitipeuw, C., Samber, B. P., Tapilatu, R. F., Rei, V., Ramohia, P., Pita, J., & Dutton, P. H. (2011). Large-scale movements and high-use areas of western Pacific leatherback turtles, *Dermochelys coriacea*. *Ecosphere* 2(7):art84. <https://doi.org/https://doi.org/10.1890/ES11-00053.1>
- Bérubé, M. & Aguilar, A. (1998). A new hybrid between a blue whale, *Balaenoptera musculus*, and a fin whale, *B. physalus*: frequency and implications of hybridization. *Marine Mammal Science* 14(1):82-98.
- Bi, H., Ruppel, R. E., & Peterson, W. T. (2007). Modeling the pelagic habitat of salmon off the Pacific Northwest (USA) coast using logistic regression. *Marine Ecology Progress Series* 336:249-265.
- Bjarti, T. (2002). An experiment on how seismic shooting affects caged fish. University of Aberdeen.
- Blackwell, S. B., Nations, C. S., McDonald, T. L., Greene Jr, C. R., Thode, A. M., Guerra, M., & Michael Macrander, A. (2013). Effects of airgun sounds on bowhead whale calling rates in the Alaskan Beaufort Sea. *Marine Mammal Science* 29(4):E342-E365.
- Blackwell, S. B., Nations, C. S., McDonald, T. L., Thode, A. M., Mathias, D., Kim, K. H., Greene, C. R., Jr., & Macrander, A. M. (2015). Effects of airgun sounds on bowhead whale calling rates: evidence for two behavioral thresholds. *PLoS One* 10(6):e0125720. <https://doi.org/10.1371/journal.pone.0125720>
- Blair, H. B., Merchant, N. D., Friedlaender, A. S., Wiley, D. N., & Parks, S. E. (2016). Evidence for ship noise impacts on humpback whale foraging behaviour. *Biol Lett* 12(8). <https://doi.org/10.1098/rsbl.2016.0005>
- Booman, C., Dalen, J., Leivestad, H., Levsen, A., Meeren, T. v. d., & Toklum, K. (1996). Effeter av luftkanonskyting på egg, larver og yngel. *Fisken Og Havet* 1996(3):1-83.
- Boren, L. J., Gemmell, N. J., & Barton, K. J. (2001). Controlled approaches as an indicator of tourist disturbance on New Zealand fur seals (*Arctocephalus forsteri*). in Fourteen Biennial Conference on the Biology of Marine Mammals, 28 November-3 December Vancouver Canada. p.30.

- Borrell, A., Bloch, D., & Desportes, G. (1995). Age trends and reproductive transfer of organochlorine compounds in long-finned pilot whales from the Faroe Islands. *Environmental Pollution* 88(3):283-292.
- Bowles, A. E., Smultea, M., Würsig, B., DeMaster, D. P., & Palka, D. (1994). Relative abundance and behavior of marine mammals exposed to transmissions from the Heard Island Feasibility Test. *Journal of the Acoustic Society of America* 96(4):2469–2484.
- Bradford, A. L., Oleson, E. M., Forney, K. A., Moore, J. E., & Barlow, J. (2021). Line-transect Abundance Estimates of Cetaceans in U.S. Waters around the Hawaiian Islands in 2002, 2010, and 2017. <https://doi.org/https://doi.org/10.25923/daz4-kw84>
- Branch, T. (2008). Current status of Antarctic blue whales based on Bayesian modeling. *Report (SC/60/SH7) to the Scientific Committee of the International Whaling Commission, available on request from the Secretariat International Whaling Commission* 135.
- Buchanan, R. A., Christian, J. R., Dufault, S., & Moulton, V. D. (2004). *Impacts of underwater noise on threatened or endangered species in United States waters*. American Petroleum Institute, LGL Report SA791, Washington, D.C.
- Burdin, A. M., Sychenko, O., Volkov, A., & Mamaev, M. (2017). Status of western north Pacific gray whales off northeastern Sakhalin Island and eastern Kamchatka, Russia, in 2016. *IWC SC/67a/NH03*.
- Burtenshaw, J. C., Oleson, E. M., Hildebrand, J. A., McDonald, M. A., Andrew, R. K., Howe, B. M., & Mercer, J. A. (2004). Acoustic and satellite remote sensing of blue whale seasonality and habitat in the Northeast Pacific. *Deep Sea Research Part II: Topical Studies in Oceanography* 51(10):967-986.  
<https://doi.org/https://doi.org/10.1016/j.dsr2.2004.06.020>
- Busch, D. S. & Hayward, L. S. (2009). Stress in a conservation context: A discussion of glucocorticoid actions and how levels change with conservation-relevant variables. *Biological Conservation* 142(12):2844-2853.
- Calambokidis, J. & Barlow, J. (2020). Updated abundance estimates for blue and humpback whales along the U.S. West Coast using data through 2018.  
<https://doi.org/https://doi.org/10.25923/zrth-8n96>
- Calambokidis, J., Barlow, J., Flynn, K., Dobson, E., & Steiger, G. H. (2017). Update on abundance, trends, and migrations of humpback whales along the US West Coast. *IWC Report SC A 17*:18-21.
- Calambokidis, J., Falcone, E. A., Quinn, T. J., Burdin, A. M., Clapham, P. J., Ford, J. K. B., Gabriele, C. M., LeDuc, R., Mattila, D., RojasBracho, L., Straley, J. M., Taylor, B. L., Urbán R., J., Weller, D., Witteveen, B. H., Yamaguchi, M., Bendlin, A., Camacho, D., Flynn, K., Havron, A., Huggins, J., & Maloney, N. (2008). *SPLASH: Structure of Populations, Levels of Abundance and Status of Humpback Whales in the North Pacific*. Cascadia Research.
- Callier, M. D., Byron, C. J., Bengtson, D. A., Cranford, P. J., Cross, S. F., Focken, U., Jansen, H. M., Kamermans, P., Kiessling, A., Landry, T., O'Beirn, F., Petersson, E., Rheault, R. B., Strand, O., Sundell, K., Svasand, T., Wikfors, G. H., & McKindsey, C. W. (2018). Attraction and repulsion of mobile wild organisms to finfish and shellfish aquaculture: a review. *Reviews in Aquaculture* 10.4:924-949.
- Carder, D. A. & Ridgway, S. (1990). Auditory brainstem response in a neonatal sperm whale. *Journal of the Acoustic Society of America* 88(Supplement 1):S4.

- Carretta, J. V. (2023). Estimates of marine mammal, sea turtle, and seabird bycatch in the California large-mesh drift gillnet fishery: 1990-2022. <https://doi.org/https://doi.org/10.25923/kp3k-r222>
- Carretta, J. V., Oleson, E. M., Forney, K. A., Bradford, A., Yano, K., Weller, D., Lang, A., Baker, J., Orr, A. J., Hanson, B., Moore, J. E., Wallen, M., & Brownell Jr, R. L. (2024a). *U.S. Pacific marine mammal stock assessments: 2023*. U.S. Department of Commerce.
- Carretta, J. V., Oleson, E. M., Forney, K. A., Bradford, A. L., Yano, K., Weller, D. W., Lang, A. R., Baker, J., Orr, A. J., Hanson, B., Moore, J. E., Wallen, M., & Brownell Jr, R. L. (2025). *Draft U.S. Pacific Marine Mammal Stock Assessments: 2024*. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.
- Carretta, J. V., Oleson, E. M., Forney, K. A., Bradford, A. L., Yano, K., Weller, D. W., Lang, A. R., Baker, J., Orr, A. J., Hanson, B., Moore, J. E., Wallen, M., & Brownell, R. L., Jr. (2024b). U.S. Pacific marine mammal stock assessments: 2023. <https://doi.org/https://doi.org/10.25923/aqdn-f357>
- Carroll, A. G., Przeslawski, R., Duncan, A., Gunning, M., & Bruce, B. (2017). A critical review of the potential impacts of marine seismic surveys on fish & invertebrates. *Marine Pollution Bulletin* 114(1):24-Sep. <https://doi.org/10.1016/j.marpolbul.2016.11.038>
- Cassoff, R. M. K. M. M. W. A. M. S. G. B. D. S. R. M. J. M. (2011). Lethal entanglement in baleen whales. *Diseases of Aquatic Organisms* 96(3):175-185.
- Castellote, M., Clark, C. W., & Lammers, M. O. (2012a). Acoustic and behavioural changes by fin whales (*Balaenoptera physalus*) in response to shipping and airgun noise. *Biological Conservation*. <https://doi.org/10.1016/j.biocon.2011.12.021>
- Castellote, M., Clark, C. W., & Lammers, M. O. (2012b). Acoustic and behavioural changes by fin whales (*Balaenoptera physalus*) in response to shipping and airgun noise. *Biological Conservation* 147(1):115-122. <https://doi.org/10.1016/j.biocon.2011.12.021>
- Cattet, M. R. L., Christison, K., Caulkett, N. A., & Stenhouse, G. B. (2003a). Physiologic responses of grizzly bears to different methods of capture. *Journal of Wildlife Diseases* 39(3):649-654.
- Cattet, M. R. L., Christison, K., Caulkett, N. A., & Stenhouse, G. B. (2003b). Physiologic responses of grizzly bears to different methods of capture. *Journal of Wildlife Diseases* 39(3-Jan):649-654.
- Cerchio, S. S. S. T. C. C. B. H. R. (2014). Seismic surveys negatively affect humpback whale singing activity off northern Angola. *PLoS ONE* 9(3):e86464.
- Chapman, C. J. & Hawkins, A. D. (1969). The importance of sound in fish behaviour in relation to capture by trawls. *FAO Fisheries Report* 62(3):717-729.
- Childers, A. R., Whitledge, T. E., & Stockwell, D. A. (2005). Seasonal and interannual variability in the distribution of nutrients and chlorophyll a across the Gulf of Alaska shelf: 1998-2000. *Deep-Sea Research II* 52:193-216.
- Chou, E., Southall, B. L., Robards, M., & Rosenbaum, H. C. (2021). International policy, recommendations, actions and mitigation efforts of anthropogenic underwater noise. *Ocean & Coastal Management* 202:105427.
- Christiansen, F., Rasmussen, M. H., & Lusseau, D. (2014). Inferring energy expenditure from respiration rates in minke whales to measure the effects of whale watching boat interactions. *Journal of Experimental Marine Biology and Ecology* 459:96-104. <https://doi.org/10.1016/j.jembe.2014.05.014>

- Clark, C. W., Ellison, W. T., Southall, B. L., Hatch, L., Van Parijs, S. M., Frankel, A., & Ponirakis, D. (2009). Acoustic masking in marine ecosystems: Intuitions, analysis, and implication. *Marine Ecology Progress Series* 395:201-222.
- Clark, C. W. & Gagnon, G. C. (2006). *Considering the temporal and spatial scales of noise exposures from seismic surveys on baleen whales.*
- Clement, D. (2013). Effects on Marine Mammals. *Ministry for Primary Industries. Literature review of ecological effects of aquaculture. Report prepared by Cawthron Institute, Nelson, New Zealand.*
- Cohen, A. N. F., Brent. (2000). The regulation of biological pollution: Preventing exotic species invasions from ballast water discharged into California coastal waters. *Golden Gate University Law Review* 30(4):787-773.
- Committee on Taxonomy. (2016). *List of marine mammal species and subspecies. Society for Marine Mammalogy.* <https://www.marinemammalscience.org>.
- Conant, T. A., Dutton, P. H., Eguchi, T., Epperly, S. P., Fahy, C. C., Godfrey, M. H., MacPherson, S. L., Possardt, E. E., Schroeder, B. A., & Seminoff, J. A. (2009). Loggerhead sea turtle (*Caretta caretta*) 2009 status review under the US Endangered Species Act. *Report of the loggerhead biological review Team to the National Marine Fisheries Service* 222:5-2.
- Constantine, R. (2001). Increased avoidance of swimmers by wild bottlenose dolphins (*Tursiops truncatus*) due to long-term exposure to swim-with-dolphin tourism. *Marine Mammal Science* 17(4):689-702.
- Cooke, J. G. (2018a). *Abundance estimates for western North Pacific gray whales for use with stock structure hypotheses of the range-wide review of the population structure and status of North Pacific gray whales. International Whaling Commission Report SC/67B/ASI/02.*
- Cooke, J. G. (2018b). *Balaenoptera physalus. The IUCN Red List of Threatened Species 2018:eT2478A50349982. in.*
- Cooke, J. G., Sychenko, O., Burdin, A., Weller, D., Bradford, A., Lang, A., & Brownell, R. (2019). Population assessment update for Sakhalin gray whales. *Western Gray Whale Advisory Panel, 20th Panel*:6-8.
- Cooke, J. G., Weller, D., Bradford, A., Sychenko, O., Burdin, A., Lang, A., & Brownell Jr, R. L. (2017). *Population assessment update for Sakhalin gray whales, with reference to stock identity. Paper SC/67a/NH11 presented to the International Whaling Commission's Scientific Committee.*
- Corkeron, P. J. (1995). Humpback whales (*Megaptera novaeangliae*) in Hervey Bay, Queensland: Behaviour and responses to whale-watching vessels. *Canadian Journal of Zoology* 73(7):1290-1299.
- Costa, D. P., Schwarz, L., Robinson, P., Schick, R. S., Morris, P. A., Condit, R., Crocker, D. E., & Kilpatrick, A. M. (2016). A bioenergetics approach to understanding the population consequences of disturbance: Elephant seals as a model system. Pages 161-169 in A. N. Popper & A. Hawkins, editors. *The Effects of Noise on Aquatic Life II.* Springer.
- Costantini, D., Marasco, V., & Moller, A. P. (2011). A meta-analysis of glucocorticoids as modulators of oxidative stress in vertebrates. *Journal of Comparative Physiology B* 181(4):447-56. <https://doi.org/10.1007/s00360-011-0566-2>
- Cowan, D. E. & Curry, B. E. (1998). *Investigation of the potential influence of fishery-induced stress on dolphins in the eastern tropical pacific ocean: Research planning.* National

- Marine Fisheries Service, Southwest Fisheries Science Center, NOAA-TM-NMFS-SWFSC-254.
- Cowan, D. E. & Curry, B. E. (2002). *Histopathological assessment of dolphins necropsied onboard vessels in the eastern tropical pacific tuna fishery*. National Marine Fisheries Service, Southwest Fisheries Science Center, NMFS SWFSC administrative report LJ-02-24C.
- Cowan, D. E. C., B. E. (2008). Histopathology of the alarm reaction in small odontocetes. *Journal of Comparative Pathology* 139(1):24-33.  
<https://doi.org/10.1016/j.jcpa.2007.11.009>
- Cox, T. M., Ragen, T. J., Read, A. J., Vos, E., Baird, R. W., Balcomb, K., Barlow, J., Caldwell, J., Cranford, T. W., Crum, L., D'amico, A., D'spain, G., Fernandez, A., Finneran, J. J., Gentry, R., Gerth, W., Gulland, F., Hildebrand, J. A., Houser, D. S., Hullar, T., Jepson, P. D., Ketten, D., Macleod, C. D., Miller, P., Moore, S., Mountain, D. C., Palka, D., Ponganis, P. J., Rommel, S. A., Rowles, T., Taylor, B. L., Tyack, P., Wartzok, D., Gisiner, R., Mead, J. G., & Benner, L. (2006). Understanding the impacts of anthropogenic sound on beaked whales. *Journal of Cetacean Research and Management* 7(3):177-187.
- Crance, J. & Kennedy, A. (2024). Contemporary sightings of eastern North Pacific right whales, 2006 to 2023. *Endangered Species Research* 54.  
<https://doi.org/https://doi.org/10.3354/esr01349>
- Cranford, T. W. & Krysl, P. (2015). Fin Whale Sound Reception Mechanisms: Skull Vibration Enables Low-Frequency Hearing. *PLOS ONE* 10(1):e0116222.  
<https://doi.org/10.1371/journal.pone.0116222>
- Creel, S. (2005). Dominance, aggression, and glucocorticoid levels in social carnivores. *Journal of Mammalogy* 86(2):255-246.
- Curtis, K. A., Calambokidis, J., Audley, K., Castaneda, M. G., De Weerd, J., García Chávez, A. J., Garita, F., Martínez-Loustalot, P., Palacios-Alfaro, J. D., Pérez, B., Quintana-Rizzo, E., Ramírez Barragan, R., Ransome, N., Rasmussen, K., Urbán R, J., Villegas Zurita, F., Flynn, K., Cheeseman, T., Barlow, J., Steel, D., & Moore, J. (2022). Abundance of humpback whales (*Megaptera novaeangliae*) wintering in Central America and southern Mexico from a one-dimensional spatial capture-recapture model.  
<https://doi.org/https://doi.org/10.25923/9cq1-rx80>
- Czech, B. & Krausman, P. R. (1997). Distribution and causation of species endangerment in the United States. *Science* 277(5329):1116-1117.
- D'Amelio, A. S. A. M. C. M. L. C. A. C. G. R. G. F. V. (1999). Biochemical responses of European sea bass (*Dicentrarchus labrax* L.) to the stress induced by offshore experimental seismic prospecting. *Marine Pollution Bulletin* 38(12):1105-1114.
- Dahlheim, M. E. (1987). Bio-acoustics of the gray whale (*Eschrichtius robustus*). University of British Columbia.
- Dalen, J. & Knutsen, G. M. (1986). Scaring effects in fish and harmful effects on eggs, larvae and fry by offshore seismic explorations. Pp.93-102 In: H.M. Merklinger (Ed), *Progress in Underwater Acoustics*. Plenum, New York. 839p.
- Dalton, T. & Jin, D. (2010). Extent and frequency of vessel oil spills in US marine protected areas. *Marine Pollution Bulletin* 60(11):1939-1945.  
<https://doi.org/http://dx.doi.org/10.1016/j.marpolbul.2010.07.036>

- Daly, E. A., Scheurer, J. A., Brodeur, R. D., Weitkamp, L. A., Beckman, B. R., & Miller, J. A. (2014). Juvenile Steelhead Distribution, Migration, Feeding, and Growth in the Columbia River Estuary, Plume, and Coastal Waters. *Marine and Coastal Fisheries* 6(1):62-80. <https://doi.org/10.1080/19425120.2013.869284>
- Davidson, J. G., Dong, H., Linné, M., Andersson, M. H., Piper, A., Prystay, T. S., Hvam, E. B., Thorstad, E. B., Whoriskey, F., Cooke, S. J., Sjursen, A. D., Rønning, L., Netland, T. C., & Hawkins, A. D. (2019). Effects of sound exposure from a seismic airgun on heart rate, acceleration and depth use in free-swimming Atlantic cod and saithe. *Conservation physiology* 7(1):coz020-coz020. <https://doi.org/10.1093/conphys/coz020>
- Davis, R. W., Evans, W. E., & Würsig, B. (2000). Cetaceans, sea turtles, and seabirds in the northern Gulf of Mexico: Distribution, abundance, and habitat associations. Volume II: Technical Report. Prepared by the GulfCet Program, Texas A&M University, for the U.S. Geological Survey, Biological Resources Division. Contract Nos. 1445-CT09-96-0004 and 1445-IA09-96-0009. OCS Study MMS 2000-03. 364p.
- Day, R. D., McCauley, R. D., Fitzgibbon, Q. P., Hartmann, K., & Semmens, J. M. (2017). Exposure to seismic air gun signals causes physiological harm and alters behavior in the scallop *Pecten fumatus*. *Proceedings of the National Academies of Science* 114(40):E8537-E8546. <https://doi.org/10.1073/pnas.1700564114>
- Deepwater Horizon NRDA Trustees. (2016). *Deepwater Horizon Oil Spill: Final Programmatic Damage Assessment and Restoration Plan (PDARP) and Final Programmatic Environmental Impact Statement*. NOAA.
- Derraik, J. G. B. (2002). The pollution of the marine environment by plastic debris: a review. *Marine Pollution Bulletin* 44(9):842-852. [https://doi.org/10.1016/s0025-326x\(02\)00220-5](https://doi.org/10.1016/s0025-326x(02)00220-5)
- Derville, S., Barlow, D. R., Hayslip, C., & Torres, L. G. (2022). Seasonal, Annual, and Decadal Distribution of Three Rorqual Whale Species Relative to Dynamic Ocean Conditions Off Oregon, USA. *Frontiers in Marine Science* Volume 9 - 2022. <https://doi.org/10.3389/fmars.2022.868566>
- Dias, L. A., Palka, D., Wicker, J., Martinez, A., Garrison, L., Reid, J., Soldevilla, M., DeAngelis, A., Wallace, J., Broughton, E., Walsh, H., Jech, M., Cholewiak, D., Haas, H., Sasso, C., Westell, A., Davis, G., Chavez-Rosales, S., Sigourney, D., Josephson, E., Dias, L., Aichinger, & Orphanides, C. (2022). 2021 Annual Report of a Comprehensive Assessment of Marine Mammal, Marine Turtle, and Seabird Abundance and Spatial Distribution in US waters of the Western North Atlantic Ocean – AMAPPS III. <https://doi.org/https://doi.org/10.25923/jazw-5467>
- Dickens, M. J., Delehanty, D. J., & Romero, L. M. (2010). Stress: An inevitable component of animal translocation. *Biological Conservation* 143(6):1329-1341. <https://doi.org/10.1016/j.biocon.2010.02.032>
- Dierauf, L. A. & Gulland, F. M. D. (2001). *CRC Handbook of Marine Mammal Medicine*, Second Edition edition, CRC Press, Boca Raton, Florida.
- Dietrich, K. S., Cornish, V. R., Rivera, K. S., & Conant., T. A. (2007). *Best practices for the collection of longline data to facilitate research and analysis to reduce bycatch of protected species*. NOAA Technical Memorandum NMFS-OPR-35. 101p. Report of a workshop held at the International Fisheries Observer Conference Sydney, Australia, November 8,.

- DON, U. S. D. o. t. N. (2019). *U.S. Navy Marine Species Density Database Phase III for the Northwest Training and Testing Study Area. NAVFAC Pacific Technical Report. Naval Facilities Engineering Command Pacific, Pearl Harbor, HI.*
- Doney, S. C., Ruckelshaus, M., Duffy, J. E., Barry, J. P., Chan, F., English, C. A., Galindo, H. M., Grebmeier, J. M., Hollowed, A. B., & Knowlton, N. (2012). Climate change impacts on marine ecosystems. *Marine Science* 4.
- Drake, J. M. & Lodge, D. M. (2007). Rate of species introductions in the Great Lakes via ships' ballast water and sediments. *Canadian Journal of Fisheries and Aquatic Sciences* 64(3):530-538.
- Dubrovskiy, N. A. L. R. G. (2004). Modeling of the click-production mechanism in the dolphin. Pages 59-64 in J. A. T. C. F. M. M. Vater, editor. *Echolocation in Bats and Dolphins*. University of Chicago Press.
- Dueñas, M.-A., Ruffhead, H. J., Wakefield, N. H., Roberts, P. D., Hemming, D. J., & Diaz-Soltero, H. (2018). The role played by invasive species in interactions with endangered and threatened species in the United States: a systematic review. *Biodiversity and Conservation*:1-13.
- Dunlop, R. A., Cato, D. H., & Noad, M. J. (2008a). Non-song acoustic communication in migrating humpback whales (*Megaptera novaeangliae*). *Marine Mammal Science* 24(3):613-629. <https://doi.org/doi:10.1111/j.1748-7692.2008.00208.x>
- Dunlop, R. A., Cato, D. H., & Noad, M. J. (2008b). Non-song acoustic communication in migrating humpback whales (*Megaptera novaeangliae*). *Marine Mammal Science* 24(3):613-629.
- Dunlop, R. A., Noad, M. J., Mccauley, R. D., Kniest, E., Slade, R., Paton, D., & Cato, D. H. (2017). The behavioural response of migrating humpback whales to a full seismic airgun array. *Proceedings of the Royal Society B-Biological Sciences* 284(1869). <https://doi.org/10.1098/rspb.2017.1901>
- Dunn, R. A. & Hernandez, O. (2009). Tracking blue whales in the eastern tropical Pacific with an ocean-bottom seismometer and hydrophone array. *The Journal of the Acoustical Society of America* 126(3):1084-1094.
- Eguchi, T., Lang, A. R., & Weller, D. W. (2023). Abundance of eastern North Pacific gray whales 2022/2023.
- Elftman, M. D., Norbury, C. C., Bonneau, R. H., & Truckenmiller, M. E. (2007). Corticosterone impairs dendritic cell maturation and function. *Immunology* 122(2):279-290. <https://doi.org/10.1111/j.1365-2567.2007.02637.x>
- Ellison, W. T., Southall, B. L., Clark, C. W., & Frankel, A. S. (2012). A new context-based approach to assess marine mammal behavioral responses to anthropogenic sounds. *Conservation Biology* 26(1):21–28. <https://doi.org/10.1111/j.1523-1739.2011.01803.x>
- Engås, A., Løkkeborg, S., Ona, E., & Vold Soldal, A. (1996). Effects of seismic shooting on local abundance and catch rates of cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*). *Canadian Journal of Fisheries and Aquatic Sciences* 53:2238-2249.
- Engås, A., Løkkeborg, S., Soldal, A. V., & Ona, E. (1993). Comparative trials for cod and haddock using commercial trawl and longline at two different stock levels. *Journal of Northwest Atlantic Fisheries Science* 19:83-90.
- Engel, M. H., Marcondes, M. C. C., Martins, C. C. A., Luna, F. O., Lima, R. P., & Campos, A. (2004). *Are seismic surveys responsible for cetacean strandings? An unusual mortality of*

- adult humpback whales in Abrolhos Bank, northeastern coast of Brazil*. International Whaling Commission.
- Erbe, C. (2002a). *Hearing abilities of baleen whales*. Defence R&D Canada – Atlantic report CR 2002-065. Contract Number: W7707-01-0828. 40pp.
- Erbe, C. (2002b). Underwater noise of whale-watching boats and potential effects on killer whales (*Orcinus orca*), based on an acoustic impact model. *Marine Mammal Science* 18(2):394-418.
- Erbe, C., Reichmuth, C., Cunningham, K., Lucke, K., & Dooling, R. (2016). Communication masking in marine mammals: A review and research strategy. *Marine Pollution Bulletin* 103(1-2):15-38. <https://doi.org/10.1016/j.marpolbul.2015.12.007>
- Erbe, C., Williams, R., Parsons, M., Parsons, S. K., Hendrawan, I. G., & Dewantama, I. M. I. (2018). Underwater noise from airplanes: An overlooked source of ocean noise. *Marine Pollution Bulletin* 137:656-661. <https://doi.org/10.1016/j.marpolbul.2018.10.064>
- Erickson, D. L. & Hightower, J. E. (2007). Oceanic distribution and behavior of green sturgeon. Pages 197 in American Fisheries Society Symposium. American Fisheries Society.
- Esperon-Rodriguez, M. & Gallo-Reynoso, J. P. (2013). Juvenile and subadult feeding preferences of the Guadalupe fur seal (*Arctocephalus townsendi*) at San Benito Archipelago, Mexico. *Aquatic Mammals* 39(2):125-131.
- Fabry, V. J., Seibel, B. A., Feely, R. A., & Orr, J. C. (2008). Impacts of ocean acidification on marine fauna and ecosystem processes. *ICES Journal of Marine Science* 65(3):414–432.
- Fair, P. A. & Becker, P. R. (2000). Review of stress in marine mammals. *Journal of Aquatic Ecosystem Stress and Recovery* 7(4):335-354.
- Falk, M. R. & Lawrence, M. J. (1973). *Seismic exploration: Its nature and effects on fish*. Department of the Environment, Fisheries and Marine Service, Resource Management Branch, Fisheries Operations Directorate, Central Region (Environment), Winnipeg, Canada.
- Felix, F. (2001). Observed changes of behavior in humpback whales during whalewatching encounters off Ecuador. Pages 69 in 14th Biennial Conference on the Biology of Marine Mammals, Vancouver, Canada.
- Fewtrell, R. D. M. J. (2013a). Experiments and observations of fish exposed to seismic survey pulses. *Bioacoustics* 17:205-207.
- Fewtrell, R. D. M. J. (2013b). Marine invertebrates, intense anthropogenic noise, and squid response to seismic survey pulses. *Bioacoustics* 17:315-318.
- Fields, D. M., Handegard, N., Dalen, J., Eichner, C., Malde, K., Karlsen, O., Skiftesvik, A. B., Durif, C. M. F., & Browman, H. (2019). Airgun blasts used in marine seismic surveys have limited effects on mortality, and no sublethal effects on behaviour or gene expression, in the copepod *Calanus finmarchicus*. *ICES Journal of Marine Science*. <https://doi.org/10.1093/icesjms/fsz126>
- Figuereroa-Carranza, A. L. (1994). Early lactation and attendance behavior of the Guadalupe fur seal females (*Arctocephalus townsendi*). University of California, Santa Cruz, California.
- Finneran, J. J. (2024). *Marine mammal auditory weighting functions and exposure functions for US Navy Phase 4 acoustic effects analyses*.
- Finneran, J. J., Schlundt, C. E., Branstetter, B. K., Trickey, J. S., Bowman, V., & Jenkins, K. (2013). Temporary threshold shift (TTS) in odontocetes in response to multiple air gun impulses.

- Finneran, J. J., Schlundt, C. E., Branstetter, B. K., Trickey, J. S., Bowman, V., & Jenkins, K. (2015). Effects of multiple impulses from a seismic air gun on bottlenose dolphin hearing and behaviora). *The Journal of the Acoustical Society of America* 137(4):1634-1646. <https://doi.org/10.1121/1.4916591>
- Fitzgibbon, Q. P., Day, R. D., McCauley, R. D., Simon, C. J., & Semmens, J. M. (2017). The impact of seismic air gun exposure on the haemolymph physiology and nutritional condition of spiny lobster, *Jasus edwardsii*. *Marine Pollution Bulletin* 125(1-2):146-156. <https://doi.org/10.1016/j.marpolbul.2017.08.004>
- Fleischer, L. A. (1978). The distribution, abundance, and population characteristics of the Guadalupe fur seal, *Arctocephalus townsendi* (Merriam 1897). University of Washington, Seattle, Washington.
- Fleishman, E., Costa, D. P., Harwood, J., Kraus, S., Moretti, D., New, L. F., Schick, R. S., Schwarz, L. K., Simmons, S. E., Thomas, L., & Wells, R. S. (2016). Monitoring population-level responses of marine mammals to human activities. *Marine Mammal Science* 32(3):1004-1021. <https://doi.org/10.1111/mms.12310>
- Foley, D. G., Watters, G. M., Hinke, J. T., & Wilson, C. (2005). Persistent habitat use by Chinook salmon *Oncorhynchus tshawytscha* in the coastal ocean. *Marine Ecology Progress Series* 304:207-220.
- Fonfara, S., Siebert, U., Prange, A., & Colijn, F. (2007). The impact of stress on cytokine and haptoglobin mRNA expression in blood samples from harbour porpoises (*Phocoena phocoena*). *Journal of the Marine Biological Association of the United Kingdom* 87(1):305-311.
- Foote, A. D. O., Richard W.; Hoelzel, A. Rus. (2004). Whale-call response to masking boat noise. *Nature* 428:910.
- Francis, C. D. & Barber, J. R. (2013). A framework for understanding noise impacts on wildlife: An urgent conservation priority. *Frontiers in Ecology and the Environment* 11(6):305-313.
- Frantzis, A. & Alexiadou, P. (2008). Male sperm whale (*Physeter macrocephalus*) coda production and coda-type usage depend on the presence of conspecifics and the behavioural context. *Canadian Journal of Zoology* 86(1):62-75.
- Frazer, L. N. & Mercado, I., Eduardo. (2000). A sonar model for humpback whale song. *IEEE Journal of Oceanic Engineering* 25(1):160-182.
- Freshwater, C., Anderson, S. C., Huff, D. D., Smith, J. M., Jackson, D., Hendriks, B., Hinch, S. G., Johnston, S., Trites, A. W., & King, J. (2024). Chinook salmon depth distributions on the continental shelf are shaped by interactions between location, season, and individual condition. *Movement Ecology* 12(1):21. <https://doi.org/10.1186/s40462-024-00464-y>
- Gabriele, C., Kipple, B., & Erbe, C. (2003). Underwater acoustic monitoring and estimated effects of vessel noise on humpback whales in Glacier Bay, Alaska. Pages 56-57 in Fifteenth Biennial Conference on the Biology of Marine Mammals, Greensboro, North Carolina.
- Gabriele, C. M., Amundson, C. L., Neilson, J. L., Straley, J. M., Baker, C. S., & Danielson, S. L. (2022). Sharp decline in humpback whale (*Megaptera novaeangliae*) survival and reproductive success in southeastern Alaska during and after the 2014–2016 Northeast Pacific marine heatwave. *Mammalian Biology* 102(4):1113-1131. <https://doi.org/10.1007/s42991-021-00187-2>

- Gailey, G., Wursig, B., & McDonald, T. L. (2007). Abundance, behavior, and movement patterns of western gray whales in relation to a 3-D seismic survey, northeast Sakhalin Island, Russia. *Environmental Monitoring and Assessment* 134(3-Jan):75-91.
- Gall, S. C. & Thompson, R. C. (2015). The impact of debris on marine life. *Marine Pollution Bulletin* 92(1-2):170–179. <https://doi.org/10.1016/j.marpolbul.2014.12.041>
- Gallo-Reynoso, J. P. (1994). Factors affecting the population status of Guadalupe fur seals, *Arctocephalus townsendi* (Merriam 1897), at Isla de Guadalupe, Baja California, Mexico. University of California, Santa Cruz.
- Gallo-Reynoso, J. P., Boeuf, B. J. L., & Figueroa, A. L. (1995). Track, location, duration and diving behavior during foraging trips of Guadalupe fur seal females. Pages 41 in Eleventh Biennial Conference on the Biology of Marine Mammals, Orlando, Florida.
- Gallo, F., Fossi, C., Weber, R., Santillo, D., Sousa, J., Ingram, I., Nadal, A., & Romano, D. (2018). Marine litter plastics and microplastics and their toxic chemicals components: the need for urgent preventive measures. *Environmental Sciences Europe* 30(1). <https://doi.org/10.1186/s12302-018-0139-z>
- Gálvez, C., Raverty, S., Galván-Magaña, F., Field, C. L., & Elorriaga-Verplancken, F. R. (2023). Mortality in an off-shore predator critical habitat during the Northeast Pacific marine heatwave. *Frontiers in Marine Science* Volume 10 - 2023. <https://doi.org/10.3389/fmars.2023.1202533>
- García-Aguilar, M. C., Elorriaga-Verplancken, F. R., Rosales-Nanduca, H., & Schramm, Y. (2018). Population status of the Guadalupe fur seal (*Arctocephalus townsendi*). *Journal of Mammalogy* 99(6):1522-1528. <https://doi.org/10.1093/jmammal/gyy132>
- García-Capitanachi, B., Schramm, Y., & Heckel, G. (2017). Population Fluctuations of Guadalupe Fur Seals (*Arctocephalus philippii townsendi*) Between the San Benito Islands and Guadalupe Island, Mexico, During 2009 and 2010. *Aquatic Mammals* 43(5).
- Gardiner, K. J. & Hall, A. J. (1997). Diel and annual variation in plasma cortisol concentrations among wild and captive harbor seals (*Phoca vitulina*). *Canadian Journal of Zoology* 75(11):1773-1780.
- Garrett, C. (2004). *Priority Substances of Interest in the Georgia Basin - Profiles and background information on current toxics issues*. Canadian Toxics Work Group Puget Sound/Georgia Basin International Task Force, GBAP Publication No. EC/GB/04/79.
- Garrison, L., Ortega-Ortiz, J., & Rappucci, G. (2020). Abundance of marine mammals in the waters of the US Gulf of Mexico in the summer of 2017 and 2018. southeast fisheries science center, protected resources and biodiversity division, 75 Virginia beach dr., Miami, Florida 33140. PRBD contribution# PRBD-2020-07. 55pp. in.
- Glass, A. H., Cole, T. V. N., & Garron, M. (2010). *Mortality and serious injury determinations for baleen whale stocks along the United States and Canadian Eastern Seaboards, 2004-2008*. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Fisheries Science Center.
- Gomez, C., Lawson, J., Wright, A. J., Buren, A., Tollit, D., & Lesage, V. (2016). A systematic review on the behavioural responses of wild marine mammals to noise: The disparity between science and policy. *Canadian Journal of Zoology* 94(12):801–819. <https://doi.org/10.1139/cjz-2016-0098>
- Goold, J. C. (1999). Behavioural and acoustic observations of sperm whales in Scapa Flow, Orkney Islands. *Journal of the Marine Biological Association of the United Kingdom* 79(3):541–550.

- Goold, J. C. & Coates, R. F. W. (2006). Near source, high frequency air-gun signatures. *Paper SC/58/E30, prepared for the International Whaling Commission (IWC) Seismic Workshop, St. Kitts, 24-25 May 2006. 7p.*
- Goold, J. C. & Jones, S. E. (1995a). Time and frequency domain characteristics of sperm whale clicks. *Journal of the Acoustical Society of America* 98(3):1279-1291.
- Goold, J. C. & Jones, S. E. (1995b). Time and frequency domain characteristics of sperm whale clicks. *Journal of the Acoustical Society of America* 98(3):1279-1291.
- Gordon, J., Antunes, R., Jaquet, N., & Wursig, B. (2006). *An investigation of sperm whale headings and surface behaviour before, during and after seismic line changes in the Gulf of Mexico. [Pre-meeting]*. Unpublished paper to the IWC Scientific Committee. 10 pp. St Kitts and Nevis, West Indies, June (SC/58/E45).
- Gordon, J., Gillespie, D., Potter, J., Frantzis, A., Simmonds, M. P., Swift, R., & Thompson, D. (2003). A Review of the Effects of Seismic Surveys on Marine Mammals. *Marine Technology Society Journal* 37(4):16-34. <https://doi.org/10.4031/002533203787536998>
- Gordon, J., Gillespie, D., Potter, J., Frantzis, A., Simmonds, M. P., Swift, R., & Thompson, D. (2004). A review of the effects of seismic surveys on marine mammals. *Marine Technology Society Journal* 37(4):16-34.
- Grant, S. C. H. & Ross, P. S. (2002). *Southern Resident killer whales at risk: toxic chemicals in the British Columbia and Washington environment*. Fisheries and Oceans Canada., Sidney, B.C.
- Greene Jr, C. R., Altman, N. S., & Richardson, W. J. (1999). *Bowhead whale calls*. Western Geophysical and NMFS.
- Greer, A. W., Stankiewicz, M., Jay, N. P., Mcanulty, R. W., & Sykes, A. R. (2005). The effect of concurrent corticosteroid induced immuno-suppression and infection with the intestinal parasite *Trichostrongylus colubriformis* on food intake and utilization in both immunologically naive and competent sheep. *Animal Science* 80:89-99.
- Gregory, L. F. & Schmid, J. R. (2001). Stress responses and sexing of wild Kemp's ridley sea turtles (*Lepidochelys kempii*) in the northwestern Gulf of Mexico. *General and Comparative Endocrinology* 124:66-74.
- Guerra, A. A. F. G. F. R. (2004). A review of the records of giant squid in the north-eastern Atlantic and severe injuries in *Architeuthis dux* stranded after acoustic explorations. in ICES Annual Science Conference, Vigo, Spain.
- Gulland, F. M. D., Haulena, M., Lowenstine, L. J., Munro, C., Graham, P. A., Bauman, J., & Harvey, J. (1999). Adrenal function in wild and rehabilitated Pacific harbor seals (*Phoca vitulina richardii*) and in seals with phocine herpesvirus-associated adrenal necrosis. *Marine Mammal Science* 15(3):810-827.
- Gustafson, R., Richerson, K. E., Somers, K. A., Tuttle, V. J., & Jannot, J. E. (2022). Information in Support of a Five-Year Status Review of Eulachon (*Thaleichthys pacificus*) Listed under the Endangered Species Act: Southern Distinct Population Segment. <https://doi.org/https://doi.org/10.25923/p7mr-sk77>
- Hakamada, T., Matsuoka, K., Murase, H., & Kitakado, T. (2017). Estimation of the abundance of the sei whale *Balaenoptera borealis* in the central and eastern North Pacific in summer using sighting data from 2010 to 2012. *Fisheries science* 83(6):887-895.
- Hare, S. R. & Mantua, N. J. (2001). *An historical narrative on the Pacific Decadal Oscillation, interdecadal climate variability and ecosystem impacts*. University of Washington.

- Hare, S. R., Mantua, N. J., & Francis, R. C. (1999). Inverse production regimes: Alaska and West Coast Pacific salmon. *Fisheries* 24(1):6-14.
- Harlacher, J. M. (2020). Whale, what do we have here? Evidence of microplastics in top predators: analysis of two populations of Resident killer whale fecal samples.
- Harris, C. M., Thomas, L., Falcone, E. A., Hildebrand, J., Houser, D., Kvadsheim, P. H., Lam, F.-P. A., Miller, P. J. O., Moretti, D. J., Read, A. J., Slabbekoorn, H., Southall, B. L., Tyack, P. L., Wartzok, D., Janik, V. M., & Blanchard, J. (2018). Marine mammals and sonar: Dose-response studies, the risk-disturbance hypothesis and the role of exposure context. *Journal of Applied Ecology* 55(1):396-404. <https://doi.org/10.1111/1365-2664.12955>
- Harris, R. E., Elliott, T., & Davis, R. A. (2007). *Results of mitigation and monitoring program, Beaufort Span 2-D marine seismic program, open-water season 2006*. GX Technology Corporation, Houston, Texas.
- Harris, R. E., Miller, G. W., & Richardson, W. J. (2001). Seal responses to airgun sounds during summer seismic surveys in the Alaskan Beaufort Sea. *Marine Mammal Science* 17(4):795-812.
- Hartwell, S. I. (2004). Distribution of DDT in sediments off the central California coast. *Marine Pollution Bulletin* 49(4):299-305.
- Hassel, A., Knutsen, T., Dalen, J., Løkkeborg, S., Skaar, K., Østensen, Ø., Haugland, E. K., Fonn, M., Høines, Å., & Misund, O. A. (2003). *Reaction of sandeel to seismic shooting: a field experiment and fishery statistics study*. Institute of Marine Research, Bergen, Norway.
- Hassel, A., Knutsen, T., Dalen, J., Skaar, K., Løkkeborg, S., Misund, O. A., Ostensen, O., Fonn, M., & Haugland, E. K. (2004). Influence of seismic shooting on the lesser sandeel (*Ammodytes marinus*). *ICES Journal of Marine Science* 61:1165-1173.
- Haver, S. M., Gedamke, J., Hatch, L. T., Dziak, R. P., Van Parijs, S., McKenna, M. F., Barlow, J., Berchok, C., DiDonato, E., Hanson, B., Haxel, J., Holt, M., Lipski, D., Matsumoto, H., Meinig, C., Mellinger, D. K., Moore, S. E., Oleson, E. M., Soldevilla, M. S., & Klinck, H. (2018). Monitoring long-term soundscape trends in U.S. Waters: The NOAA/NPS Ocean Noise Reference Station Network. *Marine Policy* 90:6–13. <https://doi.org/10.1016/j.marpol.2018.01.023>
- Hayes, S., Josephson, E., Maze-Foley, K., Rosel, P., & McCordic, J. (2024). *U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments 2023*.
- Hazel, J., Lawler, I. R., Marsh, H., & Robson, S. (2007). Vessel speed increases collision risk for the green turtle *Chelonia mydas*. *Endangered Species Research* 3:105-113.
- Hazen, E. L., Jorgensen, S., Rykaczewski, R. R., Bograd, S. J., Foley, D. G., Jonsen, I. D., Shaffer, S. A., Dunne, J. P., Costa, D. P., Crowder, L. B., & Block, B. A. (2012). Predicted habitat shifts of Pacific top predators in a changing climate. *Nature Climate Change* 3(3):234-238. <https://doi.org/10.1038/nclimate1686>
- Hazen, E. L., Palacios, D. M., Forney, K. A., Howell, E. A., Becker, E., Hoover, A. L., Irvine, L., DeAngelis, M., Bograd, S. J., Mate, B. R., & Bailey, H. (2017). WhaleWatch: a dynamic management tool for predicting blue whale density in the California Current. *Journal of Applied Ecology* 54(5):1415-1428. <https://doi.org/https://doi.org/10.1111/1365-2664.12820>

- Herraez, P., Sierra, E., Arbelo, M., Jaber, J. R., de los Monteros, A. E., & Fernandez, A. (2007). Rhabdomyolysis and myoglobinuric nephrosis (capture myopathy) in a striped dolphin. *Journal of Wildlife Diseases* 43(4):770–774.
- Hildebrand, J. (2004). Impacts of anthropogenic sound on cetaceans. *Unpublished paper submitted to the International Whaling Commission Scientific Committee SC/56 E 13*.
- Hildebrand, J. A. (2009). Anthropogenic and natural sources of ambient noise in the ocean. *Marine Ecology Progress Series* 395:20-May. <https://doi.org/10.3354/meps08353>
- Hodge, R. P. & Wing, B. L. (2000). Occurrences of marine turtles in Alaska waters: 1960-1998. *Herpetological Review* 31(3):148.
- Holliday, D. V., Piper, R. E., Clarke, M. E., & Greenlaw, C. F. (1987). *The effects of airgun energy release on the eggs, larvae, and adults of the northern anchovy (Engraulis mordax)*. American Petroleum Institute, Washington, D.C.
- Holt, M. M. (2008). *Sound exposure and Southern Resident killer whales (Orcinus orca): A review of current knowledge and data gaps*. U.S. Department of Commerce, NMFS-NWFSC-89.
- Holt, M. M., Noren, D. P., Veirs, V., Emmons, C. K., & Veirs, S. (2009). Speaking up: Killer whales (*Orcinus orca*) increase their call amplitude in response to vessel noise. *Journal of the Acoustical Society of America* 125(1):E127-E132.
- Holt, M. M., Tennessen, J. B., Ward, E. J., Hanson, M. B., Emmons, C. K., Giles, D. A., & Hogan, J. T. (2021). Effects of vessel distance and sex on the behavior of endangered killer whales. *Frontiers in Marine Science* 7:1211.
- Holt, M. M. D. P. N. V. V. C. K. E. S. V. (2009). Speaking up: Killer whales (*Orcinus orca*) increase their call amplitude in response to vessel noise. *Journal of the Acoustical Society of America* 125(1):E127-E132.
- Houser, D. S. (2021). When is temporary threshold shift injurious to marine mammals? *Journal of Marine Science and Engineering* 9(7):757.
- Houser, D. S., Kvadsheim, P. H., Kleivane, L., Mulsow, J., Ølberg, R. A., Harms, C. A., Teilmann, J., & Finneran, J. J. (2024). Direct hearing measurements in a baleen whale suggest ultrasonic sensitivity. *Science* 386(6724):902-906. <https://doi.org/doi:10.1126/science.ado7580>
- Hoyt, E. (2001). *Whale Watching 2001: Worldwide Tourism Numbers, Expenditures, and Expanding Socioeconomic Benefits*. International Fund for Animal Welfare, Yarmouth Port, MA, USA.
- Hubbs, C. L. (1956). Back from oblivion. Guadalupe fur seal: Still a living species. *Pacific Discovery* 9(6):14-21.
- Huff, D. D., Lindley, S. T., Rankin, P. S., & Mora, E. A. (2011). Green Sturgeon Physical Habitat Use in the Coastal Pacific Ocean. *PLOS ONE* 6(9):e25156. <https://doi.org/10.1371/journal.pone.0025156>
- Hunt, K. E., Rolland, R. M., Kraus, S. D., & Wasser, S. K. (2006). Analysis of fecal glucocorticoids in the North Atlantic right whale (*Eubalaena glacialis*). *General and Comparative Endocrinology* 148(2):260-72. <https://doi.org/10.1016/j.ygcen.2006.03.012>
- Iagc. (2004). *Further analysis of 2002 Abrolhos Bank, Brazil humpback whale straddings coincident with seismic surveys*. International Association of Geophysical Contractors, Houston, Texas.
- Iorio, L. D. & Clark, C. W. (2009). Exposure to seismic survey alters blue whale acoustic communication. *Biology Letters* in press(in press):in press.

- Irvine, L. M., Mate, B. R., Winsor, M. H., Palacios, D. M., Bograd, S. J., Costa, D. P., & Bailey, H. (2014). Spatial and Temporal Occurrence of Blue Whales off the U.S. West Coast, with Implications for Management. *PLOS ONE* 9(7):e102959. <https://doi.org/10.1371/journal.pone.0102959>
- Iwata, H., S. Tanabe, N. Sakai, and R. Tatsukawa. (1993). Distribution of persistent organochlorines in the oceanic air and surface seawater and the role of ocean on their global transport and fate. *Environmental Science and Technology* 27:1080-1098.
- IWC. (2007). *Annex K: Report of the standing working group on environmental concerns*. International Whaling Commission.
- Jackson, J., Kirby, M., Berger, W., Bjorndal, K., Botsford, L., Bourque, B., Bradbury, R., Cooke, R., Erlandson, J., Estes, J., Hughes, T., Kidwell, S., Lange, C., Lenihan, H., Pandolfi, J., Peterson, C., Steneck, R., Tegner, M., & Warner, R. (2001). Historical overfishing and the recent collapse of coastal ecosystems. *Science* 293(5530):629-638.
- Jacobsen, J. K., Massey, L., & Gulland, F. (2010a). Fatal ingestion of floating net debris by two sperm whales (*Physeter macrocephalus*). *Marine Pollution Bulletin* 60:765-767.
- Jacobsen, J. K., Massey, L., & Gulland, F. (2010b). Fatal ingestion of floating net debris by two sperm whales (*Physeter macrocephalus*). *Marine Pollution Bulletin* 60(5):765-767. <https://doi.org/10.1016/j.marpolbul.2010.03.008>
- Jannot, J. E., Somers, K. A., Tuttle, V. J., Eibner, J., Richerson, K. E., McVeigh, J. T., Carretta, J. V., Young, N. C., & Freed, J. (2022). Marine Mammal Bycatch in U.S. West Coast Groundfish Fisheries, 2002-19. <https://doi.org/https://doi.org/10.25923/h6gg-c316>
- Jenner, C. M. J. C. B. V. S. C. S. K. M. M. C. A. L. M. M. C. D. (2008). *Mark recapture analysis of pygmy blue whales from the Perth Canyon, Western Australia 2000-2005*. International Whaling Commission Scientific Committee, Santiago, Chile.
- Jensen, A. S. & Silber, G. K. (2003). Large whale ship strike database.
- Jochens, A., Biggs, D. C., Engelhaupt, D., Gordon, J., Jaquet, N., Johnson, M., Leben, R., Mate, B., Miller, P., Ortega-Ortiz, J., Thode, A. M., Tyack, P., Wormuth, J., & Würsig, B. (2006). Sperm whale seismic study in the Gulf of Mexico; Summary Report 2002-2004. *U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2006-034. 352p.*
- Jochens, A. E. & Biggs, D. C. (2004). Sperm whale seismic study in the Gulf of Mexico: Annual report: Year 2. *U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2004-067, 167p.*
- Jochens, A. E. B., Douglas C. (2003). *Sperm whale seismic study in the Gulf of Mexico*. Minerals Management Service, OCS MMS 2003-069, New Orleans.
- Johnson, S. R., Richardson, W. J., Yazvenko, S. B., Blokhin, S. A., Gailey, G., Jenkerson, M. R., Meier, S. K., Melton, H. R., Newcomer, M. W., Perlov, A. S., Rutenko, S. A., Würsig, B., Martin, C. R., & Egging, D. E. (2007a). A western gray whale mitigation and monitoring program for a 3-D seismic survey, Sakhalin Island, Russia. *Environmental Monitoring and Assessment* 134(3-Jan):19-Jan.
- Johnson, S. R., Richardson, W. J., Yazvenko, S. B., Blokhin, S. A., Gailey, G., Jenkerson, M. R., Meier, S. K., Melton, H. R., Newcomer, M. W., Perlov, A. S., Rutenko, S. A., Würsig, B., Martin, C. R., & Egging, D. E. (2007b). A western gray whale mitigation and monitoring program for a 3-D seismic survey, Sakhalin Island, Russia. *Environmental Monitoring and Assessment* Available online at

- [http://www.springerlink.com/content/?mode=boolean&k=ti%3a\(western+gray+whale\)&ortorder=asc](http://www.springerlink.com/content/?mode=boolean&k=ti%3a(western+gray+whale)&ortorder=asc). DOI 10.1007/s10661-007-9813-0. 19p.
- Juárez-Ruiz, A., Pardo, M. A., Hernández-Montoya, J. C., Elorriaga-Verplancken, F. R., Milanés-Salinas, M. d. I. Á., Norris, T., Beier, E., & Heckel, G. (2022). Guadalupe fur seal pup production predicted from annual variations of sea surface temperature in the southern California Current Ecosystem. *ICES Journal of Marine Science* 79(5):1637-1648.
- Julian, F. & Beeson, M. (1998). and seabird mortality for two California gillnet fisheries: 1990–1995. *Fishery Bulletin* 96:271-284.
- Kaplan, M. B. & Solomon, S. (2016). A coming boom in commercial shipping? The potential for rapid growth of noise from commercial ships by 2030. *Marine Policy* 73:119-121. <https://doi.org/https://doi.org/10.1016/j.marpol.2016.07.024>
- Kastak, D., Schusterman, R. J., Southall, B. L., & Reichmuth, C. J. (1999). Underwater temporary threshold shift induced by octave-band noise in three species of pinniped. *The Journal of the Acoustical Society of America* 106(2):1142-1148.
- Kastelein, R. A., Helder-Hoek, L., Van de Voorde, S., von Benda-Beckmann, A. M., Lam, F.-P. A., Jansen, E., de Jong, C. A. F., & Ainslie, M. A. (2017). Temporary hearing threshold shift in a harbor porpoise (*Phocoena phocoena*) after exposure to multiple airgun sounds. *The Journal of the Acoustical Society of America* 142(4):2430-2442. <https://doi.org/10.1121/1.5007720>
- Kaufman, G. A. & Kaufman, D. W. (1994). Changes in body-mass related to capture in the prairie deer mouse (*Peromyscus maniculatus*). *Journal of Mammalogy* 75(3):681-691.
- Keay, J. M., Singh, J., Gaunt, M. C., & Kaur, T. (2006). Fecal glucocorticoids and their metabolites as indicators of stress in various mammalian species: A literature review. *Journal of Zoo and Wildlife Medicine* 37(3):234-244. <https://doi.org/10.1638/05-050.1>
- Keller, R. P. & Perrings, C. (2011). International policy options for reducing the environmental impacts of invasive species. *BioScience* 61(12):1005-1012. <https://doi.org/10.1525/bio.2011.61.12.10>
- Kerby, A. S., Bell, A. M., & L., J. (2004). Two stressors are far deadlier than one. *Trends in Ecology and Evolution* 19(6):274-276.
- Ketten, D. R. (1992). The cetacean ear: Form, frequency, and evolution. Pages 53–75 in R. A. Kastelein, A. Y. Supin, & J. A. Thomas, editors. *Marine Mammal Sensory Systems*. Plenum Press, New York.
- Ketten, D. R. (1997a). Structure and function in whale ears. *Bioacoustics* 8:103–135.
- Ketten, D. R. (1997b). Structure and function in whale ears. *Bioacoustics* 8:103-135.
- Ketten, D. R. (1998). *Marine Mammal Auditory Systems: A Summary of Audiometric and Anatomical Data and its Implications for Underwater Acoustic Impacts*. Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-256, La Jolla, California.
- Ketten, D. R. & Mountain, D. C. (2014). Inner ear frequency maps: First stage audiograms of low to infrasonic hearing in mysticetes. Pages 41 in Fifth International Meeting on the Effects of Sounds in the Ocean on Marine Mammals (ESOMM - 2014), Amsterdam, The Netherlands.

- Kight, C. R. & Swaddle, J. P. (2011). How and why environmental noise impacts animals: An integrative, mechanistic review. *Ecology Letters*. <https://doi.org/10.1111/j.1461-0248.2011.01664.x>
- Kipple, B. & Gabriele, C. (2004). Underwater noise from skiffs to ships. in S. M. J. F. G. Piatt, editor Fourth Glacier Bay Science Symposium.
- Kostyuchenko, L. P. (1973). Effects of elastic waves generated in marine seismic prospecting on fish eggs in the Black Sea. *Hydrobiological Journal* 9(5):45-48.
- Krahn, M. M., Hanson, M. B., Baird, R. W., Boyer, R. H., Burrows, D. G., Emmons, C. K., Ford, J. K. B., Jones, L. L., Noren, D. P., Ross, P. S., Schorr, G. S., & Collier, T. K. (2007). Persistent organic pollutants and stable isotopes in biopsy samples (2004/2006) from Southern Resident killer whales (*Orcinus orca*). *Marine Pollution Bulletin* 54(12):1903-1911.
- Krahn, M. M., Hanson, M. B., Schorr, G. S., Emmons, C. K., Burrows, D. G., Bolton, J. L., Baird, R. W., & Ylitalo, G. M. (2009). Effects of age, sex and reproductive status on persistent organic pollutant concentrations in “Southern Resident” killer whales. *Marine Pollution Bulletin*.
- Kraus, S. D., Brown, M. W., Caswell, H., Clark, C. W., Fujiwara, M., Hamilton, P. K., Kenney, R. D., Knowlton, A. R., Landry, S., Mayo, C. A., McMellan, W. A., Moore, M. J., Nowacek, D. P., Pabst, D. A., Read, A. J., & Rolland, R. M. (2005). North Atlantic right whales in crisis. *Science* 309(5734):561-562.
- Kraus, S. D., Kenney, R. D., Mayo, C. A., McLellan, W. A., Moore, M. J., & Nowacek, D. P. (2016). Recent Scientific Publications Cast Doubt on North Atlantic Right Whale Future. *Frontiers in Marine Science*. <https://doi.org/10.3389/fmars.2016.00137>
- Kuehne, L. M., Erbe, C., Ashe, E., Bogaard, L. T., Salerno Collins, M., & Williams, R. (2020). Above and below: Military Aircraft Noise in Air and under Water at Whidbey Island, Washington. *Journal of Marine Science and Engineering* 8(11):923.
- Kujawa, S. G. & Liberman, M. C. (2009). Adding insult to injury: cochlear nerve degeneration after “temporary” noise-induced hearing loss. *Journal of Neuroscience* 29(45):14077-14085.
- La Bella, G., Cannata, S., Frogliola, C., Modica, A., Ratti, S., & Rivas, G. (1996). First assessment of effects of air-gun seismic shooting on marine resources in the Central Adriatic Sea. Pages 227-238 in Society of Petroleum Engineers, International Conference on Health, Safety and Environment, New Orleans, Louisiana.
- Laist, D. W., Knowlton, A. R., Mead, J. G., Collet, A. S., & Podesta, M. (2001). Collisions between ships and whales. *Marine Mammal Science* 17(1):35-75.
- Lambert, E., Hunter, C., Pierce, G. J., & MacLeod, C. D. (2010). Sustainable whale-watching tourism and climate change: Towards a framework of resilience. *Journal of Sustainable Tourism* 18(3):409–427.
- Lambourn, D. M., Jeffries, S. J., Wilkinson, K., Huggins, J., Rice, J., Duffield, D., & Raverty, S. A. (2012). 2007-2009 Pacific Northwest Guadalupe Fur Seal (*Arctocephalus townsendi*) Unusual Mortality Event (UME) Summary Report.
- Lang, A. R., Calambokidis, J., Scordino, J., Pease, V. L., Klimek, A., Burkanov, V. N., Gearin, P., Litovka, D. I., Robertson, K. M., & Mate, B. R. (2014). Assessment of genetic structure among eastern North Pacific gray whales on their feeding grounds. *Marine Mammal Science* 30(4):1473-1493.

- Lang, A. R., Weller, D. W., Burdin, A. M., Robertson, K., Sychenko, O., Urbán, J., Martínez-Aguilar, S., Pease, V. L., LeDuc, R. G., & Litovka, D. I. (2022). Population structure of North Pacific gray whales in light of trans-Pacific movements. *Marine Mammal Science* 38(2):433-468.
- Langan, R. (2004). Balancing marine aquaculture inputs and extraction: combined culture of finfish and bivalve molluscs in the open ocean. *BULLETIN-FISHERIES RESEARCH AGENCY JAPAN*:51-58.
- Laplanche, C., Adam, O., Lopatka, M., & Motsch, J. F. (2005a). Sperm whales click focussing: Towards an understanding of single sperm whale foraging strategies. Pages 56 in Nineteenth Annual Conference of the European Cetacean Society, La Rochelle, France.
- Laplanche, C., Adam, O., Lopatka, M., & Motsch, J. F. (2005b). Sperm whales click focussing: Towards an understanding of single sperm whale foraging strategies. Pages 56 in Nineteenth Annual Conference of the European Cetacean Society, La Rochelle, France.
- Law, K. L., Moret-Ferguson, S., Maximenko, N. A., Proskurowski, G., Peacock, E. E., Hafner, J., & Reddy, C. M. (2010). Plastic accumulation in the North Atlantic subtropical gyre. *Science* 329(5996):1185-1188. <https://doi.org/10.1126/science.1192321>
- Leaper, R. & Miller, C. (2011). Management of Antarctic baleen whales amid past exploitation, current threats and complex marine ecosystems. *Antarctic Science* 23(6):503-529.
- Lesage, V. B., C.; Kingsley, M. C. S.; Sjare, B. (1999). The effect of vessel noise on the vocal behavior of Belugas in the St. Lawrence River estuary, Canada. *Marine Mammal Science* 15(1):65-84.
- Lesage, V. C. B. M. C. S. K. (1993). The effect of noise from an outboard motor and a ferry on the vocal activity of beluga (*Delphinapterus leucas*) in the St. Lawrence Estuary, Canada. Pages 70 in Tenth Biennial Conference on the Biology of Marine Mammals, Galveston, Texas.
- LGL. (2025). *Draft Environmental Assessment of Marine Geophysical Surveys by R/V Sally Ride at the Cascadia Subduction Zone, northeast Pacific Ocean, September 2025. Prepared for National Science Foundation, Division of Ocean Sciences.*
- Li, W. C., Tse, H. F., & Fok, L. (2016). Plastic waste in the marine environment: A review of sources, occurrence and effects. *Sci Total Environ* 566-567:333-349. <https://doi.org/10.1016/j.scitotenv.2016.05.084>
- Lieberman, M. C., Epstein, M. J., Cleveland, S. S., Wang, H., & Maison, S. F. (2016). Toward a differential diagnosis of hidden hearing loss in humans. *PLOS ONE* 11(9):e0162726.
- Ljungblad, D. K., Würsig, B., Swartz, S. L., & Keene, J. M. (1988). Observations on the behavioral responses of bowhead whales (*Balaena mysticetus*) to active geophysical vessels in the Alaskan Beaufort Sea. *Arctic* 41(3):183-194.
- Lloyd, B. D. (2003). *Potential effects of mussel farming on New Zealand's marine mammals and seabirds: A discussion paper*, Department of Conservation.
- Løkkeborg, S. (1991). Effects of geophysical survey on catching success in longline fishing. Pages 1-9 in International Council for the Exploration of the Sea (ICES) Annual Science Conference.
- Løkkeborg, S. & Soldal, A. V. (1993). The influence of seismic explorations on cod (*Gadus morhua*) behaviour and catch rates. *ICES Marine Science Symposium* 196:62-67.
- Lowry, D., Wright, S., Neuman, M., Stevenson, D., Hyde, J., Lindeberg, M., Tolimieri, N., Lonhart, S., Traiger, S., & Gustafson, R. (2022). *Endangered Species Act Status Review Report: Sunflower Sea Star (*Pycnopodia helianthoides*). Final Report to the National*

- Marine Fisheries Service, Office of Protected Resources*. National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce.
- Lucke, K., Siebert, U., Lepper, P. A., & Blanchet, M.-A. (2009). Temporary shift in masked hearing thresholds in a harbor porpoise (*Phocoena phocoena*) after exposure to seismic airgun stimuli. *The Journal of the Acoustical Society of America* 125(6):4060-4070. <https://doi.org/10.1121/1.3117443>
- Luksenburg, J. & Parsons, E. (2009). *The effects of aircraft on cetaceans: implications for aerial whalewatching*. International Whaling Commission, SC/61/WW2.
- Machovsky-Capuska, G. E., Amiot, C., Denuncio, P., Grainger, R., & D., R. (2019). A nutritional perspective on plastic ingestion in wildlife. *Science of the Total Environment* 656:789-796.
- MacLeod, C. D. (2009). Global climate change, range changes and potential implications for the conservation of marine cetaceans: A review and synthesis. *Endangered Species Research* 7(2):125-136. <https://doi.org/10.3354/esr00197>
- Madsen, P. T., Carder, D. A., Au, W. W. L., Nachtigall, P. E., Møhl, B., & Ridgway, S. H. (2003). Sound production in neonate sperm whales. *Journal of the Acoustical Society of America* 113(6):2988–2991.
- Madsen, P. T., Johnson, M., Miller, P. J. O., Aguilar Soto, N., Lynch, J., & Tyack, P. (2006). Quantitative measurements of air-gun pulses recorded on sperm whales (*Physeter macrocephalus*) using acoustic tags during controlled exposure experiments. *Journal of the Acoustical Society of America* 120(4):2366–2379.
- Madsen, P. T., Møhl, B., Nielsen, B. K., & Wahlberg, M. (2002a). Male sperm whale behaviour during exposures to distant seismic survey pulses. *Aquatic Mammals* 28(3):231-240.
- Madsen, P. T., Møhl, B., Nielsen, B. K., & Wahlberg, M. (2002b). Male sperm whale behaviour during seismic survey pulses. *Aquatic Mammals* 28(3):231-240.
- Magalhaes, S., Prieto, R., Silva, M. A., Goncalves, J., Afonso-Dias, M., & Santos, R. S. (2002). Short-term reactions of sperm whales (*Physeter macrocephalus*) to whale-watching vessels in the Azores. *Aquatic Mammals* 28(3):267-274.
- Malme, C. I. & Miles, P. R. (1985). Behavioral responses of marine mammals (gray whales) to seismic discharges. Pages 253-280 in G. D. Greene, F. R. Engelhard, & R. J. Paterson, editors. Proc. Workshop on Effects of Explosives Use in the Marine Environment. Canada Oil & Gas Lands Administration, Environmental Protection Branch, Ottawa, Canada.
- Malme, C. I., Miles, P. R., Clark, C. W., Tyack, P., & Bird, J. E. (1984a). Investigations of the Potential Effects of Underwater Noise from Petroleum Industry Activities on Migrating Gray Whale Behavior Phase II: January 1984 Migration. Report prepared for the U.S. Department of Interior, Minerals Management Service, Alaska OCS Office under Contract No. 14-12-0001-29033. 357p.
- Malme, C. I., Miles, P. R., Clark, C. W., Tyack, P., & Bird, J. E. (1984b). *Investigations of the Potential Effects of Underwater Noise from Petroleum Industry Activities on Migrating Gray Whale Behavior Phase II: January 1984 Migration*. U.S. Department of Interior, Minerals Management Service, Alaska OCS Office, Report prepared under Contract No. 14-12-0001-29033, Anchorage, Alaska.
- Malme, C. I., Miles, P. R., Tyack, P., Clark, C. W., & Bird, J. E. (1985). *Investigation of the potential effects of underwater noise from petroleum industry activities on feeding*

- humpback whale behavior*. U.S. Department of Interior, Minerals Management Service, Alaska OCS Office, Report No. 5851, Anchorage, Alaska.
- Malme, C. I., Wursig, B., Bird, J. E., & Tyack, P. (1987). Observations of feeding gray whale responses to controlled industrial noise exposure. Pages 55-73 in Ninth International Conference on Port and Ocean Engineering Under Arctic Conditions, Fairbanks, Alaska.
- Malme, C. I., Würsig, B., Bird, J. E., & Tyack, P. (1986). *Behavioral responses of gray whales to industrial noise: Feeding observations and predictive modeling*. U.S. Department of the Interior, Outer Continental Shelf Environmental Assessment Program, Research Unit 675.
- Mancia, A., Warr, W., & Chapman, R. W. (2008). A transcriptomic analysis of the stress induced by capture-release health assessment studies in wild dolphins (*Tursiops truncatus*). *Molecular Ecology* 17(11):2581-2589. <https://doi.org/10.1111/j.1365-294X.2008.03784.x>
- Mann, J., Connor, R. C., Barre, L. M., & Heithaus, M. R. (2000). Female reproductive success in bottlenose dolphins (*Tursiops* sp.): Life history, habitat, provisioning, and group-size effects. *Behavioral Ecology* 11(2):210-219.
- Mantua, N. J. & Hare, S. R. (2002). The Pacific decadal oscillation. *Journal of Oceanography* 58(1):35-44.
- Mantua, N. J., Hare, S. R., Zhang, Y., Wallace, J. M., & Francis, R. C. (1997). A Pacific interdecadal climate oscillation with impacts on salmon production. *Bulletin of the American Meteorological Society* 78(6):1069-1079.
- Marcoux, M., Whitehead, H., & Rendell, L. (2006). Coda vocalizations recorded in breeding areas are almost entirely produced by mature female sperm whales (*Physeter macrocephalus*). *Canadian Journal of Zoology* 84(4):609–614.
- Marine Geospatial Ecology Lab Duke University. (2021). Mapping Tool for the Navy Marine Species Density Database for the U.S. Pacific and Gulf of Alaska. in *OBIS-SEAMAP*, editor.
- Martien, K. K., Taylor, B. L., Archer, F. I., Audley, K., Calambokidis, J., Cheeseman, T., De Weerd, J., Frisch Jordán, A., Martínez-Loustalot, P., Ortega-Ortiz, C. D., Patterson, E. M., Ransome, N., Ruvelas, P., Urbán Ramírez, J., & Villegas-Zurita, F. (2021). Evaluation of Mexico Distinct Population Segment of Humpback Whales as units under the Marine Mammal Protection Act. <https://doi.org/https://doi.org/10.25923/nvw1-mz45>
- Martínez-Aguilar, S. (2011). Abundancia y tasa de incremento de la ballena jorobada *Megaptera novaeangliae* en el Pacífico Mexicano. *Maestro en Ciencias, Universidad Autónoma de Baja California Sur*. 92pp.
- Martínez-Aguilar, S., Urbán R., J., Weller, D., Tyurneva, O., Bradford, A., Burdin, A., Lang, A., Swartz, S., Sychenko, O., Vilorio-Gómora, L., Hernández, E., & Yakovlev, Y. (2022). *Gray whale (*Eschrichtius robustus*) migratory movements between the western North Pacific and the Mexican breeding grounds: 2022 Update. Paper SC/68D/CMP/09 presented to the International Whaling Commission's Scientific Committee*.
- Mate, B. R., Ilyashenko, V. Y., Bradford, A. L., Vertyankin, V. V., Tsidulko, G. A., Rozhnov, V. V., & Irvine, L. M. (2015). Critically endangered western gray whales migrate to the eastern North Pacific. *Biology letters* 11(4):20150071.
- Mate, B. R., Stafford, K. M., & Ljungblad, D. K. (1994). A change in sperm whale (*Physeter macrocephalus*) distribution correlated to seismic surveys in the Gulf of Mexico. *Journal of the Acoustic Society of America* 96(5 part 2):3268–3269.

- Maybaum, H. L. (1990). Effects of 3.3 kHz sonar system on humpback whales, *Megaptera novaeangliae*, in Hawaiian waters. *EOS Transactions of the American Geophysical Union* 71(2):92.
- McCall Howard, M. P. (1999a). Sperm whales *Physeter macrocephalus* in the Gully, Nova Scotia: Population, distribution, and response to seismic surveying. Dalhousie University, Halifax, Nova Scotia.
- McCall Howard, M. P. (1999b). Sperm whales, *Physeter macrocephalus*, in the Gully, Nova Scotia: Population, distribution, and response to seismic surveying. Dalhousie University, Halifax, Nova Scotia.
- McCauley, R. & Jenner, C. (2010). Migratory patterns and estimated population size of pygmy blue whales (*Balaenoptera musculus brevicauda*) traversing the Western Australian coast based on passive acoustics. *IWC SC/62/SH26*.
- McCauley, R. D., Day, R. D., Swadling, K. M., Fitzgibbon, Q. P., Watson, R. A., & Semmens, J. M. (2017). Widely used marine seismic survey air gun operations negatively impact zooplankton. *Nature Ecology and Evolution* 1(7):195. <https://doi.org/10.1038/s41559-017-0195>
- McCauley, R. D., Fewtrell, J., Duncan, A. J., Jenner, C., Jenner, M.-N., Penrose, J. D., Prince, R. I. T., Adhitya, A., Murdoch, J., & McCabe, K. (2000a). Marine seismic surveys: analysis and propagation of air-gun signals; and effects of air-gun exposure on humpback whales, sea turtles, fishes and squid. *Prepared for the Australian Petroleum Production Exploration Association by the Centre for Marine Science and Technology, Project CMST 163, Report R99-15. 203p*.
- McCauley, R. D., Fewtrell, J., Duncan, A. J., Jenner, C., Jenner, M.-N., Penrose, J. D., Prince, R. I. T., Adhitya, A., Murdoch, J., & McCabe, K. (2000b). Marine seismic surveys - a study of environmental implications. *Australian Petroleum Production & Exploration Association (APPEA) Journal* 40:692-708.
- McCauley, R. D., Fewtrell, J., & Popper, A. N. (2003). High intensity anthropogenic sound damages fish ears. *Journal of the Acoustical Society of America* 113:5.
- McCauley, R. D., Jenner, M.-N., Jenner, C., McCabe, K. A., & Murdoch, J. (1998). The response of humpback whales (*Megaptera novaeangliae*) to offshore seismic survey noise: preliminary results of observations about a working seismic vessel and experimental exposures. *APPEA Journal* 38:692-707.
- McDonald, M. A., Calambokidis, J., Teranishi, A. M., & Hildebrand, J. A. (2001). The acoustic calls of blue whales off California with gender data. *Journal of the Acoustical Society of America* 109(4):1728–1735.
- McDonald, M. A., Hildebrand, J. A., & Mesnick, S. (2009). Worldwide decline in tonal frequencies of blue whale songs. *Endangered Species Research* 9:13-21.
- McDonald, M. A., Hildebrand, J. A., Webb, S., Dorman, L., & Fox, C. G. (1993). Vocalizations of blue and fin whales during a midocean ridge airgun experiment. *Journal of the Acoustic Society of America* 94(3 part 2):1849.
- McDonald, M. A., Hildebrand, J. A., & Webb, S. C. (1995a). Blue and fin whales observed on a seafloor array in the northeast Pacific. *Journal of the Acoustical Society of America* 98(2 Part 1):712–721.
- McDonald, M. A., Hildebrand, J. A., & Webb, S. C. (1995b). Blue and fin whales observed on a seafloor array in the northeast Pacific. *Journal of the Acoustical Society of America* 98(2 Part 1):712-721.

- McDonald, M. A., Hildebrand, J. A., & Wiggins, S. M. (2006). Increases in deep ocean ambient noise in the Northeast Pacific west of San Nicolas Island, California. *Journal of the Acoustical Society of America* 120(2):711-718.
- McDonald, M. A., Hildebrand, J. A., Wiggins, S. M., Thiele, D., Glasgow, D., & Moore, S. E. (2005). Sei whale sounds recorded in the Antarctic. *Journal of the Acoustical Society of America* 118(6):3941–3945.
- McFarlane, G. A., King, J. R., & Beamish, R. J. (2000). Have there been recent changes in climate? Ask the fish. *Progress in Oceanography* 47(4-Feb):147-169.
- McKenna, M. F., Ross, D., Wiggins, S. M., & Hildebrand, J. A. (2013). Relationship between container ship underwater noise levels and ship design, operational and oceanographic conditions. *Sci Rep* 3.
- Mearns, A. J. (2001). Long-term contaminant trends and patterns in Puget Sound, the Straits of Juan de Fuca, and the Pacific Coast. in T. Droscher, editor 2001 Puget Sound Research Conference. Puget Sound Action Team, Olympia, Washington.
- Meier, S. K., Yazvenko, S. B., Blokhin, S. A., Wainwright, P., Maminov, M. K., Yakovlev, Y. M., & Newcomer, M. W. (2007). Distribution and abundance of western gray whales off northeastern Sakhalin Island, Russia, 2001-2003. *Environmental Monitoring and Assessment* 134(3-Jan):107-136.
- Mellinger, D. K. & Clark, C. W. (2003). Blue whale (*Balaenoptera musculus*) sounds from the North Atlantic. *Journal of the Acoustical Society of America* 114(2):1108–1119.
- Miksis-Olds, J. L., Harris, D. V., & Heaney, K. D. (2019). Comparison of estimated 20-Hz pulse fin whale source levels from the tropical Pacific and Eastern North Atlantic Oceans to other recorded populations. *The Journal of the Acoustical Society of America* 146(4):2373-2384. <https://doi.org/10.1121/1.5126692>
- Miller, G. W., Elliot, R. E., Koski, W. R., Moulton, V. D., & Richardson, W. J. (1999). Whales. R. W.J., editor. *Marine mammal and acoustical monitoring of Western Geophysical's open-water seismic program in the Alaskan Beaufort Sea, 1998*.
- Miller, G. W., Moulton, V. D., Davis, R. A., Holst, M., Millman, P., MacGillivray, A., & Hannay, D. (2005). Monitoring seismic effects on marine mammals—southeastern Beaufort Sea, 2001-2002. Pages 511-542 in S. L. Armsworthy, P. J. Cranford, & K. Lee, editors. *Offshore Oil and Gas Environmental Effects Monitoring/Approaches and Technologies*. Battelle Press, Columbus, Ohio.
- Miller, P. J. O., Johnson, M. P., & Tyack, P. L. (2004a). Sperm whale behaviour indicates the use of echolocation click buzzes 'creaks' in prey capture. *Proceedings of the Royal Society of London Series B Biological Sciences* 271(1554):2239–2247.
- Miller, P. J. O., Johnson, M. P., & Tyack, P. L. (2004b). Sperm whale behaviour indicates the use of echolocation click buzzes 'creaks' in prey capture. *Proceedings of the Royal Society of London Series B Biological Sciences* 271(1554):2239-2247.
- Miller, P. J. O., M.P.Johnson, P.T.Madsen, N.Biassoni, M.Quero, & P.L.Tyack. (2009). Using at-sea experiments to study the effects of airguns on the foraging behavior of sperm whales in the Gulf of Mexico. *Deep-Sea Research* 56:1168–1181.
- Mizroch, S. A. & Rice, D. W. (2013). Ocean nomads: Distribution and movements of sperm whales in the North Pacific shown by whaling data and Discovery marks. *Marine Mammal Science* 29(2):E136-E165.
- MMC. (2007). *Marine mammals and noise: A sound approach to research and management*. Marine Mammal Commission.

- Moberg, G. P. (2000). Biological response to stress: Implications for animal welfare. Pages 21-  
Jan in G. P. Moberg & J. A. Mench, editors. *The Biology of Animal Stress*. Oxford  
University Press, Oxford, United Kingdom.
- Mohl, B., Wahlberg, M., Madsen, P. T., Heerfordt, A., & Lund, A. (2003a). The monopulsed  
nature of sperm whale clicks. *Journal of the Acoustical Society of America* 114(2):1143-  
1154.
- Mohl, B., Wahlberg, M., Madsen, P. T., Heerfordt, A., & Lund, A. (2003b). The monopulsed  
nature of sperm whale clicks. *Journal of the Acoustical Society of America* 114(2):1143-  
1154.
- Molnar, J. L., Gamboa, R. L., Revenga, C., & Spalding, M. D. (2008). Assessing the global  
threat of invasive species to marine biodiversity. *Frontiers in Ecology and the  
Environment* 6(9):485-492. <https://doi.org/10.1890/070064>
- Moncheva, S. P. & Kamburska, L. T. (2002). Plankton stowaways in the Black Sea - Impacts on  
biodiversity and ecosystem health. Pages 47-51 in Alien marine organisms introduced by  
ships in the Mediterranean and Black seas. CIESM Workshop Monographs, Istanbul,  
Turkey.
- Mongillo, T. M., Holmes, E. E., Noren, D. P., VanBlaricom, G. R., Punt, A. E., O'Neill, S. M.,  
Ylitalo, G. M., Hanson, M. B., & Ross, P. S. (2012). Predicted polybrominated diphenyl  
ether (PBDE) and polychlorinated biphenyl (PCB) accumulation in southern resident  
killer whales. *Marine Ecology Progress Series* 453:263-277.  
<https://doi.org/10.3354/meps09658>
- Mongillo, T. M., Ylitalo, G. M., Rhodes, L. D., O'Neill, S. M., Noren, D. P., & Hanson, M. B.  
(2016). Exposure to a mixture of toxic chemicals: implications for the health of  
endangered southern resident killer whales.
- Monnahan, C. C., Branch, T. A., & Punt, A. E. (2015). Do ship strikes threaten the recovery of  
endangered eastern North Pacific blue whales? *Marine Mammal Science* 31(1):279-297.
- Monnahan, C. C., Branch, T. A., Stafford, K. M., Ivashchenko, Y. V., & Oleson, E. M. (2014).  
Estimating historical eastern North Pacific blue whale catches using spatial calling  
patterns. *PLOS ONE* 9(6):e98974.
- Moore, P. W. B. & Schusterman, R. J. (1987). Audiometric assessment of northern fur seals,  
*Callorhinus ursinus*. *Marine Mammal Science* 3(1):31-53.
- Moore, P. W. B. D. A. P. (1990). Investigations on the control of echolocation pulses in the  
dolphin (*Tursiops truncatus*). Pages 305-316 in J. A. T. R. A. Kastelein, editor. *Sensory  
Abilities of Cetaceans: Laboratory and Field Evidence*. Plenum Press, New York.
- Moore, S. E. & Angliss, R. P. (2006). Overview of planned seismic surveys offshore northern  
Alaska, July-October 2006. in Paper SC/58/E6 presented to IWC Scientific Committee,  
St Kitts and Nevis.
- Moore, S. E., Stafford, K. M., Dahlheim, M. E., Fox, C. G., Braham, H. W., Polovina, J. J., &  
Bain, D. E. (1998). SEASONAL VARIATION IN RECEPTION OF FIN WHALE  
CALLS AT FIVE GEOGRAPHIC AREAS IN THE NORTH PACIFIC. *Marine Mammal  
Science* 14(3):617-627. [https://doi.org/https://doi.org/10.1111/j.1748-  
7692.1998.tb00749.x](https://doi.org/https://doi.org/10.1111/j.1748-7692.1998.tb00749.x)
- Moulton, V. D. & Lawson, J. W. (2002). Seals, 2001. W. J. Richardson, editor. *Marine Mammal  
and Acoustical Monitoring of Western Geco's Open Water Seismic Program in the  
Alaskan Beaufort Sea, 2001*, volume LGL Report TA2564 4. LGL Ltd.

- Moulton, V. D. & Miller, G. W. (2005). Marine mammal monitoring of a seismic survey on the Scotian Slope, 2003. K. Lee, H. Bain, & G. V. Hurley, editors. *Acoustic monitoring and marine mammal surveys in the Gully and outer Scotian Shelf before and during active seismic programs*, volume Environmental Studies Research Funds Report No. 151. Fisheries and Oceans Canada Centre for Offshore Oil and Gas Environmental Research, Dartmouth, Nova Scotia.
- MPI. (2013). *Overview of ecological effects of aquaculture.*, Wellington, New Zealand.
- Mundy, P. R. (2005). *The Gulf of Alaska: Biology and Oceanography*, Alaska Sea Grant College Program, University of Alaska, Fairbanks.
- Mundy, P. R. & Cooney, R. T. (2005). Physical and biological background. Pages 15-23 in P. R. Mundy, editor. *The Gulf of Alaska: Biology and oceanography*. Alaska Sea Grant College Program, University of Alaska, Fairbanks, Alaska.
- Munger, L. M., Wiggins, S. M., Moore, S. E., & Hildebrand, J. A. (2008). North Pacific right whale (*Eubalaena japonica*) seasonal and diel calling patterns from long-term acoustic recordings in the southeastern Bering Sea, 2000–2006. *Marine Mammal Science* 24(4):795-814. <https://doi.org/https://doi.org/10.1111/j.1748-7692.2008.00219.x>
- Nadeem, K., Moore, J. E., Zhang, Y., & Chipman, H. (2016). Integrating population dynamics models and distance sampling data: a spatial hierarchical state-space approach. *Ecology* 97(7):1735-1745.
- Nakamoto, R. J., Kisanuki, T. T., & Goldsmith, G. H. (1995). Age and growth of Klamath River green sturgeon (*Acipenser medirostris*).
- NAS. (2017). *Approaches to Understanding the Cumulative Effects of Stressors on Marine Mammals*. National Academies of Sciences, Engineering, and Medicine. The National Academies Press, Washington, District of Columbia.
- Nations, C. S., Blackwell, S. B., Kim, K. H., Thode, A. M., Charles R. Greene, J., & McDonald, T. L. (2009). Effects of seismic exploration in the Beaufort Sea on bowhead whale call distributions. *Journal of the Acoustical Society of America* 126(4):2230.
- New, L. F., Clark, J. S., Costa, D. P., Fleishman, E., Hindell, M. A., Klanjscek, T., Lusseau, D., Kraus, S., McMahon, C. R., Robinson, P. W., Schick, R. S., Schwarz, L. K., Simmons, S. E., Thomas, L., Tyack, P., & Harwood, J. (2014). Using short-term measures of behaviour to estimate long-term fitness of southern elephant seals. *Marine Ecology Progress Series* 496:99-108.
- Nieukirk, S. L., Mellinger, D. K., Moore, S. E., Klinck, K., Dziak, R. P., & Goslin, J. (2012). Sounds from airguns and fin whales recorded in the mid-Atlantic Ocean, 1999-2009. *J Acoust Soc Am* 131(2):1102-12. <https://doi.org/10.1121/1.3672648>
- Nieukirk, S. L., Stafford, K. M., Mellinger, D. k., Dziak, R. P., & Fox, C. G. (2004). Low-frequency whale and seismic airgun sounds recorded in the mid-Atlantic Ocean *Journal of the Acoustical Society of America* 115:1832-1843.
- NMFS. (2006). *Biological Opinion on the issuance of Section 10(a)(1)(A) permits to conduct scientific research on the southern resident killer whale (*Orcinus orca*) distinct population segment and other endangered or threatened species*. Northwest Regional Office, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, NWR-2006-470, Seattle, Washington.
- NMFS. (2006h). *Biological Opinion on the Funding and Permitting of Seismic Surveys by the National Science Foundation and the National Marine Fisheries Service in the Eastern*

- Tropical Pacific Ocean from March to April 2006. *National Marine Fisheries Service, Silver Spring, Maryland. 76p.*
- NMFS. (2010a). Final recovery plan for the fin whale (*Balaenoptera physalus*).
- NMFS. (2010b). Final recovery plan for the sperm whale (*Physeter macrocephalus*).
- NMFS. (2010c). *Final recovery plan for the sperm whale (Physeter macrocephalus)*. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland.
- NMFS. (2011). Final recovery plan for the Sei whale (*Balaenoptera borealis*).
- NMFS. (2019). *Fin Whale (Balaenoptera physalus) 5-Year Review: Summary and Evaluation*.
- NMFS. (2020). Recovery Plan for the Blue Whale (*Balaenoptera musculus*): first revision.
- NMFS. (2022). RECOVERY OUTLINE FOR THE CENTRAL AMERICA, MEXICO, AND WESTERN NORTH PACIFIC DISTINCT POPULATION SEGMENTS OF HUMPBACK WHALES.
- NMFS. (2024). *Update to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 3.0): Unverwater and In-Air Criteria for Onset of Auditory Injury and Temporary Threshold Shifts*. U.S. Dept. of Commerce, NOAA. NOAA Technical Memorandum NMFS-OPR-71.
- NMFS & USFWS. (2013). Leatherback Sea Turtle (*Dermochelys Coriacea*) 5-Year Review : Summary and Evaluation.
- Noda, K., Akiyoshi, H., Aoki, M., Shimada, T., & Ohashi, F. (2007). Relationship between transportation stress and polymorphonuclear cell functions of bottlenose dolphins, *Tursiops truncatus*. *Journal of Veterinary Medical Science* 69(4):379-383.
- Noren, D. P., Johnson, A. H., Rehder, D., & Larson, A. (2009). Close approaches by vessels elicit surface active behaviors by southern resident killer whales. *Endangered Species Research* 8(3):179–192.
- Norris, T., DeRango, G., DiGiovanni, R., & Field, C. (2015). Distribution of and threats to Guadalupe fur seals off the California coast. *in*. Poster session at the 21st Biennial Conference of the Society of Marine ...
- Norris, T. & Elorriaga-Verplancken, F. (2019). Guadalupe fur seal population census and tagging in support of marine mammal monitoring across multiple navy training areas in the Pacific Ocean. *The Marine Mammal Center and National Polytechnic Institution, Interdisciplinary Center of Marine Science*.
- Norris, T., Fauquier, D., Field, C., Whoriskey, S., Gálvez, C., Rowles, T., Viezbicke, J., & Elorriaga-Verplancken, F. (2017). At-sea distribution and habitat use of free-ranging and rehabilitated Guadalupe fur seals. *in* Poster presented at the 6th International Biologging Science Symposium, Konstanz, Germany.
- Norse, E. A., Crowder, L. B., Gjerde, K., Hyrenbach, D., Roberts, C. M., Safina, C., & Soule, M. E. (2005). Place-based ecosystem management in the open ocean. Pages 302-327 *in* L. B. E. A. C. Norse, editor. *Marine Conservation Biology: The Science of Maintaining the Sea's Biodiversity*. Island Press, Washington, D. C.
- Nowacek, D. P., Bröker, K., Donovan, G., Gailey, G., Racca, R., Reeves, R. R., Vedenev, A. I., Weller, D. W., & Southall, B. L. (2013). Responsible practices for minimizing and monitoring environmental impacts of marine seismic surveys with an emphasis on marine mammals. *Aquatic Mammals* 39(4):356.
- Nowacek, D. P., Clark, C. W., Mann, D., Miller, P. J. O., Rosenbaum, H. C., Golden, J. S., Jasny, M., Kraska, J., & Southall, B. L. (2015). Marine seismic surveys and ocean noise:

- Time for coordinated and prudent planning. *Frontiers in Ecology and the Environment* 13(7):378-386. <https://doi.org/10.1890/130286>
- Nowacek, D. P., Thorne, L. H., Johnston, D. W., & Tyack, P. L. (2007). Responses of cetaceans to anthropogenic noise. *Mammal Review* 37(2):81-115.
- Nowacek, S. M. W., R. S.; Solow, A. R. (2001). Short-term effects of boat traffic on bottlenose dolphins, *Tursiops truncatus*, in Sarasota Bay, Florida. *Marine Mammal Science* 17(4):673-688.
- NRC. (2003a). *National Research Council: Ocean noise and marine mammals.*, National Academies Press, Washington, D.C.
- NRC. (2003b). *Ocean Noise and Marine Mammals*. National Research Council of the National Academies of Science. The National Academies Press, Washington, District of Columbia.
- NRC. (2003c). *Ocean Noise and Marine Mammals*, National Academy Press, Washington, D.C.
- NRC. (2005). *Marine mammal populations and ocean noise. Determining when noise causes biologically significant effects*. National Academy of Sciences, Washington, D. C.
- NRC. (2008). *Tackling marine debris in the 21st Century*. National Research Council of the National Academies of Science. The National Academies Press, Washington, District of Columbia.
- O'Connor, S., Campbell, R., Cortez, H., & Knowles, T. (2009). *Whale Watching Worldwide: Tourism numbers, expenditures and expanding economic benefits, a special report from the International Fund for Animal Welfare*. International Fund for Animal Welfare, Yarmouth, Massachusetts.
- Ohsumi, S. & Wada, S. (1974). *Status of whale stocks in the North Pacific, 1972*. Appendix IV Annex N (SC/25/11), International Whaling Commission.
- Ortega-Ortiz, C. D., Vargas-Bravo, M. H., Olivos-Ortiz, A., Zapata, M. G. V., & Elorriaga-Verplancken, F. R. (2019). Short note guadalupe fur seal encounters in the mexican central pacific. *Aquatic Mammals* 45(2):244-252.
- Palka, D., Chavez-Rosales, S., Josephson, E., Cholewiak, D., Haas, H., Garrison, L., & Orphanides, C. (2017). Atlantic Marine Assessment Program for Protected Species: 2010–2014 US Dept. of the Interior, Bureau of Ocean Energy Management, Atlantic OCS Region, Washington, DC. OCS Study BOEM 2017-071. *in*.
- Panti, C., Bains, M., Lusher, A., Hernandez-Milan, G., Bravo Rebolledo, E. L., Unger, B., Syberg, K., Simmonds, M. P., & Fossi, M. C. (2019). Marine litter: One of the major threats for marine mammals. Outcomes from the European Cetacean Society workshop. *Environmental Pollution* 247:72-79. <https://doi.org/10.1016/j.envpol.2019.01.029>
- Parente, C. L., Araujo, J. P., & Araujo, M. E. (2007). Diversity of cetaceans as tool in monitoring environmental impacts of seismic surveys. *Biota Neotropica* 7(1).
- Parks, S. E. (2003). Response of North Atlantic right whales (*Eubalaena glacialis*) to playback of calls recorded from surface active groups in both the North and South Atlantic. *Marine Mammal Science* 19(3):563-580.
- Parks, S. E. (2009a). *Assessment of acoustic adaptations for noise compensation in marine mammals*. Office of Naval Research.
- Parks, S. E. (2009b). *Assessment of acoustic adaptations for noise compensation in marine mammals*. Office of Naval Research, Award Number: N00014-08-1-0967.

- Parks, S. E., Clark, C. W., & Tyack, P. L. (2007). Short- and long-term changes in right whale calling behavior: The potential effects of noise on acoustic communication. *Journal of the Acoustical Society of America* 122(6):3725-3731.
- Parks, S. E. C. W. C. P. L. T. (2007). Short- and long-term changes in right whale calling behavior: The potential effects of noise on acoustic communication. *Journal of the Acoustical Society of America* 122(6):3725-3731.
- Parry, G. D., Heislors, S., Werner, G. F., Asplin, M. D., & Gason, A. (2002). *Assessment of environmental effects of seismic testing on scallop fisheries in Bass Strait*. Marine and Fresh-water Resources Institute, Report No. 50.
- Parsons, E. C. M. (2012). The Negative Impacts of Whale-Watching. *Journal of Marine Biology* 2012:1-9. <https://doi.org/10.1155/2012/807294>
- Patenaude, N. J., Richardson, W. J., Smultea, M. A., Koski, W. R., Miller, G. W., Wursig, B., & Greene, C. R. (2002). Aircraft sound and disturbance to bowhead and beluga whales during spring migration in the Alaskan Beaufort Sea. *Marine Mammal Science* 18(2):309-335.
- Pavan, G., Hayward, T. J., Borsani, J. F., Priano, M., Manghi, M., Fossati, C., & Gordon, J. (2000a). Time patterns of sperm whale codas recorded in the Mediterranean Sea 1985-1996. *Journal of the Acoustical Society of America* 107(6):3487-3495.
- Pavan, G., Hayward, T. J., Borsani, J. F., Priano, M., Manghi, M., Fossati, C., & Gordon, J. (2000b). Time patterns of sperm whale codas recorded in the Mediterranean Sea 1985-1996. *Journal of the Acoustical Society of America* 107(6):3487-3495.
- Payne, J. F. J. C. D. W. (2009). *Potential effects of seismic airgun discharges on monkfish eggs (Lophius americanus) and larvae.*, St. John's, Newfoundland.
- Payne, K. (1985). Singing in humpback whales. *Whalewatcher* 19(1):3-6.
- Payne, R. S. & McVay, S. (1971). Songs of humpback whales. Humpbacks emit sounds in long, predictable patterns ranging over frequencies audible to humans. *Science* 173(3997):585-597.
- Pearson, W. H., Skalski, J. R., & Malme, C. I. (1992). Effects of sounds from a geophysical survey device on behavior of captive rockfish (*Sebastes* spp.). *Canadian Journal of Fisheries and Aquatic Sciences* 49:1343-1356.
- Pecl, G. T. & Jackson, G. D. (2008). The potential impacts of climate change on inshore squid: Biology, ecology and fisheries. *Reviews in Fish Biology and Fisheries* 18:373-385.
- Peterson, R. S., Hubbs, C. L., Gentry, R. L., & Delong, R. L. (1968). The Guadalupe fur seal: Habitat, behavior, population size and field identification. *Journal of Mammalogy* 49(4):665-675.
- Phillips, A. J., Ralston, S., Brodeur, R. D., Auth, T. D., Emmett, R. L., Johnson, C., & Weststad, V. G. (2007). Recent pre-recruit Pacific hake (*Merluccius productus*) occurrences in the northern California current suggest a northward expansion of their spawning area. *CalCOFI Reports* 48:215-229.
- Pierson, M. O. (1978). A study of the population dynamics and breeding behavior of the Guadalupe fur seal, (*Arctocephalus townsendi*). University of California, Santa Cruz.
- Pierson, M. O., Wagner, J. P., Langford, V., Birnie, P., & Tasker, M. L. (1998). Protection from, and mitigation of, the potential effects of seismic exploration on marine mammals. Pages 23-25 in *Seismic and Marine Mammals Workshop*, London.

- Pirotta, V., Grech, A., Jonsen, I. D., Laurance, W. F., & Harcourt, R. G. (2019). Consequences of global shipping traffic for marine giants. *Frontiers in Ecology and the Environment* 17(1):39-46. <https://doi.org/10.1002/fee.1987>
- Popper, A., Hawkins, A., Fay, R., Mann, D., Bartol, S., Carlson, T., Coombs, S., Ellison, W., Gentry, R., Halvorsen, M., Lokkeborg, S., Rogers, P. H., Southall, B. L., Zeddies, B. G., & Tavalga, W. N. (2014). Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI.
- Popper, A. N., M. E. Smith, P. A. Cott, B. W. Hanna, A. O. Macgillivray, M. E. Austin, & Mann, D. A. (2005). Effects of exposure to seismic airgun use on hearing of three fish species. *Journal of the Acoustical Society of America* 117(6):3958-3971.
- Potter, J. R., Thillet, M., Douglas, C., Chitre, M. A., Doborzynski, Z., & Seekings, P. J. (2007). Visual and Passive Acoustic Marine Mammal Observations and High-Frequency Seismic Source Characteristics Recorded During a Seismic Survey. *IEEE Journal of Oceanic Engineering* 32(2):469-483. <https://doi.org/10.1109/joe.2006.880427>
- Price, C. S., Keane, E., Morin, D., Vaccaro, C., Bean, D., & Morris, J. A. (2017). *Protected Species Marine Aquaculture Interactions*. NOAA Technical Memorandum NOS NCCOS 211.
- Price, C. S. & Morris, J. A. (2013). Marine cage culture and the environment: Twenty-first century science informing a sustainable industry.
- Pughiuc, D. (2010). Invasive species: Ballast water battles. *Seaways*.
- Raaymakers, S. (2003). The GEF/UNDP/IMO global ballast water management programme integrating science, shipping and society to save our seas. *Proceedings of the Institute of Marine Engineering, Science and Technology Part B: Journal of Design and Operations* (B4):2-10.
- Raaymakers, S. & Hilliard, R. (2002). Harmful aquatic organisms in ships' ballast water - Ballast water risk assessment. Pages 103-110 in *Alien marine organisms introduced by ships in the Mediterranean and Black seas*. CIESM Workshop Monographs, Istanbul, Turkey.
- Ramp, C. & Sears, R. (2013). *Distribution, densities, and annual occurrence of individual blue whales (Balaenoptera musculus) in the Gulf of St. Lawrence, Canada from 1980-2008*, Fisheries and Oceans Canada, Science.
- Redfern, J. V. M. F. M. T. J. M. J. C. M. L. D. E. A. B. J. B. K. A. (2013). Assessing the risk of ships striking large whales in marine spatial planning. *Conservation Biology* 27(2):292-302.
- Reep, R. L., Joseph C. Gaspard, I., Sarko, D., Rice, F. L., Mann, D. A., & Bauer, G. B. (2011). Manatee vibrissae: Evidence for a lateral line function. *Annals of the New York Academy of Sciences* 1225(1):101-109.
- Reichmuth, C., Ghoul, A., Sills, J. M., Rouse, A., & Southall, B. L. (2016). Low-frequency temporary threshold shift not observed in spotted or ringed seals exposed to single air gun impulses). *The Journal of the Acoustical Society of America* 140(4):2646-2658. <https://doi.org/10.1121/1.4964470>
- Reichmuth, C., Sills, J. M., Mulsow, J., & Ghoul, A. (2019). Long-term evidence of noise-induced permanent threshold shift in a harbor seal (*Phoca vitulina*). *The Journal of the Acoustical Society of America* 146(4):2552-2561.
- Rendell, L. & Whitehead, H. (2004a). Do sperm whales share coda vocalizations? Insights into coda usage from acoustic size measurement. *Animal Behaviour* 67(5):865-874.

- Rendell, L. & Whitehead, H. (2004b). Do sperm whales share coda vocalizations? Insights into coda usage from acoustic size measurement. *Animal Behaviour* 67(5):865–874.
- Rexstad, E. A. & Pikitch, E. K. (1986). Stomach contents and food consumption estimates of Pacific hake, *Merluccius productus*. *Fishery Bulletin* 84(4).
- Richardson, W. J. (1995). Marine mammal hearing. Pages 205-240 in C. R. W. J. G. J. Richardson, C. I. Malme, & D. H. Thomson, editors. *Marine Mammals and Noise*. Academic Press, San Diego, California.
- Richardson, W. J., Greene, C. R., Malme, C. I., & Thomson, D. H. (1995a). *Marine Mammals and Noise*, Academic Press, Inc., San Diego, California.
- Richardson, W. J., Greene, C. R. J., Malme, C. I., & Thomson, D. H. (1995b). *Marine Mammals and Noise*, Academic Press, Inc., San Diego, California.
- Richardson, W. J., Miller, G. W., & Greene, C. R. J. (1999). Displacement of migrating bowhead whales by sounds from seismic surveys in shallow waters of the Beaufort Sea. *Journal of the Acoustical Society of America* 106(4-2):2281.
- Richardson, W. J., Würsig, B., & Greene, C. R., Jr. (1986a). Reactions of bowhead whales, *Balaena mysticetus*, to seismic exploration in the Canadian Beaufort Sea. *Journal of the Acoustical Society of America* 79(4):1117-1128.
- Richardson, W. J., Würsig, B., & Greene, C. R. J. (1986b). Reactions of bowhead whales, *Balaena mysticetus*, to seismic exploration in the Canadian Beaufort Sea. *Journal of the Acoustical Society of America* 79(4):1117-1128.
- Richter, C. F., Dawson, S. M., & Slooten, E. (2003). Sperm whale watching off Kaikoura, New Zealand: Effects of current activities on surfacing and vocalisation patterns. *Science for Conservation* 219.
- Robertson, F. C., Koski, W. R., Thomas, T. A., Richardson, W. J., Würsig, B., & Trites, A. W. (2013). Seismic operations have variable effects on dive-cycle behavior of bowhead whales in the Beaufort Sea. *Endangered Species Research* 21(2):143-160.
- Rockwood, R. C., Adams, J. D., Hastings, S., Morten, J., & Jahncke, J. (2021). Modeling whale deaths from vessel strikes to reduce the risk of fatality to endangered whales. *Frontiers in Marine Science* 8:649890.
- Rockwood, R. C., Calambokidis, J., & Jahncke, J. (2017). High mortality of blue, humpback and fin whales from modeling of vessel collisions on the U.S. West Coast suggests population impacts and insufficient protection. *PLoS One* 12(8):e0183052.  
<https://doi.org/10.1371/journal.pone.0183052>
- Roemmich, D. & McGowan, J. (1995). Climate warming and the decline of zooplankton in the California Current. *Science* 267:1324-1326.
- Rolland, R. M., Parks, S. E., Hunt, K. E., Castellote, M., Corkeron, P. J., Nowacek, D. P., Wasser, S. K., & Kraus, S. D. (2012a). Evidence that ship noise increases stress in right whales. *Proceedings of the Royal Society of London Series B Biological Sciences* 279(1737):2363-2368.
- Rolland, R. M., Parks, S. E., Hunt, K. E., Castellote, M., Corkeron, P. J., Nowacek, D. P., Wasser, S. K., & Kraus, S. D. (2012b). Evidence that ship noise increases stress in right whales. *Proc Biol Sci* 279(1737):2363-8. <https://doi.org/10.1098/rspb.2011.2429>
- Romanenko, E. V. & Kitain, V. Y. (1992). The functioning of the echolocation system of *Tursiops truncatus* during noise masking. Pages 415-419 in J. A. Thomas, R. A. Kastelein, & A. Y. Supin, editors. *Marine Mammal Sensory Systems*. Plenum Press, New York.

- Romanenko, E. V. V. Y. K. (1992). The functioning of the echolocation system of *Tursiops truncatus* during noise masking. Pages 415-419 in J. A. T. R. A. K. A. Y. Supin, editor. *Marine Mammal Sensory Systems*. Plenum Press, New York.
- Romano, T. A., Felten, D. L., Stevens, S. Y., Olschowka, J. A., Quaranta, V., & Ridgway, S. H. (2002). Immune response, stress, and environment: Implications for cetaceans. Pages 253-279 in *Molecular and Cell Biology of Marine Mammals*. Krieger Publishing Co., Malabar, Florida.
- Romano, T. A., Keogh, M. J., Kelly, C., Feng, P., Berk, L., Schlundt, C. R., Carder, D. A., & Finneran, J. J. (2004). Anthropogenic sound and marine mammal health: Measures of the nervous and immune systems before and after intense sound exposure. *Canadian Journal of Fisheries and Aquatic Sciences* 61:1124-1134.
- Romero, L. M., Meister, C. J., Cyr, N. E., Kenagy, G. J., & Wingfield, J. C. (2008). Seasonal glucocorticoid responses to capture in wild free-living mammals. *American Journal of Physiology-Regulatory Integrative and Comparative Physiology* 294(2):R614-R622. <https://doi.org/10.1152/ajpregu.00752.2007>
- Rone, B. K., Zerbini, A. N., Douglas, A. B., Weller, D. W., & Clapham, P. J. (2017). Abundance and distribution of cetaceans in the Gulf of Alaska. *Marine Biology* 164(1):23.
- Roni, P., Weitkamp, L. A., & Scordino, J. (1999). Identification of essential fish habitat for salmon in the Pacific Northwest: initial efforts, information needs, and future direction. *Fish habitat: essential fish habitat and rehabilitation*. American Fisheries Society, Bethesda, Maryland, USA:93-107.
- Ross, D. (1976). *Mechanics of Underwater Noise*, Pergamon Press, New York.
- Ross, D. (1993). On ocean underwater ambient noise. *Acoustics Bulletin* 18:8-May.
- Ross, D. (2005). Ship Sources of Ambient Noise. *IEEE Journal of Oceanic Engineering* 30(2):257-261. <https://doi.org/10.1109/joe.2005.850879>
- Ross, P. S. (2002). The role of immunotoxic environmental contaminants in facilitating the emergence of infectious diseases in marine mammals. *Human and Ecological Risk Assessment* 8(2):277-292.
- Royer, T. C. (2005). Hydrographic responses at a coastal site in the northern Gulf of Alaska to seasonal and interannual forcing. *Deep-Sea Research Part II-Topical Studies in Oceanography* 52(1-2):267-288. <https://doi.org/10.1016/j.dsr2.2004.09.022>
- RPS. (2022a). *Protected species mitigation and monitoring report: Survey 01, Marine Geophysical (Seismic) Survey, North Pacific Ocean, Cascadia Subduction Zone, R/V Marcus G. Langseth*. Rep. from RPS, Houston, TX, for Lamont-Doherty Earth Observatory of Columbia University, Palisades, NY. 110 p.
- RPS. (2022b). *Protected species mitigation and monitoring report: Survey 02, Marine Geophysical (Seismic) Survey, North Pacific Ocean, Canales ROV, R/V Marcus G. Langseth*. Rep. from RPS, Houston, TX, for Lamont-Doherty Earth Observatory of Columbia University, Palisades, NY. 43 p. .
- RPS. (2023). *Protected Species Mitigation and Monitoring Report. Marine Geophysical (Seismic) Survey and Heat Flow Survey, North Pacific Ocean, R/V Marcus G. Langseth*, Rep from RPS. Houston, TX, for Lamont-Doherty Earth Observatory of Columbia University, Palisades, N.Y. 33 p.

- Samaran, F., Guinet, C., Adam, O., Motsch, J.-F., & Cansi, Y. (2010). Source level estimation of two blue whale subspecies in southwestern Indian Ocean. *The Journal of the Acoustical Society of America* 127(6):3800-3808. <https://doi.org/10.1121/1.3409479>
- Samuels, A., Bejder, L., & Heinrich, S. (2000). *A review of the literature pertaining to swimming with wild dolphins*. Final report to the Marine Mammal Commission. Contract No. T74463123. 58pp.
- Santora, J. A., Mantua, N. J., Schroeder, I. D., Field, J. C., Hazen, E. L., Bograd, S. J., Sydeman, W. J., Wells, B. K., Calambokidis, J., Saez, L., Lawson, D., & Forney, K. A. (2020). Habitat compression and ecosystem shifts as potential links between marine heatwave and record whale entanglements. *Nature Communications* 11(1):536. <https://doi.org/10.1038/s41467-019-14215-w>
- Santulli, A., Modica, A., Messina, C., Curatolo, L. C. A., Rivas, G., Fabi, G., & D'Amelio, V. (1999). Biochemical responses of European sea bass (*Dicentrarchus labrax* L.) to the stress induced by offshore experimental seismic prospecting. *Marine Pollution Bulletin* 38(12):1105-1114.
- Sato, C. L. (2017a). Periodic Status Review for the Leatherback Sea Turtle.
- Sato, C. L. (2017b). Periodic Status Reviews for Green and Loggerhead Sea Turtles.
- Scheidat, M., Castro, C., Gonzalez, J., & Williams, R. (2004). Behavioural responses of humpback whales (*Megaptera novaeangliae*) to whalewatching boats near Isla de la Plata, Machalilla National Park, Ecuador. *Journal of Cetacean Research and Management* 6(1):63-68.
- Schmitt, T. L., St. Leger, J., Inglis, B. A., Michal, I., Stedman, N., Nollens, H. H., Dennison-Gibby, S., Herrick, K., Clarke, E. O., Mena, A., & Cook, P. F. (2023). Twenty Years of Managed Epilepsy for a Stranded Male Guadalupe Fur Seal (*Arctocephalus townsendi*) Secondary to Suspect Domoic Acid Toxicosis. *Journal of Zoological and Botanical Gardens* 4(4):665-679.
- Seminoff, J. A., Allen, C. D., Balazs, G. H., Dutton, P. H., Eguchi, T., Haas, H., Hargrove, S. A., Jensen, M., Klemm, D. L., Lauritsen, A. M., MacPherson, S. L., Opay, P., Possardt, E. E., Pultz, S., Seney, E. E., Van Houtan, K. S., & Waples, R. S. (2015). Status review of the green turtle (*Chelonia mydas*) under the Endangered Species Act.
- Silber, G. K. (1986). The relationship of social vocalizations to surface behavior and aggression in the Hawaiian humpback whale (*Megaptera novaeangliae*). *Canadian Journal of Zoology* 64(10):2075-2080.
- Sills, J. M., Ruscher, B., Nichols, R., Southall, B. L., & Reichmuth, C. (2020). Evaluating temporary threshold shift onset levels for impulsive noise in seals. *The Journal of the Acoustical Society of America* 148(5):2973-2986. <https://doi.org/10.1121/10.0002649>
- Simmonds, M. P. (2005). *Whale watching and monitoring: some considerations*. Unpublished paper submitted to the Scientific Committee of the International Whaling Commission SC/57/WW5, Cambridge, United Kingdom.
- Simmonds, M. P. & Elliott, W. J. (2009). Climate change and cetaceans: Concerns and recent developments. *Journal of the Marine Biological Association of the United Kingdom* 89(1):203-210.
- Širović, A., Hildebrand, J. A., & Wiggins, S. M. (2007). Blue and fin whale call source levels and propagation range in the Southern Ocean. *The Journal of the Acoustical Society of America* 122(2):1208-1215. <https://doi.org/10.1121/1.2749452>

- Širović, A., Johnson, S. C., Roche, L. K., Varga, L. M., Wiggins, S. M., & Hildebrand, J. A. (2015). North Pacific right whales (*Eubalaena japonica*) recorded in the northeastern Pacific Ocean in 2013. *Marine Mammal Science* 31(2):800-807. <https://doi.org/https://doi.org/10.1111/mms.12189>
- Skalski, J. R. P., W. H.; Malme, C. I. (1992). Effects of sounds from a geophysical survey device on catch-per-unit-effort in a hook-and-line fishery for rockfish (*Sebastes* spp.). *Canadian Journal of Fisheries and Aquatic Sciences* 49:1357-1365.
- Slotte, A., Hansen, K., Dalen, J., & Ona, E. (2004). Acoustic mapping of pelagic fish distribution and abundance in relation to a seismic shooting area off the Norwegian west coast. *Fisheries Research* 67:143-150.
- Smultea, M. A., Holst, M., Koski, W. R., & Stoltz, S. (2004). Marine mammal monitoring during Lamont-Doherty Earth Observatory's seismic program in the Southeast Caribbean Sea and adjacent Atlantic Ocean, April–June 2004. *LGL Rep. TA2822-26. Report from LGL Ltd., King City, Ontario, for Lamont-Doherty Earth Observatory of Columbia Univ., Palisades, NY, and National Marine Fisheries Service, Silver Spring, MD. 106 p.*
- Smultea, M. A., Mobley, J. J. R., Fertl, D., & Fulling, G. L. (2008a). An unusual reaction and other observations of sperm whales near fixed-wing aircraft. *Gulf and Caribbean Research* 20:75–80.
- Smultea, M. A., Mobley, J. R., Fertl, D., & Fulling, G. L. (2008b). An unusual reaction and other observations of sperm whales near fixed-wing aircraft. *Gulf and Caribbean Research* 20:75-80.
- Soule, D. C. & Wilcock, W. S. D. (2013). Fin whale tracks recorded by a seismic network on the Juan de Fuca Ridge, Northeast Pacific Ocean. *The Journal of the Acoustical Society of America* 133(3):1751-1761. <https://doi.org/10.1121/1.4774275>
- Southall, B. L., Bowles, A. E., Ellison, W. T., Finneran, J. J., Gentry, R. L., Greene, C. R., Jr., Kastak, D., Ketten, D. R., Miller, J. H., Nachtigall, P. E., Richardson, W. J., Thomas, J. A., & Tyack, P. L. (2007a). Marine mammal noise exposure criteria: initial scientific recommendations. *Aquatic Mammals* 33(4):411-521.
- Southall, B. L., Bowles, A. E., Ellison, W. T., Finneran, J. J., Gentry, R. L., Greene Jr, C. R., Kastak, D., Ketten, D. R., Miller, J. H., & Nachtigall, P. E. (2007b). Structure of the noise exposure criteria. *Aquatic Mammals* 33(4):427.
- Southall, B. L., Bowles, A. E., Ellison, W. T., Finneran, J. J., Gentry, R. L., Greene Jr., C. R., Kastak, D., Ketten, D. R., Miller, J. H., Nachtigall, P. E., Richardson, W. J., Thomas, J. A., & Tyack, P. L. (2007c). Marine mammal noise exposure criteria: Initial scientific recommendations. *Aquatic Mammals* 33(4):411-521.
- Southall, B. L., Finneran, J. J., Reichmuth, C., Nachtigall, P. E., Ketten, D. R., Bowles, A. E., Ellison, W. T., Nowacek, D. P., & Tyack, P. L. (2019). Marine mammal noise exposure criteria: updated scientific recommendations for residual hearing effects. *Aquatic Mammals* 45(2):125-232.
- Southall, B. L., Nowacek, D. P., Miller, P. J. O., & Tyack, P. L. (2016). Experimental field studies to measure behavioral responses of cetaceans to sonar. *Endangered Species Research* 31:293-315. <https://doi.org/10.3354/esr00764>
- St. Aubin, D. J. & Geraci, J. R. (1988). Capture and handling stress suppresses circulating levels of thyroxine (T4) and triiodothyronine (T3) in beluga whale, *Delphinapterus leucas*. *Physiological Zoology* 61(2):170-175.

- St. Aubin, D. J., Ridgway, S. H., Wells, R. S., & Rhinehart, H. (1996). Dolphin thyroid and adrenal hormones: Circulating levels in wild and semidomesticated *Tursiops truncatus*, and influence of sex, age, and season. *Marine Mammal Science* 12(1):13-Jan.
- Stabeno, P. J., Bond, N. A., Hermann, A. J., Kachel, N. B., Mordy, C. W., & Overland, J. E. (2004). Meteorology and oceanography of the northern Gulf of Alaska. *Continental Shelf Research* 24-Jan(8-Jul):859-897.
- Stafford, K. M., Nieukirk, S. L., & Cox, C. G. (2001). Geographic and seasonal variation of blue whale calls in the North Pacific. *J. Cetacean Res. Manage.* 3(1):65-76.
- Stone, C. J. (2003). *The effects of seismic activity on marine mammals in UK waters 1998-2000*. Joint Nature Conservation Committee, Aberdeen, Scotland.
- Stone, C. J., Hall, K., Mendes, S., & Tasker, M. L. (2017). The effects of seismic operations in UK waters: analysis of Marine Mammal Observer data. *Journal of Cetacean Research and Management* 16:71–85.
- Stone, C. J. & Tasker, M. L. (2006). The effects of seismic airguns on cetaceans in UK waters. *Journal of Cetacean Research and Management* 8(3):255-263.
- Strayer, D. L. (2010). Alien species in fresh waters: Ecological effects, interactions with other stressors, and prospects for the future. *Freshwater Biology* 55:152-174.  
<https://doi.org/DOI> 10.1111/j.1365-2427.2009.02380.x
- Suryan, R. M., Arimitsu, M. L., Coletti, H. A., Hopcroft, R. R., Lindeberg, M. R., Barbeaux, S. J., Batten, S. D., Burt, W. J., Bishop, M. A., Bodkin, J. L., Brenner, R., Campbell, R. W., Cushing, D. A., Danielson, S. L., Dorn, M. W., Drummond, B., Esler, D., Gelatt, T., Hanselman, D. H., Hatch, S. A., Haught, S., Holderied, K., Iken, K., Irons, D. B., Kettle, A. B., Kimmel, D. G., Konar, B., Kuletz, K. J., Laurel, B. J., Maniscalco, J. M., Matkin, C., McKinstry, C. A. E., Monson, D. H., Moran, J. R., Olsen, D., Palsson, W. A., Pegau, W. S., Piatt, J. F., Rogers, L. A., Rojek, N. A., Schaefer, A., Spies, I. B., Straley, J. M., Strom, S. L., Sweeney, K. L., Szymkowiak, M., Weitzman, B. P., Yasumiishi, E. M., & Zador, S. G. (2021). Ecosystem response persists after a prolonged marine heatwave. *Scientific Reports* 11(1):6235. <https://doi.org/10.1038/s41598-021-83818-5>
- Swingle, W. M., Barco, S. G., Pitchford, T. D., McLellan, W. A., & Pabst, D. A. (1993). Appearance of juvenile humpback whales feeding in the nearshore waters of Virginia. *Marine Mammal Science* 9(3):309-315.
- Szescioroka, A. R., Allen, A. N., Calambokidis, J., Fahlbusch, J., McKenna, M. F., & Southall, B. (2019). A Case Study of a Near Vessel Strike of a Blue Whale: Perceptual Cues and Fine-Scale Aspects of Behavioral Avoidance. *Frontiers in Marine Science* 6(761).  
<https://doi.org/10.3389/fmars.2019.00761>
- Tal, D., Shachar-Bener, H., Hershkovitz, D., Arieli, Y., & Shupak, A. (2015). Evidence for the initiation of decompression sickness by exposure to intense underwater sound. *Journal of Neurophysiology* 114(3):1521-1529.
- Taylor, B., Barlow, J., Pitman, R., Ballance, L., Klinger, T., Demaster, D., Hildebrand, J., Urban, J., Palacios, D., & Mead, J. (2004). *A call for research to assess risk of acoustic impact on beaked whale populations*. International Whaling Commission Scientific Committee.
- Taylor, B. L., Martien, K. K., Archer, F. I., Audley, K., Calambokidis, J., Cheeseman, T., De Weerd, J., Frisch Jordán, A., Martínez-Loustalot, P., Ortega-Ortiz, C. D., Patterson, E. M., Ransome, N., Ruvelas, P., & Urbán Ramírez, J. (2021). Evaluation of humpback whales wintering in Central America and southern Mexico as a demographically independent population. <https://doi.org/https://doi.org/10.25923/sgek-1937>

- Terdalkar, S., Kulkarni, A. S., Kumbhar, S. N., & Matheickal, J. (2005). Bio-economic risks of ballast water carried in ships, with special reference to harmful algal blooms. *Nature, Environment and Pollution Technology* 4(1):43-47.
- Terhune, J. M. (1999). Pitch separation as a possible jamming-avoidance mechanism in underwater calls of bearded seals (*Erignathus barbatus*). *Canadian Journal of Zoology* 77(7):1025-1034.
- Thode, A., Straley, J., Tiemann, C. O., Folkert, K., & O'Connell, V. (2007). Observations of potential acoustic cues that attract sperm whales to longline fishing in the Gulf of Alaska. *Journal of the Acoustical Society of America* 122(2):1265-1277.
- Thomas, J. A. J. L. P. W. W. L. A. (1990). Masked hearing abilities in a false killer whale (*Pseudorca crassidens*). Pages 395-404 in J. A. T. R. A. Kastelein, editor. *Sensory Abilities of Cetaceans: Laboratory and Field Evidence*. Plenum Press, New York.
- Thompson, P. O., Cummings, W. C., & Ha., S. J. (1986). Sounds, source levels, and associated behavior of humpback whales, Southeast Alaska. *Journal of the Acoustical Society of America* 80(3):735-740.
- Thompson, P. O., Findley, L. T., & Vidal, O. (1992). 20-Hz pulses and other vocalizations of fin whales, *Balaenoptera physalus*, in the Gulf of California, Mexico. *The Journal of the Acoustical Society of America* 92(6):3051-3057.
- Thomsen, B. (2002). An experiment on how seismic shooting affects caged fish. University of Aberdeen, Aberdeen, Scotland.
- Thomson, C. A. & Geraci, J. R. (1986). Cortisol, aldosterone, and leukocytes in the stress response of bottlenose dolphins, *Tursiops truncatus*. *Canadian Journal of Fisheries and Aquatic Sciences* 43(5):1010-1016.
- Titova, O. V., Filatova, O. A., Fedutin, I. D., Ovsyanikova, E. N., Okabe, H., Kobayashi, N., Acebes, J. M. V., Burdin, A. M., & Hoyt, E. (2018). Photo-identification matches of humpback whales (*Megaptera novaeangliae*) from feeding areas in Russian Far East seas and breeding grounds in the North Pacific. *Marine Mammal Science* 34(1):100-112. <https://doi.org/https://doi.org/10.1111/mms.12444>
- Tønnessen, J. N. & Johnsen, A. O. (1982). *The history of modern whaling*, Univ of California Press.
- Townsend, C. H. (1924). The northern elephant seal and the Guadalupe fur seal. *Natural History* 24(5):567-577.
- Tremblay, C. J., Van Parijs, S. M., & Cholewiak, D. (2019). 50 to 30-Hz triplet and singlet down sweep vocalizations produced by sei whales (*Balaenoptera borealis*) in the western North Atlantic Ocean. *Journal of the Acoustic Society of America* 145(6):3351-3358.
- Tubelli, A. A., Zosuls, A., Ketten, D. R., & Mountain, D. C. (2018). A model and experimental approach to the middle ear transfer function related to hearing in the humpback whale (*Megaptera novaeangliae*). *The Journal of the Acoustical Society of America* 144(2):525-535. <https://doi.org/10.1121/1.5048421>
- Turnpenny, A. W. H., Thatcher, K. P., & Nedwell, J. R. (1994). The effects on fish and other marine animals of high-level underwater sound. *Research Report for the Defence Research Agency, Fawley Aquatic Research Laboratories, Ltd., FRR 127/94. 34p.*
- Tyack, P. (1983). Differential response of humpback whales, *Megaptera novaeangliae*, to playback of song or social sounds. *Behavioral Ecology and Sociobiology* 13(1):49-55.
- Tyack, P., Johnson, M., & Miller, P. (2003). Tracking responses of sperm whales to experimental exposures of airguns. Pages 115-120 in A. E. Jochens & D. C. Biggs,

- editors. *Sperm whale seismic study in the Gulf of Mexico/Annual Report: Year 1*, volume OCS Study MMS 2003-069. Texas A&M University and Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, Louisiana.
- Tyurneva, O. Y., Yakovlev, Y. M., Vertyankin, V., & Selin, N. (2010). The peculiarities of foraging migrations of the Korean-Okhotsk gray whale (*Eschrichtius robustus*) population in Russian waters of the Far Eastern seas. *Russian Journal of Marine Biology* 36:117-124.
- Urbán, R., Weller, D., Martínez, S., Tyurneva, O., Bradford, A., Burdin, A., Lang, A., Swartz, S., Sychenko, O., & Gómora, L. (2019a). New information on the gray whale migratory movements between the western and eastern North Pacific. *IWC SC/68A/CMP/11 Rev 1*.
- Urbán, R. J., Weller, D., Martínez, A. S., Tyurneva, O., Bradford, A., Burdin, A., Lang, A., Swartz, S., Sychenko, O., Viloría-Gómora, L., & Yakovlev, Y. (2019b). *New information on the gray whale migratory movements between the western and eastern North Pacific*.
- Van Waerebeek, K. & Leaper, R. (2008). Second report of the IWC vessel strike data standardisation working group. *IWC Scientific Committee document SC/60/BC5 620*.
- Vanderlaan, A. S. & Taggart, C. T. (2007a). Vessel collisions with whales: The probability of lethal injury based on vessel speed. *Marine Mammal Science* 23(1):144-156.
- Vanderlaan, A. S. M. & Taggart, C. T. (2007b). VESSEL COLLISIONS WITH WHALES: THE PROBABILITY OF LETHAL INJURY BASED ON VESSEL SPEED. *Marine Mammal Science* 23(1):144-156. <https://doi.org/https://doi.org/10.1111/j.1748-7692.2006.00098.x>
- Vertyankin, V., Nikulin, V., Bednykh, A., & Kononov, A. (2004). Sighting of gray whales (*Eschrichtius robustus*) near southern Kamchatka. Pages 126-128 in the book: *Marine Mammals in the Holarctic. Collection of scientific papers of International Conference Koktebel, Krimea, Ukraine*.
- Wade, P., Quinn, T., Barlow, J., Baker, C. S., Burden, A., Calambokidis, J., Clapham, P., Falcone, E., Ford, J., & Gabriele, C. (2021). Estimates of abundance and migratory destination for North Pacific humpback whales in both summer feeding areas and winter mating and calving areas. *Paper SC/66b/IA21 submitted to the Scientific Committee of the International Whaling Commission, June 2016, Bled, Slovenia*.
- Wade, P. R. & Gerrodette, T. (1993). Estimates of cetacean abundance and distribution in the eastern tropical Pacific. *Report of the International Whaling Commission* 43(477-493).
- Walker, R. V., Sviridov, V. V., Urawa, S., & Azumaya, T. (2007). Spatio-temporal variation in vertical distributions of Pacific salmon in the ocean. *North Pacific Anadromous Fish Commission Bulletin* 4:193-201.
- Wardle, C. S., T.J. Carter, G.G. Urquhart, A.D.F. Johnstone, Ziolkowski, A. M., Hampson, G., & Mackie, D. (2001). Effects of seismic air guns on marine fish. *Continental Shelf Research* 21:1005-1027.
- Waring, G. T., Josephson, E., Fairfield, C. P., & Maze-Foley, K. (2008). *U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments - 2007*. National Marine Fisheries Service Northeast Fisheries Science Center, NOAA Technical Memorandum NMFS-NE-205, Woods Hole, Massachusetts.
- Waring, G. T., Josephson, E., Maze-Foley, K., & Rosel, P. E. (2016). *US Atlantic and Gulf of Mexico Marine Mammal Stock Assessments - 2015*. National Marine Fisheries Service Northeast Fisheries Science Center NMFS-NE-238, Woods Hole, Massachusetts.

- Watkins, W. A. (1977). Acoustic behavior of sperm whales. *Oceanus* 20:50–58.
- Watkins, W. A. (1986). Whale Reactions to Human Activities in Cape-Cod Waters. *Marine Mammal Science* 2(4):251-262.
- Watkins, W. A., Moore, K. E., & Tyack, P. L. (1985a). Sperm whale acoustic behaviors in the southeast Caribbean. *Cetology* 49:1-15.
- Watkins, W. A., Moore, K. E., & Tyack, P. L. (1985b). Sperm whale acoustic behaviors in the southeast Caribbean. *Cetology* 49:1–15.
- Watkins, W. A. & Schevill, W. E. (1975a). Sperm whales (*Physeter catodon*) react to pingers. *Deep Sea Research and Oceanographic Abstracts* 22(3):123–129 +1pl.
- Watkins, W. A. & Schevill, W. E. (1975b). Sperm whales (*Physeter catodon*) react to pingers. *Deep Sea Research and Oceanographic Abstracts* 22(3):123-129 +1pl.
- Watkins, W. A. & Schevill, W. E. (1977). Spatial distribution of *Physeter catodon* (sperm whales) underwater. *Deep Sea Research* 24(7):693–699.
- Watkins, W. A., Tyack, P., Moore, K. E., & Bird, J. E. (1987). The 20-Hz signals of finback whales (*Balaenoptera physalus*). *The Journal of the Acoustical Society of America* 82(6):1901-1912.
- Watters, D. L., Yoklavich, M. M., Love, M. S., & Schroeder, D. M. (2010). Assessing marine debris in deep seafloor habitats off California. *Marine Pollution Bulletin* 60:131–138.
- Watters, G. M., Hinke, J. T., Boehlert, G. W., & Zedonis, P. (2005). Ocean habitat use in autumn by Chinook salmon in coastal waters of Oregon and California. *Marine Ecology Progress Series* 285:181-192.
- Weilgart, L. & Whitehead, H. (1993). Coda communication by sperm whales (*Physeter macrocephalus*) off the Galápagos Islands. *Canadian Journal of Zoology* 71(4):744–752.
- Weilgart, L. S. & Whitehead, H. (1997a). Group-specific dialects and geographical variation in coda repertoire in South Pacific sperm whales. *Behavioral Ecology and Sociobiology* 40(5):277–285.
- Weilgart, L. S. & Whitehead, H. (1997b). Group-specific dialects and geographical variation in coda repertoire in South Pacific sperm whales. *Behavioral Ecology and Sociobiology* 40(5):277-285.
- Weir, C. R. (2008a). Overt responses of humpback whales (*Megaptera novaeangliae*), sperm whales (*Physeter macrocephalus*), and Atlantic spotted dolphins (*Stenella frontalis*) to seismic exploration off Angola. *Aquatic Mammals* 34(1):71-83.
- Weir, C. R. (2008b). Overt responses of humpback whales (*Megaptera novaeangliae*), sperm whales (*Physeter macrocephalus*), and Atlantic spotted dolphins (*Stenella frontalis*) to seismic exploration off Angola. *Aquatic Mammals* 34(1):71-83.
- Weir, C. R. & Dolman, S. J. (2007). Comparative review of the regional marine mammal mitigation guidelines implemented during industrial seismic surveys, and guidance towards a worldwide standard. *Journal of International Wildlife Law and Policy* 10(1):1-27.
- Weir, C. R., Frantzis, A., Alexiadou, P., & Goold, J. C. (2007). The burst-pulse nature of 'squeal' sounds emitted by sperm whales (*Physeter macrocephalus*). *Journal of the Marine Biological Association of the United Kingdom* 87(1):39–46.
- Weirathmueller, M. J., Wilcock, W. S. D., & Soule, D. C. (2013a). Source levels of fin whale 20 Hz pulses measured in the Northeast Pacific Ocean. *Journal of the Acoustical Society of America* 133(2):741–749.

- Weirathmueller, M. J., Wilcock, W. S. D., & Soule, D. C. (2013b). Source levels of fin whale 20 Hz pulses measured in the Northeast Pacific Ocean. *The Journal of the Acoustical Society of America* 133(2):741-749. <https://doi.org/10.1121/1.4773277>
- Weller, D., Burdin, A., Wursig, B., Taylor, B., & Brownell Jr, R. L. (2002). The western gray whale: a review of past exploitation, current status and potential threats.
- Weller, D. W., Burdin, A. M., & Brownell Jr, R. L. (2013). A gray area: on the matter of gray whales in the western North Pacific. *Journal of the American Cetacean Society* 42(1):29-33.
- Weller, D. W., Klimek, A., Bradford, A. L., Calambokidis, J., Lang, A. R., Gisborne, B., Burdin, A. M., Szaniszlo, W., Urbán, J., & Unzueta, A. G.-G. (2012). Movements of gray whales between the western and eastern North Pacific. *Endangered Species Research* 18(3):193-199.
- Werth, A. J., Kahane-Rapport, S. R., Potvin, J., Goldbogen, J. A., & Savoca, M. S. (2024). Baleen–Plastic Interactions Reveal High Risk to All Filter-Feeding Whales from Clogging, Ingestion, and Entanglement. *Oceans* 5(1):48-70.
- Whitehead, H. (2009). Sperm whale: *Physeter macrocephalus*. Pages 1091–1097 in W. F. Perrin, B. Würsig, & J. G. M. Thewissen, editors. *Encyclopedia of Marine Mammals*, Second edition. Academic Press, San Diego, California.
- Whitehead, H. & Weilgart, L. (1991a). Patterns of visually observable behaviour and vocalizations in groups of female sperm whales. *Behaviour* 118(3/4):275-295.
- Whitehead, H. & Weilgart, L. (1991b). Patterns of visually observable behaviour and vocalizations in groups of female sperm whales. *Behaviour* 118(3/4):275–295.
- Wilcove, D. S., Rothstein, D., Dubow, J., Phillips, A., & Losos, E. (1998). Quantifying threats to imperiled species in the United States. *BioScience* 48(8):607-615.
- Wilcox, C., Heathcote, G., Goldberg, J., Gunn, R., Peel, D., & Hardesty, B. D. (2015). Understanding the sources and effects of abandoned, lost, and discarded fishing gear on marine turtles in northern Australia. *Conservation Biology* 29(1):198-206. <https://doi.org/10.1111/cobi.12355>
- Wiley, D. N., Asmutis, R. A., Pitchford, T. D., & Gannon, D. P. (1995). Stranding and mortality of humpback whales, *Megaptera novaeangliae*, in the mid-Atlantic and southeast United States, 1985-1992. *Fishery Bulletin* 93(1):196-205.
- Williams, R., Hedley, S. L., Branch, T. A., Bravington, M. V., Zerbini, A. N., & Findlay, K. P. (2011). Chilean Blue Whales as a Case Study to Illustrate Methods to Estimate Abundance and Evaluate Conservation Status of Rare Species. *Conservation Biology* 25(3):526-535. <https://doi.org/https://doi.org/10.1111/j.1523-1739.2011.01656.x>
- Williams, R. M., Trites, A. W., & Bain, D. E. (2002). Behavioural responses of killer whales (*Orcinus orca*) to whale-watching boats: Opportunistic observations and experimental approaches. *Journal of Zoology* 256(2):255–270.
- Winn, H. E., Perkins, P. J., & Poulter, T. C. (1970). Sounds of the humpback whale. in *Proceedings of the 7th Annual Conference on Biological Sonar and Diving Mammals*, Stanford Research Institute Menlo Park CA. p.39-52.
- Winsor, M. H. & Mate, B. R. (2006). *Seismic survey activity and the proximity of satellite tagged sperm whales*.
- Wright, A. J. (2014). Reducing impacts of human ocean noise on cetaceans: knowledge gap analysis and recommendations. *WWF International, Gland, Switzerland*.

- Wright, A. J. & Cosentino, A. M. (2015). JNCC guidelines for minimising the risk of injury and disturbance to marine mammals from seismic surveys: We can do better. *Marine Pollution Bulletin* 100(1):231-239.
- Würsig, B. G., Weller, D. W., Burdin, A. M., Reeve, S. H., Bradford, A. L., Blokhin, S. A., & R.L Brownell, J. (1999). *Gray whales summering off Sakhalin Island, Far East Russia: July-October 1997. A joint U.S.-Russian scientific investigation. Final Report.* Sakhalin Energy Investment Co. Ltd and Exxon Neftegas Ltd, Yuzhno-Sakhalinsk, Russia.
- Yazvenko, S. B., McDonald, T. L., Blokhin, S. A., Johnson, S. R., Melton, H. R., Newcomer, M. W., Nielson, R., & Wainwright, P. W. (2007). Feeding of western gray whales during a seismic survey near Sakhalin Island, Russia. *Environmental Monitoring and Assessment* 134(3-Jan):93-106.
- Yost, W. A. (2007). *Fundamentals of Hearing: An Introduction.* Academic Press, New York.
- Young, N. C., Brower, A. A., Muto, M. M., Freed, J. C., Angliss, R. P., Friday, N. A., Boveng, P. L., Brost, B. M., Cameron, M. F., Crance, J. L., Dahle, S. P., Fadely, B. S., Ferguson, M. C., Goetz, K. T., London, J. M., Oleson, E. M., Ream, R. R., Richmond, E. L., Sheldon, K. E. W., Sweeney, K. L., Towell, R. G., Wade, P. R., Waite, J. M., & Zerbini, A. N. (2023). Alaska Marine Mammal Stock Assessments, 2022. <https://doi.org/https://doi.org/10.25923/ds2w-9545>
- Zamon, J. E. & Welch, D. W. (2005). Rapid shift in zooplankton community composition on the northeast Pacific shelf during the 1998-1999 El Niño-La Niña event. *Canadian Journal of Fisheries and Aquatic Sciences* 62:133-144.
- Zerbini, A. N., Waite, J. M., Laake, J. L., & Wade, P. R. (2006). Abundance, trends and distribution of baleen whales off Western Alaska and the central Aleutian Islands. *Deep Sea Research Part I: Oceanographic Research Papers* 53(11):1772-1790.
- Zimmer, W. M. X. & Tyack, P. L. (2007). Repetitive shallow dives pose decompression risk in deep-diving beaked whales. *Marine Mammal Science* 23(4):888-925.
- NMFS. (2024a). *2024 Update to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 3.0): Underwater and In-Air Criteria for Onset of Auditory Injury and Temporary Threshold Shifts.* U.S. Department of Commerce, NOAA, Silver Spring, Maryland.
- NMFS. (2024b). *Reinitiation and Conference of the Amended Programmatic Concurrence Letter for Launch and Reentry Vehicle Operations in the Marine Environment and Starship-Super Heavy Launch Vehicle Operations at SpaceX's Boca Chica Launch Site, Cameron County, Texas.* National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Silver Spring, MD.
- NMFS & USFWS. (2007). *Loggerhead sea turtle (Caretta caretta) 5-year review: Summary and evaluation.* National Marine Fisheries Service and U.S. Fish and Wildlife Service, Silver Spring, Maryland.
- NMFS & USFWS. (2008a). *Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle (Caretta caretta), Second Revision* National Marine Fisheries Service, Silver Spring, MD.
- NMFS & USFWS. (2008b). *Recovery plan for the northwest Atlantic population of the loggerhead sea turtle (Caretta caretta), second revision.* National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland.

- NMFS & USFWS. (2011). *Bi-National Recovery Plan for the Kemp's Ridley Sea Turtle (Lepidochelys kempii), Second Revision*. National Oceanic and Atmospheric Administration, National Marine Fisheries Service and U.S. Fish and Wildlife Service, Silver Spring, Maryland.
- NMFS & USFWS. (2015). *Kemp's ridley sea turtle (Lepidochelys kempii) 5-year review: Summary and evaluation*. National Oceanic and Atmospheric Administration, National Marine Fisheries Service and U.S. Fish and Wildlife Service.
- NMFS, USFWS, & SEMARNAT. (2011a). *Bi-National Recovery Plan for the Kemp's Ridley Sea Turtle (Lepidochelys kempii), Second Revision*. Pages 156 *in*. National Marine Fisheries Service, Silver Spring, Maryland.
- NMFS, USFWS, & SEMARNAT. (2011b). *Bi-national recovery plan for the Kemp's ridley sea turtle (Lepidochelys kempii), second revision*. National Oceanic and Atmospheric Administration, National Marine Fisheries Service and U.S. Fish and Wildlife Service, Silver Spring, Maryland.
- NMFS and USFWS. (2013). *Hawksbill Sea Turtle (Eretmochelys Imbricata) 5-Year Review : Summary and Evaluation*.
- NMFS and USFWS. (2023). *Loggerhead Sea Turtle (Caretta caretta) Northwest Atlantic Ocean DPS 5-Year Review: Summary and Evaluation* Silver Spring, MD and Jacksonville, FL.
- NMFS USFWS. (2013). *Leatherback sea turtle (Dermochelys coriacea) 5-year review: Summary and evaluation*. NOAA, National Marine Fisheries Service, Office of Protected Resources and U.S. Fish and Wildlife Service, Southeast Region, Jacksonville Ecological Services Office.
- NOAA. (2021). *Hurricane Ida*. *in*. Office of Response and Restoration.
- NOAA. (2023). *Crude Oil release: Main Pass, LA*. *in*. NOAA IncidentNews.
- NOAA. (2024a). *Flint Hills Dock #5 Oil Spill*. *in*. Damage Assessment, Remediation, and Restoration Program.
- NOAA. (2024b). *Gulf of Mexico 'dead zone' larger than average, scientists find*. *in*.
- NOAA. (2024c). *Red Tides and Sea Turtles - Frequently Asked Questions*. *in*.
- Noren, D. P., Johnson, A. H., Rehder, D., & Larson, A. (2009). *Close approaches by vessels elicit surface active behaviors by southern resident killer whales*. *Endangered Species Research* 8(3):179–192.
- Norse, E. A., Crowder, L. B., Gjerde, K., Hyrenbach, D., Roberts, C. M., Safina, C., & Soule, M. E. (2005). *Place-based ecosystem management in the open ocean*. Pages 302-327 *in* L. B. E. A. C. Norse, editor. *Marine Conservation Biology: The Science of Maintaining the Sea's Biodiversity*. Island Press, Washington, D. C.
- Nowacek, D. P., Thorne, L. H., Johnston, D. W., & Tyack, P. L. (2007). *Responses of cetaceans to anthropogenic noise*. *Mammal Review* 37(2):81-115.
- NPS. (2013). *Padre Island National SeaShore Kemp's Ridley Sea Turtle nesting 1985-2013*. *in*. National Park Service Padre Island National Seashore.
- NRC. (1990). *Decline of the Sea Turtles: Causes and Prevention*. National Academy Press, 030904247X, Washington, D.C.
- NRC. (2003a). *National Research Council: Ocean noise and marine mammals.*, National Academies Press, Washington, D.C.
- NRC. (2003b). *Ocean Noise and Marine Mammals*, National Academies Press.

- NRC. (2003c). *Ocean Noise and Marine Mammals*. National Research Council of the National Academies of Science. The National Academies Press, Washington, District of Columbia.
- NRC. (2003d). *Ocean Noise and Marine Mammals*, National Academy Press, Washington, D.C.
- Nufer, B. (2010). *Hypergolic Propellants: The Handling Hazards and Lessons Learned From Use*. NASA Kennedy Space Center, Engineering Directorate, Fluids Division, Hypergolic and Hydraulic Systems Branch, Kennedy Space Center, FL
- O'Hara, J. & Wilcox, J. R. (1990). Avoidance responses of loggerhead turtles, *Caretta caretta*, to low frequency sound. *Copeia* 2:564-567.
- O'Reilly, C., Silva, M., Asl, S. D., Meurer, W. P., MacDonald, I. R., O'Reilly, C., Silva, M., Daneshgar Asl, S., Meurer, W. P., & MacDonald, I. R. (2022). Distribution, Magnitude, and Variability of Natural Oil Seeps in the Gulf of Mexico. *Remote Sensing* 2022, Vol. 14, Page 3150 14(13). <https://doi.org/10.3390/rs14133150>
- Orós, J., Gonzalez-Diaz, O., & Monagas, P. (2009). High levels of polychlorinated biphenyls in tissues of Atlantic turtles stranded in the Canary Islands, Spain. *Chemosphere* 74(3):473-478.
- Overstreet, R. M. & Hawkins, W. E. (2017). Diseases and Mortalities of Fishes and Other Animals in The Gulf of Mexico. *Habitats and Biota of the Gulf of Mexico: Before the Deepwater Horizon Oil Spill*. [https://doi.org/10.1007/978-1-4939-3456-0\\_6](https://doi.org/10.1007/978-1-4939-3456-0_6)
- Patel, S. H., Winton, M. V., Hatch, J. M., Haas, H. L., Saba, V. S., Fay, G., & Smolowitz, R. J. (2021). Projected shifts in loggerhead sea turtle thermal habitat in the Northwest Atlantic Ocean due to climate change. *Scientific Reports* 11(1):8850. <https://doi.org/10.1038/s41598-021-88290-9>
- Patenaude, N. J., Richardson, W. J., Smultea, M. A., Koski, W. R., Miller, G. W., Wursig, B., & Greene, C. R. (2002a). Aircraft sound and disturbance to bowhead and beluga whales during spring migration in the Alaskan Beaufort Sea. *Marine Mammal Science* 18(2):309-335.
- Patenaude, N. J., Richardson, W. J., Smultea, M. A., Koski, W. R., Miller, G. W., Würsig, B., & Greene Jr, C. R. (2002b). Aircraft sound and disturbance to bowhead and beluga whales during spring migration in the Alaskan Beaufort Sea. *Marine Mammal Science* 18(2):309-335.
- Patterson, W. F., Robinson, K. L., Barnett, B. K., Campbell, M. D., Chagaris, D. C., Chanton, J. P., Daly, K. L., Hanisko, D. S., Hernandez, F. J., Murawski, S. A., Pollack, A. G., Portnoy, D. S., & Pulster, E. L. (2023). Evidence of population-level impacts and resiliency for Gulf of Mexico shelf taxa following the Deepwater Horizon oil spill. *Frontiers in Marine Science* 10. <https://doi.org/10.3389/fmars.2023.1198163>
- Perrault, J. R., Levin, M., Mott, C. R., Boverly, C. M., Bresette, M. J., Chabot, R. M., Gregory, C. R., Guertin, J. R., Hirsch, S. E., & Ritchie, B. W. (2021a). Insights on immune function in free-ranging green sea turtles (*Chelonia mydas*) with and without fibropapillomatosis. *Animals* 11.
- Perrault, J. R., Levin, M., Mott, C. R., Boverly, C. M., Bresette, M. J., Chabot, R. M., Gregory, C. R., Guertin, J. R., Hirsch, S. E., Ritchie, B. W., Weege, S. T., Welsh, R. C., Witherington, B. E., & Page-Karjian, A. (2021b). Insights on Immune Function in Free-Ranging Green Sea Turtles (*Chelonia mydas*) with and without Fibropapillomatosis. *Animals* 11(3):861.

- Perrault, J. R., Stacy, N. I., Lehner, A. F., Mott, C. R., Hirsch, S., Gorham, J. C., Buchweitz, J. P., Bresette, M. J., & Walsh, C. J. (2017). Potential effects of brevetoxins and toxic elements on various health variables in Kemp's ridley (*Lepidochelys kempii*) and green (*Chelonia mydas*) sea turtles after a red tide bloom event. *Science of the Total Environment* 605-606:967-979.  
<https://doi.org/https://doi.org/10.1016/j.scitotenv.2017.06.149>
- Pike, D. A., Antworth, R. L., & Stiner, J. C. (2006). Earlier Nesting Contributes to Shorter Nesting Seasons for the Loggerhead Seaturtle, *Caretta caretta*. *Journal of Herpetology* 40(1):91-94.
- Piniak, W. E. D. & Eckert, K. L. (2011). Sea turtle nesting habitat in the Wider Caribbean Region. *Endangered Species Research* 15(2):129-141.
- Plotkin, P., Wicksten, M., & Amos, A. (1993). Feeding ecology of the loggerhead sea turtle *Caretta caretta* in the Northwestern Gulf of Mexico. *Marine Biology* 115:1-5.
- Plotkin, P. T. (2016). Introduction to the Special Issue on the Kemp's Ridley Sea Turtle (*Lepidochelys kempii*). *Gulf of Mexico Science* 2016(2):1.
- Popper, A., Hawkins, A., Fay, R., Mann, D., Bartol, S., Carlson, T., Coombs, S., Ellison, W., Gentry, R., Halvorsen, M., Lokkeborg, S., Rogers, P. H., Southall, B. L., Zeddies, B. G., & Tavalga, W. N. (2014a). Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI.
- Popper, A. N., Hawkins, A. D., Fay, R. R., Mann, D. A., Bartol, S. M., Carlson, T. J., Coombs, S., Ellison, W. T., Gentry, R. L., Halvorsen, M. B., Løkkeborg, S., Rogers, P. H., Southall, B. L., Zeddies, D. G., & Tavalga, W. N. (2014b). *ASA S3/SC1.4 TR-2014 Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI*. Acoustical Society of America Press and Springer Briefs in Oceanography, ISSN 2196-1212 ISSN 2196-1220 (electronic)  
 ISBN 978-3-319-06658-5 ISBN 978-3-319-06659-2 (eBook), New York, NY and London, United Kingdom.
- Presti, S. M., Landry, A. M., & Sollod, A. E. (2000). Mercury concentration in scute scrapings of sea turtles in the Gulf of Mexico. *in* Proceedings of the Eighteenth International Sea Turtle Symposium 1998.
- Pughiuc, D. (2010). Invasive species: Ballast water battles. *Seaways*.
- Putman, N. F., Verley, P., Endres, C. S., & Lohmann, K. J. (2015). Magnetic navigation behavior and the oceanic ecology of young loggerhead sea turtles. *Journal of Experimental Biology* 218(7):1044–1050.
- Raaymakers, S. (2003). The GEF/UNDP/IMO global ballast water management programme integrating science, shipping and society to save our seas. *Proceedings of the Institute of Marine Engineering, Science and Technology Part B: Journal of Design and Operations* (B4):2-10.
- Raaymakers, S. & Hilliard, R. (2002). *Harmful aquatic organisms in ships' ballast water - Ballast water risk assessment*. 1726-5886, Istanbul, Turkey.
- Rabalais, N. N., Diaz, R. J., Levin, L. A., Turner, R. E., Gilbert, D., & Zhang, J. (2010). Dynamics and distribution of natural and human-caused hypoxia. *Biogeosciences* 7(2):585-619. <https://doi.org/10.5194/bg-7-585-2010>

- Rabalais, N. N. & Turner, R. E. (2001). *Coastal hypoxia: consequences for living resources and ecosystems*, American Geophysical Union.
- Ramajo, L., Pérez-León, E., Hendriks, I. E., Marbà, N., Krause-Jensen, D., Sejr, M. K., Blicher, M. E., Lagos, N. A., Olsen, Y. S., & Duarte, C. M. (2016). Food supply confers calcifiers resistance to ocean acidification. *Scientific Reports* 6:19374. <https://doi.org/10.1038/srep19374>
- <https://www.nature.com/articles/srep19374#supplementary-information>
- Ramos-Cartelle, A., García-Cortés, B., Ortíz de Urbina, J., Fernández-Costa, J., González-González, I., & Mejuto, J. (2012). Standardized catch rates of the oceanic whitetip shark (*Carcharhinus longimanus*) from observations of the Spanish longline fishery targeting swordfish in the Indian Ocean during the 1998–2011 period. IOTC–2012–WPEB08–27.
- Record, N. R., Runge, J. A., Pendleton, D. E., Balch, W. M., Davies, K. T., Pershing, A. J., Johnson, C. L., Stamieszkin, K., Ji, R., & Feng, Z. (2019a). Rapid climate-driven circulation changes threaten conservation of endangered North Atlantic right whales. *Oceanography* 32(2):162-169.
- Record, N. R., Runge, J. A., Pendleton, D. E., Balch, W. M., Davies, K. T. A., Pershing, A. J., Johnson, C. L., Stamieszkin, K., Ji, R., Feng, Z., Kraus, S. D., Kenney, R. D., Hudak, C. A., Mayo, C. A., Chen, C., Salisbury, J. E., & Thompson, C. R. S. (2019b). Rapid Climate-Driven Circulation Changes Threaten Conservation of Endangered North Atlantic Right Whales. *Oceanography* 32(2):162-169.
- Rees, A. F., Al-Kiyumi, A., Broderick, A. C., Papatathanasopoulou, N., & Godley, B. J. (2012). Conservation related insights into the behaviour of the olive ridley sea turtle *Lepidochelys olivacea* nesting in Oman. *Marine Ecology Progress Series* 450:195-205.
- Rees, A. F., Al Saady, S., Broderick, A. C., Coyne, M. S., Papatathanasopoulou, N., & Godley, B. J. (2010). Behavioural polymorphism in one of the world's largest populations of loggerhead sea turtles *Caretta caretta*. *Marine Ecology Progress Series* 418:201-212.
- Rguez-Baron, J. M., Kelez, S., Liles, M., Zavala-Norzagaray, A., Torres-Suárez, O. L., Amorocho, D. F., & Gaos, A. R. (2019). Sea Turtles in the East Pacific Ocean Region. *MTSG Annual Regional Report. Draft Report of the IUCN-SSC Marine Turtle Specialist Group*.
- Richardson, W. J., Greene, C. R. J., Malme, C. I., & Thomson, D. H. (1995). *Marine mammals and noise*, Academic Press, San Diego, CA.
- Richter, C. F., Dawson, S., & Slooten, E. (2003a). *Sperm whale watching off Kaikoura, New Zealand: effects of current activities on surfacing and vocalisation patterns*, volume 219. Department of Conservation Wellington.
- Richter, C. F., Dawson, S. M., & Slooten, E. (2003b). Sperm whale watching off Kaikoura, New Zealand: Effects of current activities on surfacing and vocalisation patterns. *Science for Conservation* 219.
- Ridgway, S. H., Wever, E. G., McCormick, J. G., Palin, J., & Anderson, J. H. (1969). Hearing in the giant sea turtle, *Chelonia mydas*. *Proceedings of the National Academies of Science* 64.
- Riley, K. L., Wickliffe, L. C., Jossart, J. A., MacKay, J. K., Randall, A. L., Bath, G. E., Balling, M. B., Jensen, B. M., & Morris, J. A., Jr. (2021). An Aquaculture Opportunity Area Atlas for the U.S. Gulf of Mexico. <https://doi.org/https://doi.org/10.25923/8cb3-3r66>
- Roberts, J. J., Best, B. D., Mannocci, L., Fujioka, E., Halpin, P. N., Palka, D. L., Garrison, L. P., Mullin, K. D., Cole, T. V. N., Khan, C. B., McLellan, W. A., Pabst, D. A., & Lockhart,

- G. G. (2016). Habitat-based cetacean density models for the U.S. Atlantic and Gulf of Mexico. *Scientific Reports* 6(1):22615. <https://doi.org/10.1038/srep22615>
- Roberts, J. J., Mack, T. M., & Halpin, P. N. (2023). *Marine mammal density models for the U.S. Navy Atlantic Fleet Training and Testing (AFTT) study area for the Phase IV Navy Marine Species Density Database (NMSDD)*.
- Roberts, J. J., Yack, T. M., Fujioka, E., Halpin, P. N., Baumgartner, M. F., Boisseau, O., Chavez-Rosales, S., Cole, T. V. N., Cotter, M. P., Davis, G. E., DiGiovanni, R. A., Jr., Ganley, L. C., Garrison, L. P., Good, C. P., Gowan, T. A., Jackson, K. A., Kenney, R. D., Khan, C. B., Knowlton, A. R., Kraus, S. D., Lockhart, G. G., Lomac-MacNair, K. S., Mayo, C. A., McKenna, B. E., McLellan, W. A., Nowacek, D. P., O'Brien, O., Pabst, D. A., Palka, D. L., Patterson, E. M., Pendleton, D. E., Quintana-Rizzo, E., Record, N. R., Redfern, J. V., Rickard, M. E., White, M., Whitt, A. D., & Zoidis, A. M. (2024). North Atlantic right whale density surface model for the US Atlantic evaluated with passive acoustic monitoring. *Marine Ecology Progress Series* 732:167-192.
- Robinson, N. J., Anders, D., Bachoo, S., HARRIS, L., HUGHES, G. R., KOTZE, D., MADURAY, S., MCCUE, S., MEYER, M., & Oosthuizen, H. (2018). Satellite tracking of leatherback and loggerhead sea turtles on the southeast African coastline. *Indian Ocean Turtle Newsletter* 28(5).
- Robinson, N. J., Morreale, S. J., Nel, R., & Paladino, F. V. (2016). Coastal leatherback turtles reveal conservation hotspot. *Scientific reports* 6(1):37851. <https://doi.org/10.1038/srep37851>
- Rodríguez, Y., Vandeperre, F., Santos, M. R., Herrera, L., Parra, H., Deshpande, A., Bjorndal, K. A., & Pham, C. K. (2022). Litter ingestion and entanglement in green turtles: An analysis of two decades of stranding events in the NE Atlantic. *Environmental Pollution* 298:118796. <https://doi.org/https://doi.org/10.1016/j.envpol.2022.118796>
- Roman, L., Schuyler, Q., Wilcox, C., & Hardesty, B. D. (2021). Plastic pollution is killing marine megafauna, but how do we prioritize policies to reduce mortality? *Conservation Letters* 14(2):e12781. <https://doi.org/https://doi.org/10.1111/conl.12781>
- Rose, K. A., Creekmore, S., Thomas, P., Craig, J. K., Rahman, M. S., & Neilan, R. M. (2018). Modeling the Population Effects of Hypoxia on Atlantic Croaker (*Micropogonias undulatus*) in the Northwestern Gulf of Mexico: Part 1—Model Description and Idealized Hypoxia. *Estuaries and Coasts* 41(1):233-254. <https://doi.org/10.1007/s12237-017-0266-6>
- Rosel, P. E., Wilcox, L. A., Yamada, T. K., & Mullin, K. D. (2021). A new species of baleen whale (Balaenoptera) from the Gulf of Mexico, with a review of its geographic distribution. *Marine Mammal Science* 37(2):577-610. <https://doi.org/https://doi.org/10.1111/mms.12776>
- Ross, D. (1976). *Mechanics of Underwater Noise*, Pergamon Press, New York.
- Ross, D. (2005). Ship sources of ambient noise. *IEEE Journal of Oceanic Engineering* 30(2):257-261.
- Ross, M. N., Danilin, M. Y., Weisenstein, D. K., & Ko, M. K. W. (2004). Ozone depletion caused by NO and H<sub>2</sub>O emissions from hydrazine-fueled rockets. *Journal of Geophysical Research: Atmospheres* 109(D21). <https://doi.org/https://doi.org/10.1029/2003JD004370>
- Rubin, R. D., Kumli, K. R., Klimley, A. P., Stewart, J. D., Ketchum, J. T., Hoyos-Padilla, E. M., Galván-Magaña, F., Zavala-Jiménez, A. A., Fonseca-Ponce, I. A., Saunders, M., Dominguez-Sanchez, P. S., Ahuja, P., Nevels, C. R., González, P. A. P., Corgos, A., &

- Diemer, S. J. (2024). Insular and mainland interconnectivity in the movements of oceanic manta rays (*Mobula birostris*) off Mexico in the Eastern Tropical Pacific. *Environmental Biology of Fishes*. <https://doi.org/10.1007/s10641-024-01622-2>
- Ryan, R. G., Marais, E. A., Balhatchet, C. J., & Eastham, S. D. (2022). Impact of rocket launch and space debris air pollutant emissions on stratospheric ozone and global climate. *Earth's Future* 10(6):e2021EF002612.
- Savoca, M. S., Brodie, S., Welch, H., Hoover, A., Benaka, L. R., Bograd, S. J., & Hazen, E. L. (2020). Comprehensive bycatch assessment in US fisheries for prioritizing management. *Nature Sustainability* 3(6):472-480. <https://doi.org/10.1038/s41893-020-0506-9>
- SCHUYLER, Q., HARDESTY, B. D., WILCOX, C., & TOWNSEND, K. (2014a). Global Analysis of Anthropogenic Debris Ingestion by Sea Turtles. *Conservation Biology* 28(1). <https://doi.org/10.1111/cobi.12126>
- Schuyler, Q., Hardesty, B. D., Wilcox, C., & Townsend, K. (2014b). Global Analysis of Anthropogenic Debris Ingestion by Sea Turtles. *Conservation Biology* 28(1):129-139. <https://doi.org/https://doi.org/10.1111/cobi.12126>
- Seminoff, J. A., Allen, C. D., Balazs, G. H., Dutton, P. H., Eguchi, T., Haas, H., Hargrove, S. A., Jensen, M., Klemm, D. L., Lauritsen, A. M., MacPherson, S. L., Opay, P., Possardt, E. E., Pultz, S., Seney, E. E., Van Houtan, K. S., & Waples, R. S. (2015). Status review of the green turtle (*Chelonia mydas*) under the Endangered Species Act.
- Shamblin, B. M., Bolten, A. B., Abreu-Grobois, F. A., Bjorndal, K. A., Cardona, L., Carreras, C., Clusa, M., Monzon-Arguello, C., Nairn, C. J., Nielsen, J. T., Nel, R., Soares, L. S., Stewart, K. R., Vilaca, S. T., Turkozan, O., Yilmaz, C., & Dutton, P. H. (2014). Geographic patterns of genetic variation in a broadly distributed marine vertebrate: New insights into loggerhead turtle stock structure from expanded mitochondrial DNA sequences. *Plos One* 9(1):e85956. <https://doi.org/10.1371/>
- Shamblin, B. M., Bolten, A. B., Bjorndal, K. a., Dutton, P. H., Nielsen, J. T., Abreu-Grobois, F. A., Reich, K. J., Witherington, B. E., Bagley, D. a., & Ehrhart, L. M. (2012). Expanded mitochondrial control region sequences increase resolution of stock structure among North Atlantic loggerhead turtle rookeries. *Marine Ecology Progress Series* 469:145-160.
- Shaver, D. J., Walker, J. S., & Backof, T. F. (2019). Fibropapillomatosis prevalence and distribution in green turtles *Chelonia mydas* in Texas (USA). *Diseases of Aquatic Organisms* 136(2):175-182.
- Smultea, M. A., Mobley, J. J. R., Fertl, D., & Fulling, G. L. (2008a). An unusual reaction and other observations of sperm whales near fixed-wing aircraft. *Gulf and Caribbean Research* 20:75-80.
- Smultea, M. A., Mobley Jr, J. R., Fertl, D., & Fulling, G. L. (2008b). An unusual reaction and other observations of sperm whales near fixed-wing aircraft. *Gulf and Caribbean Research* 20(1):75-80.
- Snyder, M. A. & Orlin, P. A. (2007). *Ambient noise classification in the Gulf of Mexico*. Naval Oceanographic Office Stennis Space Center, Mississippi.
- Solé, M., Kaifu, K., Mooney, T. A., Nedelec, S. L., Olivier, F., Radford, A. N., Vazzana, M., Wale, M. A., Semmens, J. M., Simpson, S. D., Buscaino, G., Hawkins, A., Aguilar de Soto, N., Akamatsu, T., Chauvaud, L., Day, R. D., Fitzgibbon, Q., McCauley, R. D., & André, M. (2023). Marine invertebrates and noise. *Frontiers in Marine Science* 10. <https://doi.org/10.3389/fmars.2023.1129057>

- Stacy, B. A., Hardy, R., Shaver, D. J., Purvin, C., Howell, L. N., Wilson, H., Devlin, M., Krauss, A., Macon, C., Cook, M., Wang, Z., Flewelling, L., Keene, J., Walker, A., Baker, P., & Yaw, T. (2020). *2019 sea turtle strandings in Texas: a summary of findings and analyses*. Department of Commerce, National Marine Fisheries Service, Silver Spring, MD, USA.
- Stacy, N. I., Field, C. L., Staggs, L., MacLean, R. A., Stacy, B. A., Keene, J., Cacula, D., Pelton, C., Cray, C., Kelley, M., Holmes, S., & Innis, C. J. (2017). Clinicopathological findings in sea turtles assessed during the Deepwater Horizon oil spill response. *Endangered Species Research* 33:25-37. <https://doi.org/10.3354/esr00769>
- Stewart, J. D., Hoyos-Padilla, E. M., Kumli, K. R., & Rubin, R. D. (2016). Deep-water feeding and behavioral plasticity in *Manta birostris* revealed by archival tags and submersible observations. *Zoology* 119(5):406-413. <https://doi.org/https://doi.org/10.1016/j.zool.2016.05.010>
- Stewart, J. D., Nuttall, M., Hickerson, E. L., & Johnston, M. A. (2018a). Important juvenile manta ray habitat at Flower Garden Banks National Marine Sanctuary in the northwestern Gulf of Mexico. *Marine Biology* 165(7):1-8.
- Stewart, J. D., Nuttall, M., Hickerson, E. L., & Johnston, M. A. (2018b). Important juvenile manta ray habitat at Flower Garden Banks National Marine Sanctuary in the northwestern Gulf of Mexico. *Marine Biology* 165(7):111. <https://doi.org/10.1007/s00227-018-3364-5>
- Stewart, K. R., Keller, J. M., Templeton, R., Kucklick, J. R., & Johnson, C. (2011). Monitoring persistent organic pollutants in leatherback turtles (*Dermochelys coriacea*) confirms maternal transfer. *Marine Pollution Bulletin* 62(7):1396-1409. <https://doi.org/https://doi.org/10.1016/j.marpolbul.2011.04.042>
- Steyn. (2010). Exxon Valdez Oil Spill. *in*.
- Storelli, M., Barone, M. G., & Marcotrigiano, G. O. (2007). Polychlorinated biphenyls and other chlorinated organic contaminants in the tissues of Mediterranean loggerhead turtle *Caretta caretta*. *Science of the Total Environment* 273 (2-3):456-463.
- Strayer, D. L. (2010). Alien species in fresh waters: Ecological effects, interactions with other stressors, and prospects for the future. *Freshwater Biology* 55:152-174. <https://doi.org/DOI 10.1111/j.1365-2427.2009.02380.x>
- SWOT. (2022). Printed maps of sea turtle biogeography. *in S. o. t. W. s. S. Turtles*, editor.
- TDOT, T. D. o. T. (2016). *Overview of Texas Ports and Waterways*.
- Terdalkar, S., Kulkarni, A. S., Kumbhar, S. N., & Matheickal, J. (2005). Bio-economic risks of ballast water carried in ships, with special reference to harmful algal blooms. *Nature, Environment and Pollution Technology* 4(1):43-47.
- TEWG. (1998). *An assessment of the Kemp's ridley (Lepidochelys kempii) and loggerhead (Caretta caretta) sea turtle populations in the western North Atlantic*. U. S. Dept. Commerce.
- TEWG. (2000). *Assessment update for the Kemp's ridley and loggerhead sea turtle populations in the western North Atlantic*. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center, Turtle Expert Working Group.
- Thompson, R. C., Olsen, Y., Mitchell, R. P., Davis, A., Rowland, S. J., John, A. W., McGonigle, D., & Russell, A. E. (2004). Lost at sea: where is all the plastic? *Science* 304(5672):838-838.
- Tristan, T., Shaver, D. J., Kimbro, J., deMaar, T., Metz, T., George, J., & Amos, A. (2010). Identification of Fibropapillomatosis in Green Sea Turtles (*Chelonia mydas*) on the Texas

- Coast. *Journal of Herpetological Medicine and Surgery* 20(4):109-112.  
<https://doi.org/10.5818/1529-9651-20.4.109>
- Trustees, D. H. N. (2016). *Deepwater Horizon Oil Spill: Final Programmatic Damage Assessment and Restoration Plan (PDARP) and Final Programmatic Environmental Impact Statement*. NOAA, <http://www.gulfspillrestoration.noaa.gov/restoration-planning/gulf-plan>.
- Tucker, A. D. (2010). Nest site fidelity and clutch frequency of loggerhead turtles are better elucidated by satellite telemetry than by nocturnal tagging efforts: Implications for stock estimation. *Journal of Experimental Marine Biology and Ecology* 383(1):48-55.  
<https://doi.org/DOI:10.1016/j.jembe.2009.11.009>
- U.S. Air Force Research Laboratory. (2000). *Supersonic aircraft noise at and beneath the ocean surface: estimate of risk for effects on marine mammals*.
- U.S. Navy. (2019). *Final supplemental environmental impact statement/supplemental overseas environmental impact statement for surveillance towed array sensor system low frequency active (SURTASS LFA) sonar*.
- U.S. Navy. (2024). *U.S. Navy Marine Species Density Database Phase IV for the Hawaii-California Training and Testing Study Area*. Pearl Harbor, HI.
- US-HTF. (2023). *Mississippi River/Gulf of Mexico Watershed Nutrient Task Force 2023 Report to Congress*. U.S. Hypoxia Task Force, SAN 10305.
- Valverde, R. A. & Holzworth, K. R. (2017). Sea turtles of the Gulf of Mexico. *Habitats and Biota of the Gulf of Mexico: Before the Deepwater Horizon Oil Spill: Volume 2: Fish Resources, Fisheries, Sea Turtles, Avian Resources, Marine Mammals, Diseases and Mortalities*:1189-1351.
- Van Houtan, K. S., Kittinger, J. N., Lawrence, A. L., Yoshinaga, C., Born, V. R., & Fox, A. (2012). Hawksbill sea turtles in the Northwestern Hawaiian Islands. *Chelonian Conservation and Biology* 11(1):117-121.
- VanBlaricom, G., Neuman, M., Butler, J. L., De Vogelaere, A., Gustafson, R. G., Mobley, C., Richards, D., Rumsey, S., & Taylor, B. L. (2009). Status review report for black abalone.
- Wallace, R. L., Gilbert, S., & Reynolds, J. E., 3rd. (2019). Improving the Integration of Restoration and Conservation in Marine and Coastal Ecosystems: Lessons from the Deepwater Horizon Disaster. *BioScience* 69(11):920-927.  
<https://doi.org/10.1093/biosci/biz103>
- Wambiji, N., Gwada, P., Fondo, E., Mwangi, S., & Osore, M. K. (2007). Preliminary results from a baseline survey of the port of Mombasa: with focus on molluscs. *in 5th Western Indian Ocean Marine Science Association Scientific Symposium; Science, Policy and Management pressures and responses in the Western Indian Ocean region, Durban, South Africa*.
- Weishampel, J. F., Bagley, D. A., & Ehrhart, L. M. (2004). Earlier nesting by loggerhead sea turtles following sea surface warming. *Global Change Biology* 10:1424-1427.  
<https://doi.org/10.1111/j.1529-8817.2003.00817.x>
- Werth, A. J., Kahane-Rapport, S. R., Potvin, J., Goldbogen, J. A., & Savoca, M. S. (2024). Baleen-Plastic Interactions Reveal High Risk to All Filter-Feeding Whales from Clogging, Ingestion, and Entanglement. *Oceans* 5(1):48-70.
- Wiggins, S. M., Hall, J. M., Thayre, B. J., & Hildebrand, J. A. (2016). Gulf of Mexico low-frequency ocean soundscape impacted by airguns. *The Journal of the Acoustical Society of America* 140(1):176-183. <https://doi.org/10.1121/1.4955300>

- Wilcove, D. S., Rothstein, D., Dubow, J., Phillips, A., & Losos, E. (1998). Quantifying threats to imperiled species in the United States. *BioScience* 48(8):607-615.
- Wilcox, C., Puckridge, M., Schuyler, Q. A., Townsend, K., & Hardesty, B. D. (2018). A quantitative analysis linking sea turtle mortality and plastic debris ingestion. *Scientific Reports* 8(1):12536. <https://doi.org/10.1038/s41598-018-30038-z>
- Winger, P. V., Lasier, P. J., White, D. H., & Seginak, J. T. (2000). Effects of Contaminants in Dredge Material from the Lower Savannah River. *Archives of Environmental Contamination and Toxicology* 38:9.
- Work, P. A., Sapp, A. L., Scott, D. W., & Dodd, M. G. (2010). Influence of small vessel operation and propulsion system on loggerhead sea turtle injuries. *Journal of Experimental Marine Biology and Ecology* 393(1-2):168-175.
- Würsig, B., Lynn, S., Jefferson, T., & Mullin, K. (1998). Behavior of cetaceans in the northern Gulf of Mexico relative to survey ships and aircraft. *Aquatic Mammals* 24.
- Young, C. N., Carlson, J., Hutchinson, M., Hutt, C., Kobayashi, D., McCandless, C. T., & Wraith, J. (2018). Status Review Report : Oceanic Whitetip Shark (*Carcharhinus longimanus*). Final report to the National Marine Fisheries Service, Office of Protected Resources.:170.
- Zurita, J. C., Herrera, R., Arenas, A., Torres, M. E., Calderón, C., Gómez, L., Alvarado, J. C., & Villavicencia, R. (2003a). Nesting loggerhead and green sea turtles in Quintana Roo, Mexico. Pages 25-127 in *J. A. Seminoff*, editor Twenty-Second Annual Symposium on Sea Turtle Biology and Conservation, Miami, Florida.
- Zurita, J. C., Herrera, R., Arenas, A., Torres, M. E., Calderon, C., Gomez, L., Alvarado, J. C., & Villavicencio, R. (2003b). Nesting loggerhead and green sea turtles in Quintana Roo, Mexico. Pages 125-126 in *Twenty-Second Annual Symposium on Sea Turtle Biology and Conservation*, Miami, FL.
- Zwinnenberg, A. J. (1977). Kemp's ridley, *Lepidochelys kempii* (Garman, 1880), undoubtedly the most endangered marine turtle today (with notes on the current status of *Lepidochelys olivacea*). *Bulletin Maryland Herpetological Society* 13(3):170-192.

REPORT

---

## **Appendix C: Protected Species Observers Onboard the *R/V Sally Ride***

FINAL REPORT

---

## Appendix C: Protected Species Observers Onboard the *R/V Sally Ride*

<b>Tetra Tech RPS Energy PSOs Deployed</b>	<b>Initials</b>
Ellisa Tienhaara	ET
Pamela Parnell	PP
Michelle Klein	MK

## **Appendix D: Complete Survey Datasheets (provided in attached file in Excel format)**

## Appendix E: Photos of Protected Species During the Survey

**FINAL REPORT**

---

## Appendix E: Photos of Protected Species During the Survey



*Figure 1: VD#001 - California sea lion – 05 September 2025*



*Figure 2: VD#002 - Gray whale – 05 September 2025*

**FINAL REPORT**

---



*Figure 3: VD#004 - Sea otter - 05 September 2025\_a*



*Figure 4: VD#005 - Humpback whale - 05 September 2025*

## FINAL REPORT

---



*Figure 5: VD#006 - California sea lion - 05 September 2025*



*Figure 6: VD#007 - Fin whale - 05 September 2025*

## FINAL REPORT

---



*Figure 7: VD#008 - Humpback whale - 05 September 2025*



*Figure 8: VD#009 - Sea otter - 06 September 2025*

**FINAL REPORT**

---



*Figure 9: VD#010 - Humpback whale- 06 September 2025*



*Figure 10: VD#013 - Humpback whale – 06 September 2025*

**FINAL REPORT**

---



*Figure 11: VD#015 - Pacific white-sided dolphin - 08 September 2025*



*Figure 12: VD#016 - Humpback whale - 08 September 2025*

**FINAL REPORT**

---



*Figure 13: VD#018 - Humpback whale - 08 September 2025*



*Figure 14: VD#019 - Humpback whale - 08 September 2025*

## FINAL REPORT

---



*Figure 15: VD#024 - Humpback whale - 09 September 2025*



*Figure 16: VD#025 - California sea lion - 09 September 2025*

**FINAL REPORT**

---



*Figure 17: VD#027 - Harbor porpoise - 09 September 2025*



*Figure 18: VD#028 - California sea lion - 09 September 2025*

**FINAL REPORT**

---



*Figure 19: VD#029 – Harbor seal - 09 September 2025*

## **Appendix F: Trackline shapefiles (provided separately)**

## Appendix G: Reticle Binocular Calibration Table

**FINAL REPORT**

## Appendix G: Reticle Binocular Calibration Table

Week #	Date	Observer Name	Reticle Binocular Magnification (7x,10x, etc.)	Reticle Binocular Estimated Distance (m)	True Distance from Radar (m)	Sea State (Beaufort)	Wind Force (knots)	Swell (m)	Comments
1	2024-09-06	Michelle Klein	7x50	897	950	2	6	<2	Streamer tail buoy
1	2025-09-07	Pamela Parnell	7x50	3000	3019	3	8	<2	Fishing vessel
1	2025-09-07	Ellisa Tienhaara	10x50	970	950	4	16	<2	Streamer tail buoy