



Protected Species Mitigation and Monitoring Report

Marine Geophysical (Seismic) Survey
Northeast Pacific Ocean

Axial Seamount
11 July 2019 – 13 August 2019

R/V Marcus G. Langseth

Prepared for:

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1. EXECUTIVE SUMMARY

The U.S. National Science Foundation (NSF) owned research vessel, (R/V) *Marcus G. Langseth* (*Langseth*), operating under an existing cooperative agreement by Columbia University's Lamont-Doherty Earth Observatory (L-DEO), conducted a combined three-dimensional (3D) and two-dimensional (2D) survey in the Northeast Pacific Ocean along the Axial Seamount from 11 July 2019 to 13 August 2019. The operational activities were conducted for a research survey proposed by Principal Investigators (PIs) Drs. A. Arnulf (University of Texas at Austin's Institute for Geophysics), G. Kent and A. Kell (Nevada Seismological Laboratory at the University of Nevada Reno), and A. Harding (Scripps Institution of Oceanography at the University of California San Diego).

The purpose of the survey was to collect 3D and 2D seismic reflection profiles of the Axial volcano/seamount and associated rift axes to look at the deep-seated structure of magma delivery. The data collected will be used to explore the linkages between the complex magma chamber structure, caldera dynamics, fluid pathways, and hydrothermal venting. The data will also contribute to a more comprehensive assessment of geohazards for the region that can be used to evaluate earthquake, tsunami, and submarine landslide hazards.

This report serves to comply with the reporting obligations for the survey required by the Marine Mammal Protection Act (MMPA) and Endangered Species Act (ESA). On 21 December 2018, L-DEO submitted an application to the National Marine Fisheries Service (NMFS) for an Incidental Harassment Authorization (IHA) that would allow for the potential harassment of small number of marine mammals incidental to the seismic surveys. On 10 July 2019, NMFS issued an IHA, an Incidental Take Statement (ITS), and a Biological Opinion (BO). Environmental Analysis (EA) was also prepared pursuant to Executive Order (EO) 12114 for the project and a Finding of No Significant Impact (FONSI) issued by NSF. In addition, the U.S. Fish and Wildlife Service (USFWS) issued a Letter of Concurrence (LOC) on 14 June 2019 that the proposed seismic surveys "may affect", but were not likely to "adversely affect", the endangered short-tailed albatross (*Phoebastria albatrus*) and the endangered Hawaiian petrel (*Pterodroma sanwicensis*). The USFWS also identified four non-listed migratory species at risk that could be present in the survey area, including the black-footed albatross (*Phoebastria nigripes*), the Laysan's albatross (*Phoebastria immutabilis*), the pink-footed shearwater (*Puffinus creatopus*), and the tufted puffin (*Fratercula cirrhata*), which is currently under review for listing. Mitigation measures were implemented to minimize potential impacts to marine mammals and endangered, threatened, or at-risk sea turtles and sea birds during the survey program. These measures included the use of NMFS approved Protected Species Observers (PSOs) for both visual and acoustic monitoring, the establishment of a 1,000 meter buffer zone from any source element (where operators would be alerted to the presence of the animal(s)), a 500-meter exclusion zone from any source element (where the source would be powered-down or shut down depending on the species present), 100 meter exclusion zone from a single operating source element (where the source would be shut-down), and the implementation of ramp-up procedures.

Continuous protected species observation coverage during the survey was provided by RPS, the environmental consulting company contracted by L-DEO. PSOs monitored and reported on the presence and behavior of protected species and directed the implementation of the mitigation measures as described in the NSF EA and FONSI (prepared pursuant to Executive Order 12114, Environmental Effects Abroad of Major Federal Actions (E.O. 12114)), and the IHA and ITS issued by NMFS. Additionally, PSO activities were consistent with the PSO standards identified in the Programmatic Environmental Impact Statement (EIS) / Overseas Environmental Impact Statement (OEIS) for Marine Seismic Research funded by the NSF or conducted by the U.S. Geological Survey and Record of Decision (referred to herein as the PEIS), to which the NSF EA tiered. Five PSOs, consisting of a Lead PSO and a designated Lead Passive Acoustic Monitoring (PAM) operator, were present on board the R/V *Langseth* throughout the survey program.

PSOs conducted visual observations for a total of 539 hours 13 minutes and acoustic monitoring for a total of 563 hours 29 minutes. Visual and acoustic monitoring was conducted simultaneously for a total of 365 hours 35 minutes.

The acoustic source was active for a total of 489 hours 55 minutes throughout the entire survey program, which occurred during 56% (303 hours 35 minutes) of the total visual monitoring and during 87% (487 hours 51 minutes) of the total acoustic monitoring.

There were three instances of beginning or resuming acoustic source operations did not follow the correct approved procedures. These instances were a ramp-up being started before the zones and radii were cleared after a detection of protected species, the source being resumed at full volume after a mechanical/technical shut-down when a ramp-up should have been conducted to resume source activity, and a ramp-up after a mitigation shut-down being cleared too early since additional time was required because there was a whale calf surfacing next to the adult large whale.

There was a total of 98 visual detections of protected species during the survey program totaling 229 individuals. There were no acoustic detections of protected species during the program. There was one visual sighting of a mixed pod of dolphins consisting of two different species that was only counted as one overall visual detection.

Visual detections included: 86 detections of whales, five detections of dolphins, six detections of porpoises, and one detection of pinnipeds. There were 12 positively identified species observed, including eight whale species, two dolphin species, and two porpoise species. Visual detections of positively identified species were seven sightings of blue whales (*Balaenoptera musculus*), 26 sightings of fin whales (*Balaenoptera physalus*), six sightings of humpback whales (*Megaoptera novaeangliae*), one sightings of minke whales (*Balaenoptera acutorostrata*), four sightings of sei whales (*Balaenoptera borealis*), one sighting of sperm whales (*Physeter macrocephalus*), one sighting of pygmy sperm whales (*Kogia breviceps*), one sighting of Baird's beaked whales (*Berardius bairdii*), one sighting of a mixed pod of northern right-whale dolphins (*Lissodelphis borealis*) and pacific white-sided dolphins (*Lagenorhynchus obliquidens*), four sightings of Dall's porpoises (*Phocoenides dalli*) and two sightings of harbor porpoises (*Phocena phocena*). There were also 39 detections of unidentified whales, four detections of unidentified dolphins, and one sighting of unidentified pinnipeds.

There were six mitigation actions implemented throughout the survey. These mitigation actions included two delayed operations and four shut downs. Overall, there were four hours 56 minutes of downtime attributed to mitigation actions implemented for detections of protected species, of which three hours 58 minutes were considered to be production loss.

The IHA and ITS issued by NMFS issued an IHA and ITS authorized 5,926 takes for 38 species of marine mammals (including five whale species and one pinniped species listed as endangered). Of this total, 5,865 individuals from all 38 species were authorized for Level B takes, and 61 individuals from only seven species were authorized for Level A takes. Takes for endangered species totaled 258 individuals, of which 14 individuals were authorized for Level A takes and 244 individuals were authorized for Level B takes. Authorized Level A takes for endangered species included two blue whales, seven fin whales, three humpback whales, and two sei whale. No Level A takes were authorized for the endangered sperm whale or endangered Guadalupe fur seal (*Arctocephalus townsendi*). Authorized Level B takes for endangered species included 19 blue whales, 74 fin whales, 32 humpback whales, six sei whales, 48 sperm whales, and 65 Guadalupe fur seals. Takes were authorized for one species of sea turtle, two takes for leatherback sea turtles. No specific take levels were authorized for any protected sea bird species.

During acoustic source operations, no protected marine mammals, were observed within the predicted radius at which there is 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. A total of 55 protected marine mammals were observed within the predicted 160 decibel radius (where there is potential for behavioral response), constituting potential Level B takes. This total included four blue whales, 24 fin whales, two humpback whales, three sei whales, one sperm whale, and 21 unidentified whales.

There were no sea turtles observed within the predicted 175 decibel radius (where there is a potential for behavioral response), and no sea turtles observed within the predicted 195 decibel radius (where there is potential for auditory injury based on the species hearing range). Mitigation measures for sea turtles included shutting down the acoustic source if the individual was observed approaching, entering or within the 100-meter exclusion zone for the single source element volume (40 in³) and the 3D survey source volume (3300 in³) or the 181-meter exclusion zone for the 2D survey source volume (6600 in³).

There were no sightings of protected ESA-listed seabirds. Mitigation measures for protected sea birds would have been implemented if they were observed diving or foraging within the exclusion zones while the acoustic source was active. This included powering down the source within the 500-meter exclusion zone and shutting down the source within the 100-meter exclusion zone. For the two listed species, mitigation actions would have been implemented for a single individual; however, for the four non-listed species, mitigation actions would be implemented for aggregations of any of those species. There were several sightings of two of the non-listed species, including the Laysan albatross and the black-footed albatross; however, they were only observed flying around the vessel, or in aggregations in the water outside of the exclusion zones.

A summary sheet of observation, detection, and operational totals for the survey program can be found in Appendix B.

2. INTRODUCTION

This report details protected species monitoring, mitigation actions, and seismic survey operations undertaken as part of the combined 3D and 2D marine geophysical survey onboard the *R/V Marcus G. Langseth* in the Northeast Pacific Ocean over the Axial Seamounts from 11 July to 13 August 2019.

This document serves to meet the reporting requirements dictated in the IHA and ITS issued to L-DEO by NMFS on 10 July 2019. The IHA and ITS authorized “takes” of Level A and Level B harassment of specific marine mammals, incidental to the marine seismic survey. NMFS has stated that seismic source received sound levels equal to or greater than 160 dB re 1 μ Pa (root mean square (rms)) could potentially disturb marine mammals, temporarily disrupting behavior, such that they could be considered non-lethal ‘takes’ (Level B harassment). In July 2016 and reconfirmed in 2018, NMFS released new technical guidance for assessing the effects of anthropogenic sound on marine mammal hearing, which established new thresholds for permanent threshold shift (PTS) onset, Level A harassment (auditory injury), for marine mammal species. Predicted distances to Level A harassment vary based on marine mammal 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 re 1 μ Pa (root mean square (rms)) represents the current best understanding of the threshold at which they exhibit behavioral responses, and that received sound levels equal to or greater than 195 dB re 1 μ Pa (root mean square (rms)) represents the current best understanding of the threshold at which they experience PTS.

NMFS requires that provisions such as exclusion zones (EZ), delayed operations, ramp-ups, power-downs and shut-downs be implemented as mitigation for potentially adverse effects of the acoustic source sounds on protected species. A 1,000-meter buffer zone, a 500-meter exclusion zone, a 181-meter exclusion zone, and a 100-meter exclusion zone were established from any single element on the acoustic source array as areas where the presence of a protected species would trigger the implementation of a mitigation action. This included delayed operations for all zones, a power-down or a shut-down of the acoustic source for the 500-meter EZ (depending on the species – see section 3.1) and a shut-down of the acoustic source for the 181-meter and 100-meter EZs. The 500-meter EZ is intended to be precautionary as it encompasses the zones for most species within which auditory injury (Level A harassment) could occur on the basis of instantaneous exposure. It provides additional protection from potentially more severe behavioral reactions for marine mammals at relatively close range to the acoustic source. The EZ also provides a consistent area for PSOs to conduct effective observational monitoring and is a distance where detection probabilities are reasonably high for most species under typical conditions. For sea turtles, the occurrence of an individual detected approaching, entering, or within the 100-meter or 181-meter EZ (for the single element volume of 40 in³, 3D survey volume of 3,300 in³ and for the 2D survey volume of 6,600 in³ respectively) would trigger the implementation of a shut-down of the acoustic source. For sea birds, the detection of one individual (listed species) or an aggregation of individuals (non-listed species at risk) foraging or diving within the 500-meter and 100-meter EZs would trigger a power-down and shut-down respectively.

2.1. PROJECT OVERVIEW AND LOCATION

The survey program was comprised of a combined 3D and 2D survey in the Northeast Pacific Ocean over the Axial Seamount between approximately 45.5-46.5 degrees North and 129.5-130.5 degrees West. The survey location was in International Waters outside of the U.S. Exclusive Economic Zone (EEZ), approximately 370.1 kilometers (230 miles) from shore at its closest point off the coast of Washington and Oregon. Water depths in the survey area ranged between 1,400 and 2,800 meters (4,593.2 to 9,186.4 feet) (Figure 1 and Figure 2).

The purpose of the survey was to study the Axial volcano/seamount and associated rift axes to understand the three-dimensional nature of the magmatic reservoirs that set the Axial volcano's framework. The objectives of the survey were to create a detailed image of the main and satellite magma reservoirs, image the fracture network and how they influence the magma bodies, and to connect the subsurface observations to the surface features.

All seismic survey operations were conducted by the *R/V Marcus G. Langseth*. The vessel is 72 meters (235 feet) in length and 17 meters (56 feet) in width and utilizes a particularly quiet propulsion system to avoid interference with the seismic signals. The *Langseth's* cruising speed was approximately 10 to 11 knots during transits and varied between three and five knots during survey operations when the seismic gear was being towed.

Seismic acquisition was conducted from 15 July to 11 August 2019, with the 3D portion of the survey conducted from 15 July to 08 August 2019 and the 2D portion of the survey conducted from 09 August to 11 August 2019. There was a total of 78 survey lines acquired during the survey program, including 68 3D lines and 10 2D lines (Figure 2). 53 of the 3D lines and nine of the 2D lines were considered prime lines, while the remaining survey lines were considered to be infills, re-shoots, and alternate lines. A total of 3,270.41 kilometers were surveyed during the program, including 2,903.14 kilometers during the 3D survey and 367.27 kilometers during the 2D survey.

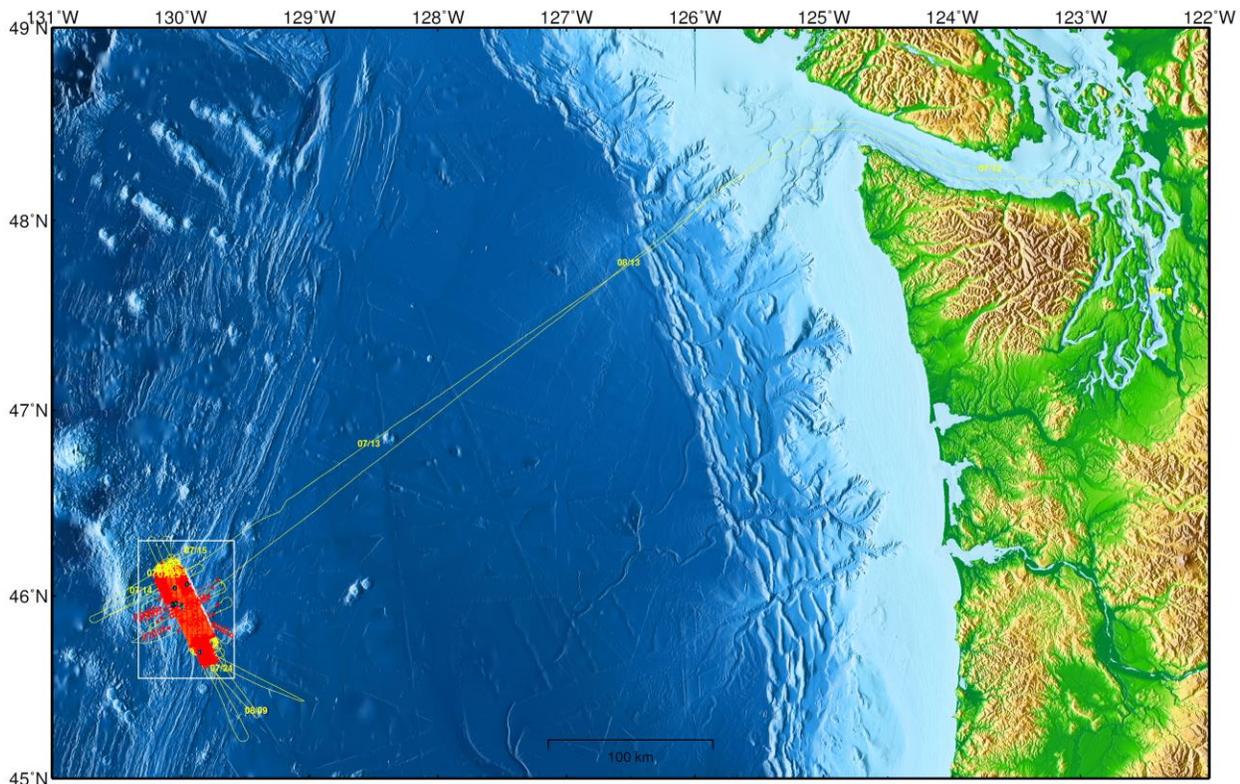


Figure 1: Location of the survey area in relation to the Washington and Oregon coasts.

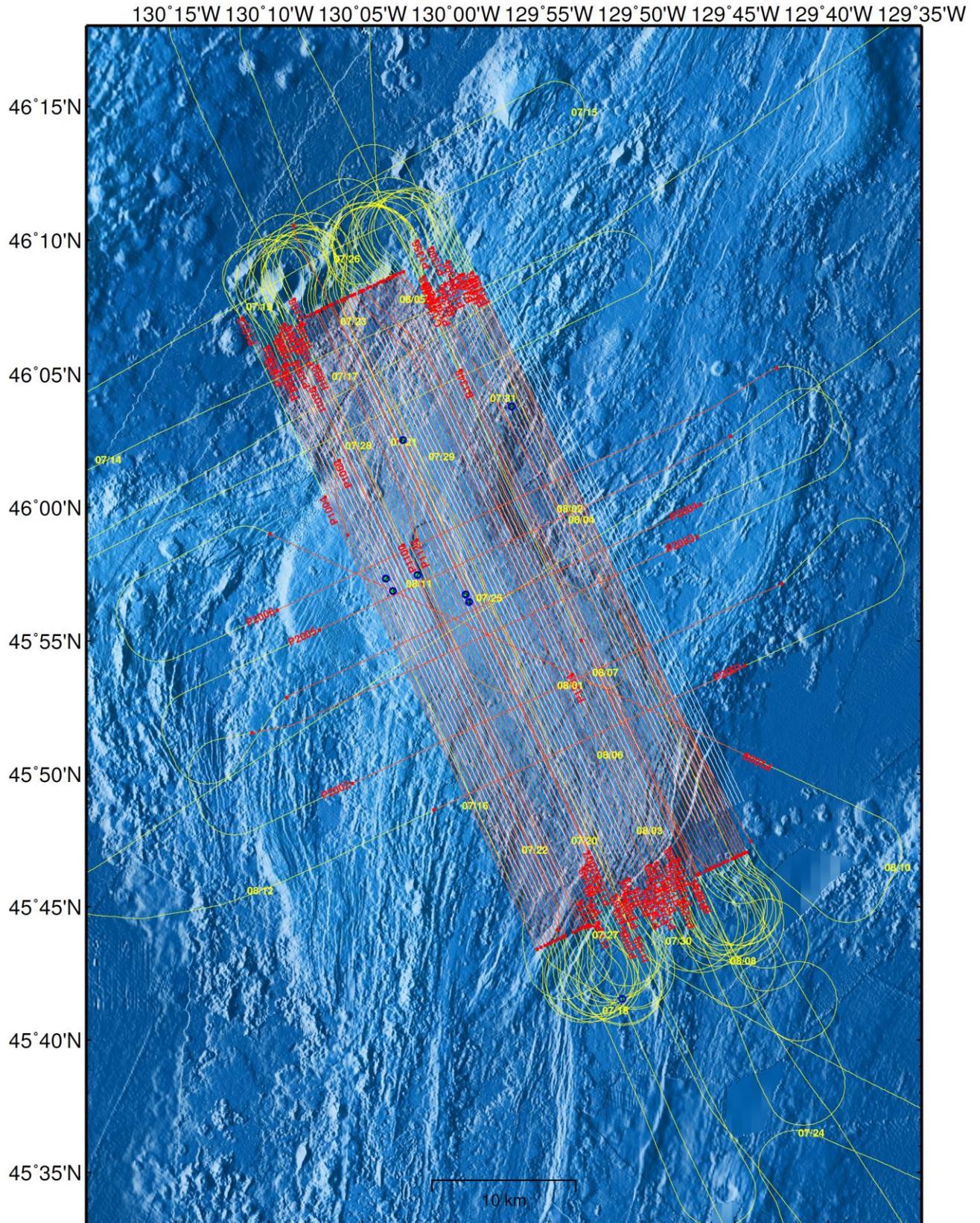


Figure 2. Survey lines of the Axial Seamount marine geophysical survey.

2.1.1. Energy Source and Receiving Systems

The energy source utilized consisted of four towed acoustic source sub-arrays, each with ten source elements (for a total of 40 source elements), deployed just aft of the vessel. The elements were a mixture of Bolt 1500LL and Bolt 1900LLX elements ranging in size from 40 to 360 cubic inches (in³), with an operating pressure of 1,950 pounds per square inch. The dominant frequency components ranged from two to 188 Hertz (Hz) and nominal source levels ranged from 259 to 265 dB re: 1 μ Pa (peak-to-peak). The source elements were towed at a depth of 12 meters. For the 3D survey, the center of the source was 280 meters from the Navigation Reference Point (NRP), which was located on the PSO observation tower. This positioned the first elements on the arrays 243 meters from the stern of the vessel. For the 2D survey, the center of the source was 230 meters from the NPR, which positioned the first elements on the arrays 193 meters from the stern of the vessel.

During the 3D part of the survey, the source was configured into two separate arrays (with two sub-arrays each) spaced 75 meters apart that were alternately activated (a flip-flop pattern). In this configuration, only a maximum of 18 elements were activated at one time, with a total maximum volume of 3,300 in³. During the 2D part of the survey, the source was configured in one array utilizing all four sub-arrays activated simultaneously. In this configuration, a maximum of 36 elements were activated at one time, with a total maximum volume of 6,600 in³. The additional elements in each configuration were considered spares that would only be activated in the event that one of the main elements could not be utilized. During times when individual sub-arrays were brought on board for maintenance or repair, or if a main element was switched with a spare, the source volumes were reduced to lower volumes depending on the size of the elements switched or the number of sub-arrays disabled.

The shot point interval was approximately 37.5 meters (123 feet of 16 to 17 seconds) for both 3D and 2D survey lines. During acquisition, the source elements would emit a brief (approximately 0.1 second) pulse of sound. During the intervening periods of operations, the source elements would be silent.

The receiving system consisted of hydrophone streamers and ocean bottom seismometers (OBSs). For the 3D part of the survey, four six-kilometer (3.2 nautical miles) hydrophone streamers spaced 150 meters apart were utilized. For the 2D part of the survey, one 11.7-kilometer (6.31 nautical miles) hydrophone streamer was utilized. As the acoustic source array was towed along the track lines, the hydrophone streamers received the returning acoustic signals and transferred the data to the onboard processing system. The long streamers allow for accurate measurements of seismic velocities and provides a large amount of data redundancy for enhancing seismic images during data processing. In addition, eight OBSs were positioned on the sea floor recording data throughout the survey. The OBSs were deployed by another vessel prior to the *Langseth* arriving in the survey area and will remain on the ocean floor for one year. The OBSs store the returning acoustic signals internally for later analysis.

Additional sound sources included a Kongsberg EM 122 multi-beam echosounder (MBES), Knudsen Chirp 3260 sub-bottom profiler (SBP), and a Teledyne RDI 75 kHz Ocean Surveyor acoustic Doppler current profiler (ADCP). The hull-mounted MBES operated at frequencies between 10.5 and 13 (usually 12) kilohertz. Each ping consists of eight (in water greater than 1,000 meters) or four (in water less than 1,000 meters) successive fan-shaped transmissions. The transmitting beam width is one or two degrees fore-aft and 150 degrees perpendicular to the ship's line of travel. The maximum source level is 242 dB re: 1 μ Pa (root mean square [rms]). The hull-mounted SBP beam is transmitted as a 27-degree cone, which is directed downward by a 3.5 kilohertz transducer. The nominal power output is 10 kilowatts; however, the actual maximum radiated power is three kilowatts or 222 dB re: 1 μ Pa m (rms). The ping duration is 64 seconds with a one second interval. The hull-mounted ADCP operates at a frequency of 75 kilohertz and a maximum source level of 224 dB re: 1 μ Pa m (rms) over a conically-shaped 30-degree beam. The MBES and SBP operated simultaneously providing information about near sea floor sedimentary features and mapping the topography of the ocean floor. The ADCP was used to measure water current velocities. The *Langseth* also towed a Geometrics G822 Cesium magnetometer approximately 110 meters off the starboard stern of the vessel during the 2D survey lines that mapped the sea floor.

3. MITIGATION AND MONITORING METHODS

The PSO monitoring program on the R/V *Langseth* met the standards set forth in the PEIS, NSF EA, USFWS LOC, IHA and ITS requirements. Survey mitigation measures were designed to minimize potential impacts of the *Langseth's* seismic activities on marine mammals, sea turtles, and other protected species of interest. The following monitoring protocols were implemented.

- Visual observations were conducted providing real-time sighting data, allowing for the implementation of mitigation procedures as required.
- A Passive Acoustic Monitoring (PAM) system operated continuously day and night during source operations to augment visual observations and provide additional marine mammal detection data.
- Effects of marine mammals, sea turtles, and sea birds exposed to sound levels constituting a take were observed and documented. The probable consequences were discussed when possible.

In addition to the mitigation objectives outlined in the PEIS, EA, USFWS LOC, IHA and ITS, PSOs collected and analyzed necessary data mandated by the IHA (see Appendix A).

3.1. MITIGATION METHODOLOGY

Mitigation actions were implemented for visual and acoustic detections of protected species, including marine mammals, sea turtles, and protected sea birds, as outlined in the IHA, ITS, BO and USFWS LOC. These actions included the establishment of a 1,000-meter buffer zone (BZ), a 500-meter, a 100-meter, and 181-meter EZs. Mitigation actions were implementation of delayed source operations, power-downs (during which the source volume was reduced to a single active 40 cubic inch element) and shut-downs (during which the source was fully silenced) for protected species detected approaching, entering, or within the designated zones.

Before the acoustic source could be activated after a period of silence, during daylight hours or during hours of darkness, two PSOs and one PAM operator conducted a 30-minute clearance survey of the BZ and EZs. In the event of a detection of protected species, a delay of source operations would be implemented if: (1) a marine mammal was detected approaching, entering, or within the 1,000-meter BZ; (2) if a protected seabird was detected foraging or diving within the 500-meter EZ; or (3) if a sea turtle was detected approaching, entering or within the 175-decibel radius. Source operations would not be cleared to begin until the protected species were observed exiting their designated zones. If the animals were not observed leaving their designated zones (i.e. if they dove within the zone and were not re-sighted), operations would not be cleared to begin until a specific time elapsed from the final detection of the animal. For detections of small odontocetes, pinnipeds, sea turtles, and sea birds, this time was 15 minutes following last sighting. For detections of mysticetes and all other odontocetes, including beaked whales, sperm whales, dwarf and pygmy sperm whales, pilot whales, and Risso's dolphins, this time was 30 minutes following last sighting.

Once the acoustic source was active, the 1,000-meter buffer zone (500 meters to 1,000 meters) from any element on the acoustic source arrays was established as an area 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 be required. PSOs and the PAM operator would keep in frequent contact with each other and the seismic team, relaying information on the location and movement of the animal(s), and the implementation of any needed mitigation actions.

The 500-meter EZ from any element on the acoustic source array was the area in which the presence of a marine mammal (with the exception of a few delphinid species) observed approaching, entering, or within the zone would initiate a shut-down of the source. A shut-down was also required for an acoustic only detection of marine mammal(s) (other than delphinids) that were confirmed to be within the 500-meter EZ. The 100-meter and 181-meter EZs from any element on the source array were established as the area in which a sea turtle observed approaching, entering, or within the zone would initiate a shut-

down of the source. The 100-meter EZ was for the smaller 3D source volume of 3,300 in³ while the 181-meter EZ was for the larger 2D source volume of 6,600 in³.

The 500-meter and 100-meter EZ were also for protected and at-risk sea birds, when an individual was visually observed diving or foraging within the EZ triggering a power-down (500-meter EZ) or a shut-down (100-meter EZ) of the source. For the listed sea bird species (short-tailed albatross and Hawaiian petrel), the observation of one individual of either of these species foraging or diving within the EZ would trigger a mitigation action. For the non-listed sea bird species (black-footed albatross, Laysan's albatross, pink-footed shearwater, and tufted puffin), only the observation of an aggregation (six or more individuals) of any of these species diving into the EZ would trigger a mitigation action.

The shut-down requirement was waived for small dolphins of the genera *Tursiops*, *Delphinus*, *Stenella*, *Lagenorhynchus*, and *Lissodelphis*. If PSOs could positively identify the dolphins sighted as one of these species, the acoustic source would be powered-down instead of shut-down if they were observed approaching, entering, or within the 500-meter EZ. However, if there was any uncertainty about the species identification, the source would instead be shut-down. If the acoustic source was powered-down due to the presence of one of these dolphin species for which the shut-down requirement was waived, the EZ was reduced to 100 meters around the single active element. If any other protected species were then observed approaching, entering, or within the smaller 100-meter EZ, the acoustic source would then be shut-down for the other species. Visual PSOs could also elect to waive the power-down requirement for these specific dolphin species if the individuals appeared to be voluntarily approaching the vessel for the purpose of interacting with the vessel or towed gear. However, if the PSOs observed the dolphins exhibiting any adverse reactions, then a power-down was required.

Once the acoustic source had been power-down for a detection of delphinids for which the shut-down requirement was waived or for a detection of a protected/at risk sea bird(s), the source had to remain powered-down until the dolphins or sea birds were no longer observed within the 500-meter EZ. Full volume source operations could then be resumed without a ramp-up. Once the source had been shut-down for a detection of protected species, a ramp-up was required to resume full volume operations, which would be cleared to begin once the protected species were confirmed to have exited their designated EZ. If the protected species were last observed within their designated EZs, ramp-up would not be cleared to begin after the specific time elapsed from the last sighting (either 15 or 30 minutes depending on the species).

The IHA and ITS also outlined several extra mitigation actions required for specific detections of protected species while the acoustic source was active.

1. The exclusion zone for all beaked whales, and dwarf and pygmy sperm whales was extended to 1,500-meters.
2. A shut-down was required when a large whale (defined as a sperm whale or any mysticete species) with a calf (defined as less than two-thirds the body size of the adult individual it is associated with) was observed at any distance from the vessel. Ramp-up would be cleared to begin 30 minutes after the whales' last sighting.
3. A shut-down was required for an aggregation of large whales (six or more individuals together in a group) observed at any distance from the vessel. Ramp-up would be cleared to begin 30 minutes after the whales' last sighting.
4. A shut-down was required for a North Pacific right whale observed at any distance from the vessel. Ramp-up would be cleared to begin 30 minutes after the whales' last sighting.
5. A shut-down was required upon the observation of any marine mammal species not authorized for take in the IHA and ITS approaching, entering, or within the 160-decibel radius. Ramp-up would be cleared to begin 15 or 30 minutes after the last sighting of the individual, depending on the species.
6. A shut-down was required upon the observation of any authorized marine mammal species that had reach it total allotted number of takes approaching, entering, or within the 160-decibel radius. Ramp-up would be cleared to begin 15 or 30 minutes after the last sighting of the individual, depending on the species.

Table 1 describes the predicted 160 decibel radius (Level B harassment zone for marine mammals), the predicted 175 decibel radius (behavioral harassment zone for sea turtles), and the predicted 195 decibel radius (auditory injury zone for sea turtles). Table 2 describes the predicted Level A harassment zones for each marine mammal hearing group per the NMFS new guidelines, and the species that could occur in the survey area assigned to each group.

Table 1: Predicted 160/175/195 Decibel Zones* for the survey program.

Source	Volume (in ³)	Water Depth (m)	160 dB radius – Level B harassment zone for marine mammals	175 dB radius – behavioural harassment zone for sea turtles	195 dB radius – auditory injury zone for sea turtles
1 element	40	>1,000	431	77	8
18 elements	3300	>1,000	3,758	814	76
36 elements	6600	>1,000	6,733	1,864	181

**Distances were from any single element on the array*

Table 2: Predicted Level A Harassment Zones* for the survey program.

Source	Volume (in ³)	Low Frequency Cetaceans (m)	Mid Frequency Cetaceans (m)	High Frequency Cetaceans (m)	Phocid Pinnipeds (m)	Otariid Pinnipeds (m)
1 element	40	1.76	0.51	12.5	1.98	0.4
18 elements	3300	75.6	11.2	118.7	25.1	9.9
36 elements	6600	426.9	13.6	268.3	43.7	10.6
Species anticipated that could occur in the survey area:	<ul style="list-style-type: none"> • Blue Whale • Humpback Whale • Fin Whale • Sei Whale • Minke Whale 	<ul style="list-style-type: none"> • Sperm Whale • All Beaked Whale Species • Bottlenose Dolphins • Striped Dolphins • Short-beaked Common Dolphins • Pacific White-sided Dolphins • Northern Right-Whale Dolphins • Risso’s Dolphins • False Killer Whale • Killer Whale • Short-finned Pilot Whale 	<ul style="list-style-type: none"> • Dall’s Porpoise • Dwarf Sperm Whale • Pygmy Sperm Whale 	<ul style="list-style-type: none"> • Northern Elephant Seal 	<ul style="list-style-type: none"> • Northern Fur Seal • Guadalupe Fur Seal 	

**Distances were from any single element on the acoustic source arrays*

3.2. VISUAL MONITORING SURVEY METHODOLOGY

There were five trained and experienced PSOs on board the *Langseth* to conduct monitoring for protected species, record and report detections, and request mitigation actions in accordance with the

PEIS, EA, USFWS LOC, IHA and ITS. The PSOs onboard were NMFS approved and held certifications from a recognized Bureau of Ocean Energy Management (BOEM) course. Visual monitoring was primarily carried out from an observation tower (Figure 3) located 18.9 meters above the surface of the water, which allowed a 360-degree view around the vessel and acoustic source.



Figure 3. Protected Species Observer observation tower with mounted big-eye binoculars, as seen from the stern of the vessel.

The PSO tower was equipped with Fujinon 7x50 and Steiner Marine 7x50 binoculars, as well as two mounted 25x150 Big-eye binoculars, and a D-300-2MS Night Optics USA, Inc. monocular (for visual clearance and monitoring of night time ramp-ups). In addition, a Butler Creek PVS-7-night vision binocular was secured in the bridge and could be requested for use by the PSOs. Inside the tarpaulin tent located in the middle of the platform was a laptop for data collection, and a telephone for communication with the PAM station, bridge, and main lab. Also, inside the tent was a monitor that displayed current information about the vessel (e.g. position, speed, heading, etc.), sea conditions (e.g. water depth, sea temperature, etc.), weather (e.g. wind speed and direction, air temperature, etc.), and source activity (e.g. survey line number, total number of active elements, volume, etc.). Environmental conditions along with vessel and acoustic source activity were recorded at least once an hour, or every time there was a change of one or more of the variables. Most observations were held from the tower; however, during severe weather or when the ships exhaust was blowing on the tower, observations would be conducted from the bridge (approximately 12.8 meters above sea level) or the catwalk (approximately 12.3 meters above sea level) around the bridge.

Visual monitoring methods were implemented in accordance with the survey requirements outlined in the IHA and ITS. Two PSOs visually monitored for protected species during daylight hours from the moment the vessel departed the dock at the beginning of the survey until the vessel returned to dock at the end of the survey, regardless of acoustic source activity. Visual monitoring during periods of acoustic source silence was conducted to gather baseline data on the presence and abundance of protected species in the areas. When the acoustic source was activated from silence at dawn or dusk, two PSOs would begin or end visual monitoring earlier or later to ensure that the entire 30-minute pre-clearance and ramp-up were monitored. When the acoustic source was activated from silence during hours of darkness, two PSOs would visually monitor the 30-minute pre-clearance and ramp-up until the source reached full volume. Visual monitoring during dawn, dusk and night hours was conducted using the two night-vision binoculars.

Visual monitoring was conducted each day 30 minutes before sunrise until 30 minutes after sunset as required by the IHA and ITS. Observation times ranged between 12:00 to 05:00 Coordinated Universal Time (UTC) (05:00 to 22:00 local time). A visual monitoring schedule was established by the PSOs.

Scheduled watches were a maximum four hours in duration followed by at least one hour of scheduled break time.

Visual observations were conducted around the entire area of the vessel and acoustic source, with each PSO on watch focused on a specific half of the area. 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 first 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, such as the acoustic source arrays and streamer head floats. PSOs would also identify the animals' species, if possible, upon initial detection to ensure that the proper mitigation measures were implemented, should any be required.

PSOs recorded the following information for each protected species detection:

- I. Date, time of first and last sighting, observers on duty during the detection, location of the observers, vessel information (e.g. position, speed, heading), water depth, acoustic source activity (e.g. volume and number of active elements), and environmental conditions (e.g. Beaufort Sea state, wind force, swell height, visibility and glare).
- II. Species, detection cue, group size (including number of adults and juveniles), visual description (e.g. overall size, shape of the head, position and shape of the dorsal fin, shape of the flukes, height and direction of the blow), observed behaviors (e.g. porpoising, logging, diving, etc.), and the initial and final pace, heading, bearing, and direction of travel in relation to both the vessel and the source (e.g. towards, away, parallel, perpendicular, etc.).
- III. Initial and final distance to the vessel and the source, time and distance of the closest distance to the source, time when entering and exiting the exclusion zones, type of mitigation action implemented, duration of the mitigation action and any production loss, description of other vessels in the area, and any avoidance maneuvers conducted.

During or immediately after each sighting event, the PSOs recorded the detection details per the requirements of the IHA and ITS in a provided detection datasheet. Each sighting event was linked to an entry on an effort datasheet where specific environmental conditions and vessel activity were logged.

Species identifications were made whenever the distance of the animal(s), length of the sighting, and visual observation conditions allowed. Whenever possible during detections, photographs were taken with two provided Canon EOS 80D cameras that had a 300-millimeter telephoto lens. Marine mammal identification manuals were consulted, and photos were examined during observation breaks to confirm identifications.

3.3. PASSIVE ACOUSTIC MONITORING (PAM) SURVEY METHODOLOGY

PAM was used to augment visual monitoring efforts in the detection of marine mammals. PAM was particularly beneficial during periods of darkness or low visibility when visual monitoring was not as effective. Acoustic monitoring was conducted continuously during all seismic operations and to the maximum extent possible during periods of acoustic source silence. When the acoustic source was activated from any period of silence, acoustic monitoring was conducted for at least 30 minutes prior to the activation of the source along with visual monitoring for the pre-clearance survey.

In accordance with the IHA and ITS, in the event of an issue with any of the PAM equipment, acoustic source activity could continue for 30 minutes without acoustic monitoring while the PAM operator diagnosed the issue. If the diagnosis indicated that the PAM system needed maintenance, operations could continue for an additional five hours without acoustic monitoring during daylight hours only provided that: (1) the sea state was less than or equal to BSS4, (2) no marine mammals (excluding delphinids) were detected solely by PAM within the exclusion zones in the previous two hours, (3) operations without

acoustic monitoring did not exceed a total of five hours in any 24 hour period, and (4) NMFS was notified as soon as practicable of the time and location operations without PAM began.

One trained PSO was designated as the Lead PAM Operator and oversaw all PAM operations during the survey. Other PSOs trained in the use of the PAM system also conducted acoustic monitoring to ensure continuous PAM operations. PAM shifts were a maximum of four hours in duration followed by at least a one-hour break.

The PAM system was located in the main science lab to provide space for the system, allow for quick communication with the visual PSOs and seismic technicians, and provide access to the vessel's instrumentation screens. Information about the vessel (e.g. position, heading, and speed), water depth, source activity (e.g. line number, total volume, number of active elements) and the PAM system (e.g. cable deployments/retrievals, changes to the system, background noise score) were recorded at least once an hour, or whenever any of the parameters changed.

Acoustic monitoring for marine mammals was conducted aurally, utilizing Sennheiser headphones, and visually with the *Pamguard* software program. Low to mid-frequency delphinid whistles, clicks, and burst pulses, as well as sperm whale clicks and baleen whale vocalizations, could be visualized in *Pamguard's* spectrogram modules. Sperm whale, beaked whale, Kogia species, and delphinid clicks could also be visualized in low and high frequency click detector modules. Setting adjustments to amplitude range, amplitude triggers, and spectral content filters, among others, could be made in *Pamguard's* spectrogram and click detector modules to maximize the distinction between cetacean vocalizations and ambient signal. The map module within *Pamguard* could be utilized to attempt localizing the position and range of vocalizing marine mammals. Sound recordings could be made using the high and low frequency sound recording modules when potential marine mammal vocalizations were detected, or when the operator noted unknown or unusual sound sources.

PAM operators recorded the following information during acoustic detections of protected species:

- I. Date, time of first and last detection, operator on duty, if the detection was linked to a visual sighting, vessel information (e.g. position, speed, heading), water depth, and acoustic source activity (e.g. volume and number of active elements).
- II. Species (if determinable), group size, methods/modules on which vocalizations were detected during the event, and vocalization characteristics (e.g. signal type, frequency and amplitude range, inter-click interval, patterns, etc.)
- III. Determinable bearings (to the hydrophones, vessel and source), estimated and/or attempted localizations and any ranges determined, type and time of any implemented mitigation actions and any resulting production loss.

3.3.1. PAM Parameters

A PAM system designed to detect most species of marine mammals was installed on board the *Langseth*. The system was developed by *Seiche Measurements Limited* and consisted of the following main components: a 250 meter hydrophone cable (configured as a separate 230 meter steel-reinforced tow cable and detachable 20 meter hydrophone array); a 100 meter deck cable; a rack-mounted electronic processing unit (EPU) that incorporated a buffer unit, RME Fireface 800 unit, and computer; two desktop monitors; acoustic analysis software package; and headphones for aural monitoring. The PAM operators used two pre-installed, wall-mounted computer monitors supplied by the *Langseth*. A spare hydrophone cable, deck cable, rack-mounted DPU and computer, monitors, and headphones were also present on board in the event the main system components became damaged or inoperable. The diagram in Figure 4 is a simplified depiction of the PAM system installed on the *Langseth*, and further PAM system specifications can be found in Appendix C.

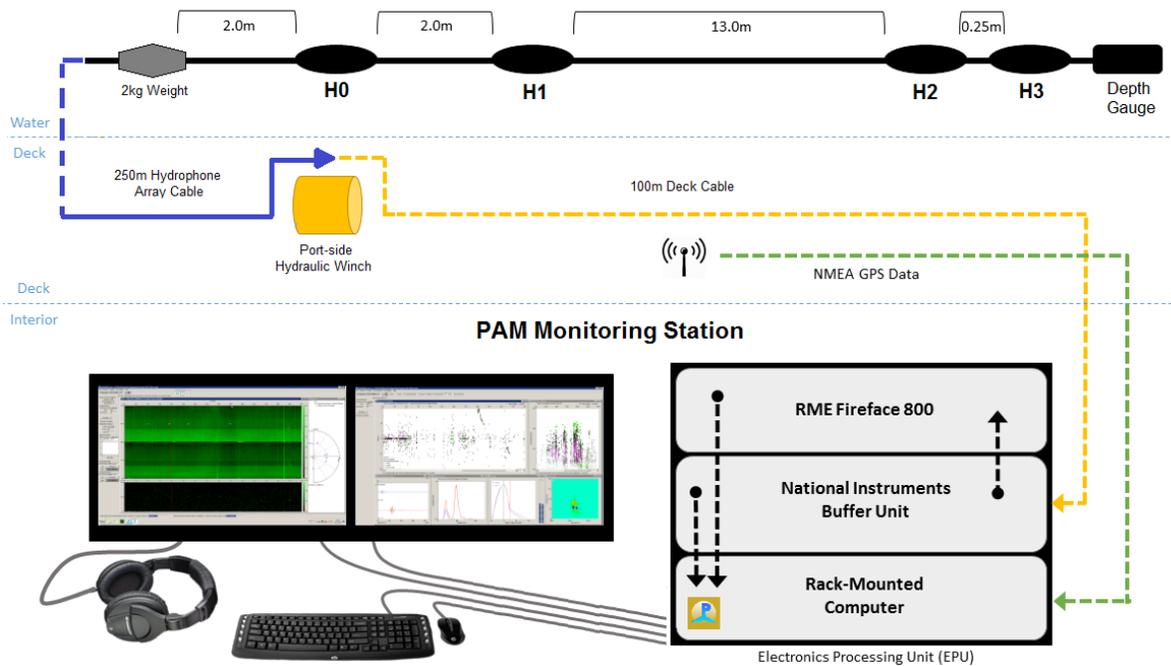


Figure 4: Simplified pathway of data through the PAM system on board the Langseth.

The hydrophone cable contained four hydrophone elements and a depth gauge molded into a 20m section of the cable. The four-element linear hydrophone array allowed the system to sample a large range of marine mammal vocalization frequencies. The first two hydrophones (H0 and H1) were broadband elements, with a frequency response of 200 hertz to 200 kilohertz. The third and fourth hydrophones (H2 and H3) were standard elements, with a frequency response of two kilohertz to 200 kilohertz.

The deck cable interfaced between the hydrophone cable and the electronics processing unit (EPU) located in the main science lab. The cable was installed on a winch on the aft deck of the vessel. The rack-mounted EPU was set up with the two pre-installed, wall-mounted monitors, keyboard, mouse and headphones. The EPU contained a buffer unit with Universal Serial Base (USB) output, an RME Fireface 800 ADC unit with firewire output, and a rack-mounted computer. A Global Positioning System (GPS) feed of GNGGA strings was supplied from the ship's Seapath navigation system and routed to the computer, reading data every 20 seconds. Data from the hydrophone cable's depth transducer was routed through the buffer unit to the computer, via USB connection. *Pamguard Beta* version 1.15.11 was the software version utilized for the survey.

Raw feed from the two standard hydrophone elements (H2 and H3) was digitized in the buffer unit using an analogue-digital National Instruments data acquisition (DAQ) soundcard at a sampling rate of 500 kilohertz. The output was filtered for high frequency (HF) content and visualized using the *Pamguard* software. Clicks were measured at sixth order (Butterworth) with a high-pass digital pre-filter of 30 kilohertz and a high-pass trigger filter of 40 kilohertz. *Pamguard* used the difference between the time that a signal arrived at each of the two hydrophones to calculate and display the bearing to the source of the signal. A scrolling bearing/time module displayed the filtered data in real time, allowing for the detection and directional mapping of click trains. Additional components of the HF click detector system in *Pamguard* were an amplitude/time display that registered click intensity data in real time, as well as click waveform, click spectrum, and Wigner plot displays, providing the PAM operator immediate review of

individual click characteristics in the identification process. One of the two monitors was designated for displaying *Pamguard* HF click detector and sound recorder modules.

Raw feed from the two broadband hydrophone elements (H0 and H1) was routed from the buffer unit to the RME Fireface 800 unit, where it was digitized at a sampling rate of 48 kilohertz. The relatively low frequency (LF) output was further processed within *Pamguard* by applying Engine Noise Fast Fourier Transform (FFT) filters, including click suppression and spectral noise removal filters (e.g. median filter, average subtraction, Gaussian kernel smoothing and thresholding). Filtered LF content was visualized in two spectrograms, one displaying two channel feeds at frequency ranges of three to 24 kilohertz, and another displaying on channel feed at a frequency range of zero to three kilohertz. LF click detector modules allowed for review of individual click characteristics as well as the detection and tracking of click trains.

A map module on the LF system interfaced with GPS data provided by the vessel to display the vessel location and could be used to determine range and bearing estimates based on clicks tracked in the click detector module. *Pamguard* contained a function for calculating the range to vocalizing marine mammals based upon the least squares fit test. This method is most effective with animals that are relatively stationary in comparison to the moving vessel, such as sperm whales. The mathematical function estimates the range to vocalizing marine mammals by calculating the most likely crossing of a series of bearing lines generated from tracked clicks or whistles and plotted on a map display. The bearings of detected whistles and moans were calculated using a Time-of-Arrival-Distance (TOAD) method (the signal time delay between the arrival of a signal on each hydrophone is compared), and presented on a radar display, along with amplitude information for the detected signal as a proxy for range.

Additional modules displayed on the LF monitor included a LF sound recorder and clip generator. The clip generator module within *Pamguard* could also be used to generate short sound clips in response to either an automatic detection or the operator manually selecting a portion of the spectrogram display. This module was useful in the event that the whistle-and-moan detector falsely triggered and identified a non-biological sound (i.e. echosounder) or if it missed detecting tonal signatures that the operator determined to be vocalizations.

3.3.2. Hydrophone Deployment

The hydrophone cable was deployed from a hydraulic winch on the port stern of the vessel's aft deck where the acoustic source arrays were deployed. Two deck cables, a main and a spare, were installed along the deck-head running from the winch to the main science lab. For the 3D survey, the hydrophone cable was deployed via roller from the lead-in for streamer four off the port stern of the vessel. A Chinese finger attached to the tow cable 30 meters from the end was secured to the roller via D-ring, which allowed the cable to move down the streamer lead-in into the water. This secured the cable to the lead-in to reduce the possibility of the cable entangling with the other seismic gear deployed astern. A second Chinese finger was attached on the tow cable 110 meters from the end, which was secured to a tow point on the stern of the vessel to reduce tension on the cable remaining on the winch. For the 2D survey, the hydrophone cable was deployed from the port side boom. The Chinese finger at 110 meters from the end of the cable was secured to the boom via lifting rope, which reduced tension on the cable remaining and moved the cable further to port and away from the source arrays.

The tailing end of the hydrophone cable was located approximately 110 meters off the port stern of the vessel. For the 3D survey, the end of the cable was approximately 133 meters ahead of the acoustic source arrays. For the 2D survey, the end of the cable was approximately 83 meters ahead of the acoustic source arrays. For both surveys, a one-meter length of chain weighing approximately 12 kilograms was secured onto the cable approximately 25 meters from the end. For the 3D survey, the extra weight assisted the roller moving down the streamer lead-in, and for the 2D survey, the extra weight assisted the hydrophones in towing at a deeper depth.

A more detailed description of the hydrophone deployment method, including photos of the installation, can be found in Appendix D.

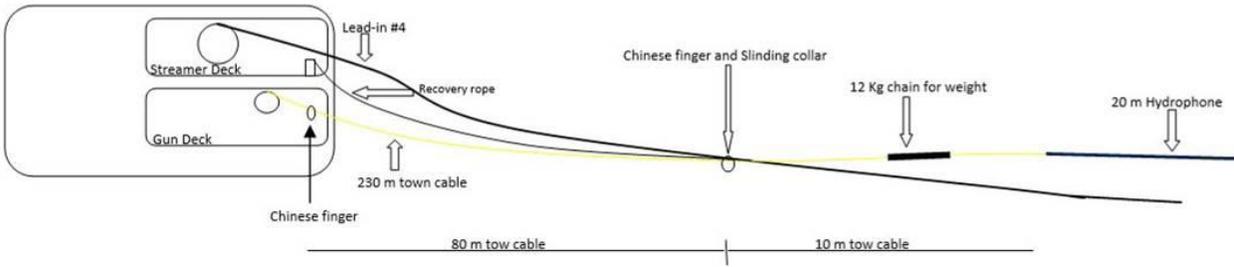


Figure 5: Location of the PAM cable in relation to the seismic gear during the 3D survey of the program.

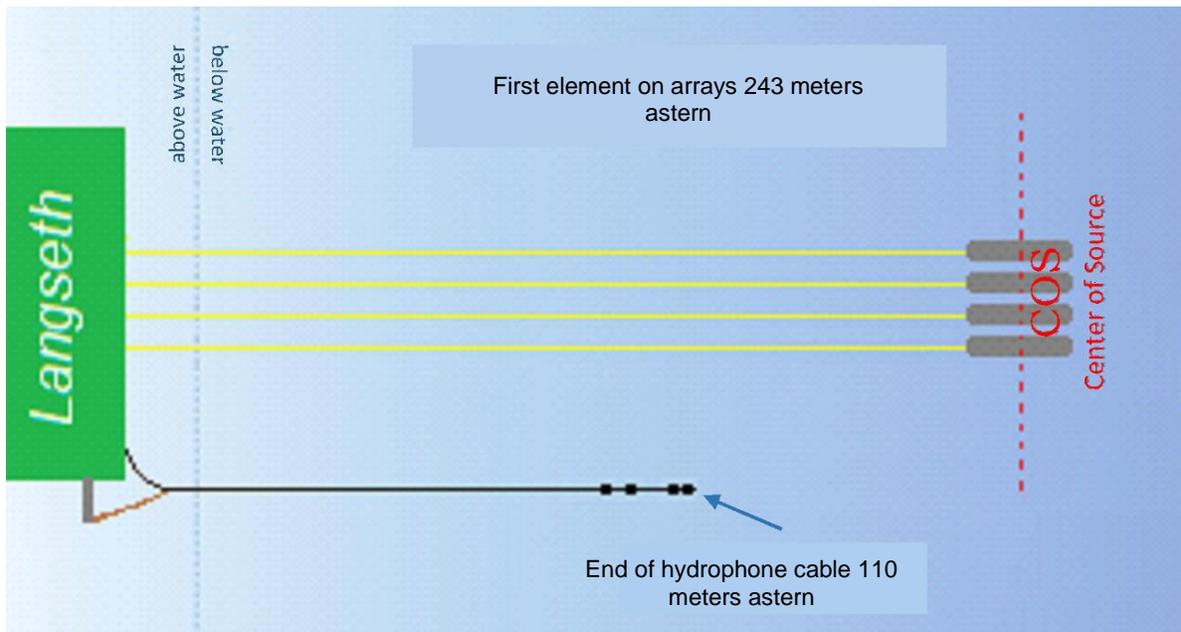


Figure 6. Location of the PAM cable in relation to the seismic gear during the 2D survey of the program.

4. MONITORING EFFORT SUMMARY

4.1. SURVEY OPERATIONS SUMMARY

4.1.1. General survey parameters

The Axial Seamount seismic survey program was conducted in one combined 3D and 2D survey (Table 3). The dates and times of acquisition for each survey line can be found in Appendix E.

Table 3: Survey parameters of the programs.

Survey Parameter	Date	Time (UTC)	Location
Mobilization	11 July 2019	15:00	Seattle, Washington
First Source Activity	15 July 2019	05:52	-
Start of Acquisition	15 July 2019	06:28	-
End of Acquisition	11 August 2019	22:14	-
Demobilization	13 August 2019	22:00	Seattle, Washington

During the program, data was acquired continuously according to the survey plan, with survey operations only suspended when operationally necessary, as outlined in Table 4.

Table 4: Suspension of survey operations during the survey program.

Date	Time Source silenced	Date	Time Ramp-up Initiated	Reason for Interruption in Acquisition
15 July 2019	21:11	16 July 2019	06:58	Engine repairs.
20 July 2019	12:43	21 July 2019	01:49	Streamer maintenance.
23 July 2019	07:57	25 July 2019	12:10	Streamer maintenance and engine repairs.
1 August 2019	18:56	2 August 2019	10:26	Streamer maintenance.
7 August 2019	06:57	7 August 2019	18:00	Streamer maintenance.
8 August 2019	16:01	9 August 2019	07:01	Seismic gear retrieved and re-configured for 2D survey lines.

4.1.2. MBES, SBP and ADCP operations

The multi-beam echosounder (MBES), sub-bottom profiler (SBP), and the Acoustic Doppler current profiler (ADCP) were active throughout the majority of the survey program while the vessel was in the permitted survey area. The systems were first activated at 05:57 UTC (MBES) and 05:58 UTC (SBP and ADCP) on 15 July 2019 after the acoustic source was activated. The systems were disabled at 02:08 UTC on 24 July 2019 as all of the seismic gear was retrieved for engine maintenance. They were re-enabled at 04:33 UTC on 25 July 2019. The systems were again disabled from 13:13 to 18:12 UTC on 07 August 2019 while operations were suspended to retrieve streamer four which had a broken lead-in. The systems were disabled at 18:35 UTC on 8 August 2019 while the seismic gear was retrieved and re-configured for the 2D survey lines. On 09 August 2019, the SBP was re-enabled at 04:19 UTC and the MBES and ADCP were re-enabled at 04:59 UTC. The systems were disabled for the last time at 22:17 UTC on 11 August 2019 concluding the survey.

4.1.3. Acoustic source operations

The acoustic source was active for 489 hours 55 minutes throughout the survey program. The acoustic source was ramped-up 49 times totaling 15 hours 44 minutes over the course of the survey program to commence full volume operations from a period of source silence or to resume full volume operations from a mitigation shut down for protected species.

Table 5 summarize the acoustic source operations.

Ramp-ups averaged 20 minutes in duration and utilized the automated controller program, DigiShot, which added source elements sequentially to achieve the full source volume over the required period. Ramp-ups were performed by cycling each source element two times at a shot point interval of 17 seconds, adding an additional element after each cycle. There were 44 ramp-ups initiated during daylight hours, and five initiated during hours of darkness. All ramp-ups were cleared and monitored by both visual and acoustic monitoring per the survey requirements. The dates and times for each ramp-up conducted during the survey program can be found in Appendix F.

There was one ramp-up that was started before it was cleared by the PSOs. On 19 July 2019, a ramp-up of the acoustic source was delayed due to a visual sighting of an adult fin whale with a calf. The ramp-up was cleared to begin at 16:32 UTC; however, due to a mis-communication between the seismic technicians and the PAM operator on duty at that time, the ramp-up was started at 16:23 UTC. Only a single 40 in³ element was activated one time before the issue was discovered and the source was silenced until the ramp-up was cleared to begin. The situation was reviewed by all personal involved, and proper communication procedures were reviewed to prevent another incident.

There was one ramp-up that was cleared to begin too early due to a whale calf not being observed during the initial detection. On 07 August 2019, the acoustic source was shut-down for a visual detection of a fin whale within the 500-meter exclusion zone. During the shut-down, an adult blue whale was observed outside of the exclusion zone, and the ramp-up was cleared 30 minutes after the fin whale was last sighted within the exclusion zone. However, when the detection pictures were reviewed a few hours later, a calf was identified having surfaced right next to the adult blue whale. Therefore, the ramp-up should have been cleared 30 minutes following the last observation of the calf. The situation was reviewed, and the PSOs determined the most appropriate approach was taken since there was no other option than to wait to review the blue whale detection pictures because several detections of protected species occurring within a short time frame.

There were no mitigation power downs for protected species during the survey. Power downs to a single 40 in³ source element for a mitigation would have been maintained until the exclusion zone was clear of the protected species, at which time the source would have been resumed to the full operating volume.

There was one occasion of acoustic source testing during the survey program. The test occurred on 21 July 2019 after operations had been suspended for streamer maintenance and consisted of a full volume source test (3300 in³ with 18 active elements) after a ramp-up which totaled two minutes.

Table 5. Total acoustic source operations during the seismic survey program.

Acoustic Source Operation	Number	Duration
Source Tests	1	00:02
Ramp-up	49	15:44
Day-time ramp-ups from source silence	44	13:53
Night-time ramp-ups from source silence	5	01:51
Full 6600 in³/Reduced Volume on a Survey Line¹		385:28
Full 6600 in³/Reduced Volume not on a Survey Line²		88:41
Single Source Element (40 in³)		00:00
Total Time Acoustic Source Was Active		489:55

1. **On a Survey Line:** 353:14 (full volume), 32:14 (reduced volume)
2. **Not on a Survey Line:** 84:03 (full volume), 04:38 (reduced volume)

Figure 7 **Error! Reference source not found.** shows the geospatial data for source operations conducted during each of the three surveys of the program. Information regarding volume changes during operations can be found in Appendix G.

In addition to the suspensions of operations outlined in Table 4, the acoustic source was silenced for mechanical/technical reasons on four occasions during the survey program (**Error! Reference source not found.**). Per the IHA, brief periods (less than 30 minutes) of operational silence due to mechanical/technical shut-downs did not require a ramp-up to resume full volume source operations provided that: (1) PSOs have maintained constant visual and/or acoustic observation, and (2) no visual or acoustic detections of protected species occurred within the applicable exclusion zone. For any brief mechanical/technical shut-down at night or in periods of poor visibility (e.g. BSS of four or greater), a ramp-up was required, but if the constant observation was maintained, a pre-clearance watch of 30 minutes was not required. For any shut-down longer than 30 minutes, both a 30-minute pre-clearance watch and a ramp-up were required.

There was one incident on 31 July 2019 where the acoustic source resumed at full volume after a mechanical/technical shut-down when a ramp-up should have been conducted to resume source activity. The source was silenced from 04:42 to 04:46 UTC; however, visual monitoring for the day had concluded at 04:41 UTC. As only acoustic monitoring was being conducted during the silent period, per the IHA, visual monitoring should have been resumed and the acoustic source should have been ramped-up to resume full volume operations. The situation was evaluated by all personal involved and the proper procedures for resuming source activity after a mechanical/technical source silence were reviewed to prevent any further occurrences of this issue.

Table 6: Mechanical and technical source silence.

Date	Reason for Source Silence	Time Acoustic Source Silenced (UTC)	Time Acoustic Source Resumed (UTC)
18 July 2019	Ramp-up aborted before completion due to a technical issue	16:13	16:14
18 July 2019	Ramp-up aborted before completion due to a technical issue	16:20	16:26
31 July 2019	Source silenced briefly while the compressors were re-started after being shut-down for an issue with the vessel's engines.	04:42	04:46
7 August 2019	Ramp-up aborted before completion due to a technical issue	22:04	22:05

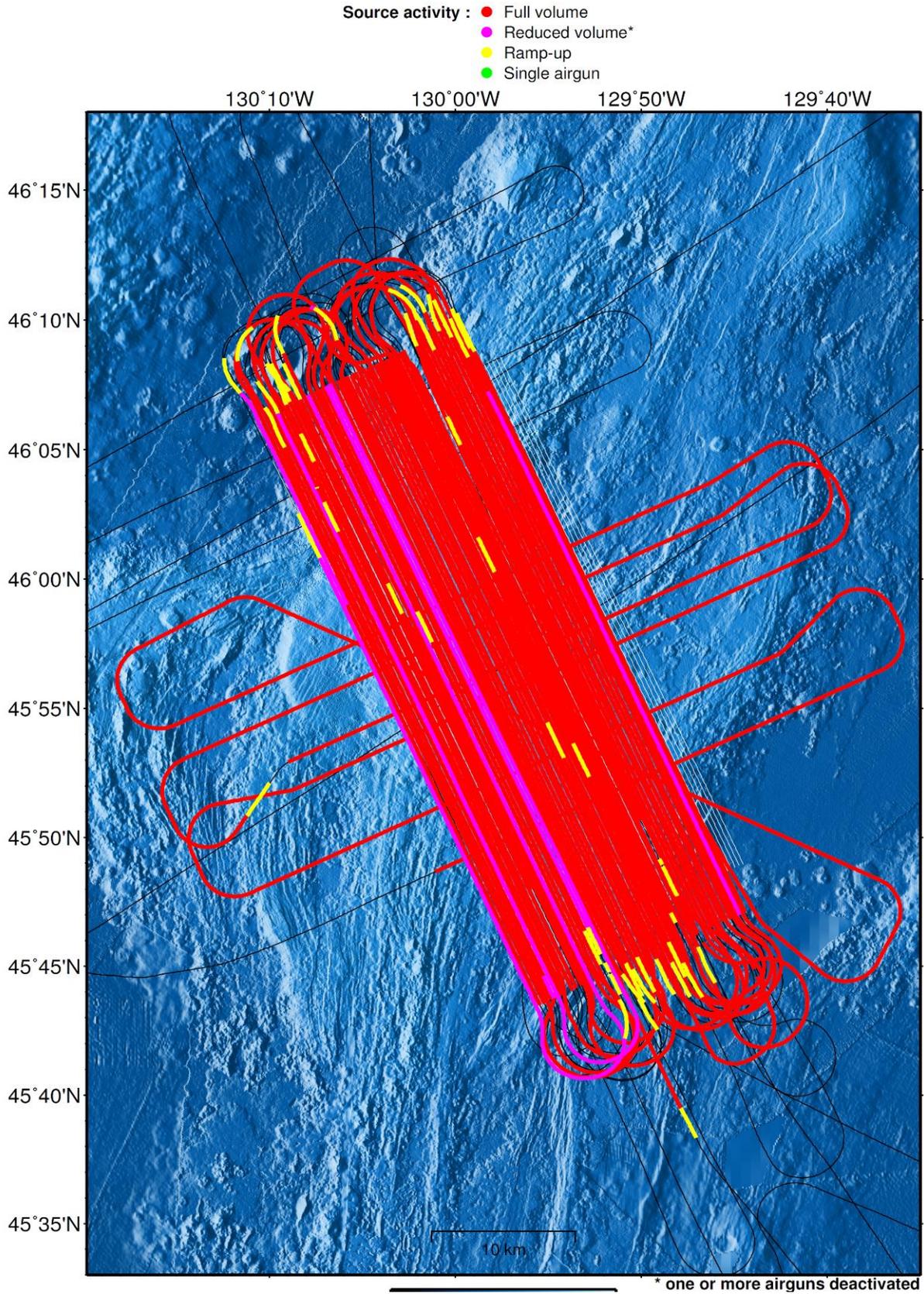


Figure 7: Geospatial data of source operations for the survey program

4.1.4. Interactions with Other Vessels

PSOs also observed and documented interactions with any other vessel traffic. 71 other vessels were observed in the vicinity of the R/V *Langseth*, including 25 cargo vessels, four cruise ships, 15 fishing boats, one navy ship, six recreational boats, 13 sail boats, six tankers, and one tug boat and barge. These vessels had an average closest distance of 4,800 meters to the *Langseth*, ranging between 100 and 15,000 meters.

Table 7 lists the number of each vessel type observed as well as the closest, farthest, and average distances each vessel type to the *Langseth*. The majority of these other vessels were observed as the *Langseth* transited to and from port and at the beginning and end of the survey program.

There were no occasions during the survey program where other vessels, or another vessels gear/equipment, were observed having some type of interaction with the *Langseth*'s seismic gear. There were no occasions during the survey program where the *Langseth* had to deviate from planned survey operations (e.g. diverge from the survey line, reduce speed) because of other vessels in the survey area.

Table 7: Other vessels observed during the survey program.

Vessel Type	Total Number Observed	Recorded Distance to the <i>Langseth</i> (meters)		
		Average	Closest	Farthest
Cargo	25	6,883	800	15,000
Cruise	4	3,250	3,000	7,000
Fishing	15	4,900	1,000	10,000
Navy	1	2,000	2,000	2,000
Recreational	6	750	100	1,000
Sail boat	13	1,915	400	5,000
Tanker	6	9,400	1,000	15,000
Tug boat and barge	1	3,500	3,500	3,500

4.2. VISUAL MONITORING SURVEY SUMMARY

Visual monitoring conducted by two PSOs during all daylight hours throughout the survey program, beginning 30 minutes before sunrise and ending 30 minutes after sunset each day, starting when the vessel left the dock and terminating upon return to port upon completion of the survey (Table 8). This included times when the vessel was in transit and deploying and retrieving equipment. Visual monitoring during times with no source operations was conducted to collect baseline data about protected species abundance in the survey areas.

Table 8: Initiation and termination of visual monitoring during the survey program.

Visual Monitoring	Date	Time (UTC)
Initiation for the survey program	15 July 2019	15:00
Termination for the survey program	13 August 2019	22:00

Visual monitoring was conducted over a period of 34 days for a total of 539 hours 13 minutes. Of the overall total visual monitoring effort, 56% (303 hours 35 minutes) was when the acoustic source was active, and 44% (235 hours 38 minutes) was when the acoustic source was silent. Visual monitoring while the acoustic source was silent was mainly conducted during the transits to and from the survey sites, and during equipment deployment, recovery and maintenance. Table 9 detail the visual monitoring effort with acoustic source operations throughout the survey program.

Table 9. Total visual monitoring effort during the survey program.

Visual Monitoring Effort	Duration (hh:mm)	% of Overall Visual Monitoring Effort
Total monitoring while acoustic source active	303:35	56
Total monitoring while acoustic source silent	235:38	44
Total monitoring effort	539:13	100

Preferred visual observations were conducted from the PSO tower, which provided a 360-degree view of the water around the vessel and the acoustic source. Visual watches were conducted from other locations including the catwalk, bridge and/or stern if monitoring conditions could not be undertaken from the tower, such as during rough weather and sea conditions which made the tower unsafe, or when the vessel was heading directly into the wind blowing the engine exhaust onto the tower. PSOs conducted visual monitoring from the tower (66%) and from the bridge (18%) more often than any other location. The majority of the monitoring from the bridge was conducted due to the exhaust from the engine stacks blowing onto the tower. Monitoring was conducted from the bridge and the catwalk and tower and catwalk simultaneously when the ships exhaust was blowing on part of the tower but monitoring conditions were otherwise favorable (Table 10).

Table 10: Total visual monitoring effort from observation locations during the survey program.

Observation Location During Visual Effort	Duration (hh:mm)	% of Overall Effort
Tower	357:24	66
Bridge	98:28	18
Catwalk	16:48	3
Stern	-	-
Tower/Bridge	03:24	1
Tower/Catwalk	14:18	3
Tower/Stern	-	-
Bridge/Catwalk	48:51	9
Bridge/Stern	-	-
Catwalk/Stern	-	-

4.3. ACOUSTIC MONITORING SURVEY SUMMARY

Acoustic monitoring conducted continuously throughout source operations and to the maximum extent possible while the source was silent (Table 11). Brief periods of source activity without acoustic monitoring were infrequently conducted for any needed assessments, adjustments, or maintenance to the PAM system. Periods without source activity or acoustic monitoring occurred when the PAM hydrophone cable was secured on board the vessel during transits, deployment and recovery of the seismic gear, and during times when operations were suspended due to rough weather and sea conditions.

Table 11: Initiation and termination of acoustic monitoring watches during survey program.

Acoustic Monitoring	Date	Time (UTC)
Initiation for the survey program	15 July 2019	04:55
Termination for the survey program	11 August 2019	22:42

Acoustic monitoring was conducted 27 days for a total of 563 hours 29 minutes. Of the overall total acoustic monitoring effort, 87% (487 hours 51 minutes) was undertaken while the acoustic source was active, and 13% (75 hours 38 minutes) was undertaken while the acoustic source was silent. Acoustic monitoring while the acoustic source was silent was mainly conducted during the brief periods of time between recovery/deployment of the seismic gear and recovery/deployment of the PAM cable. Table 12 details acoustic monitoring with acoustic source operations throughout the survey program.

Table 12. Total Passive Acoustic Monitoring (PAM) effort during the survey program.

Acoustic Monitoring Effort	Duration (hh:mm)	% of Overall Acoustic Monitoring Effort
Total night time monitoring	202:34	36
Total day time monitoring	360:55	64
Total monitoring while the acoustic source was active	487:51	87
Total monitoring while the acoustic source was silent	75:38	13
Total acoustic monitoring	563:29	100

Acoustic monitoring was suspended 11 times for a variety of reasons. This included replacement of damaged PAM equipment, assessment/adjustment of PAM equipment, seismic gear deployment/retrieval/maintenance, and vessel engine maintenance, which required the retrieval of the towed gear. Acoustic monitoring downtime was calculated as any time acoustic monitoring was not conducted between the first deployment of the hydrophone cable at the beginning of survey, and the last retrieval of the hydrophone cable at the end of the survey.

Acoustic monitoring downtime totaled 102 hours 18 minutes, the majority of which was due to seismic gear deployment/retrieval/maintenance (85%) (Table 13). Each instance of acoustic monitoring downtime is recorded in Appendix H. Acoustic monitoring downtime occurred during acoustic source activity only when unavoidable. Throughout the entire survey program, only two hours four minutes of acoustic monitoring downtime occurred while the acoustic source was still active. These occurrences were attributed to the assessment, adjustment, maintenance, and replacement of the PAM equipment.

Table 13. Passive Acoustic Monitoring (PAM) downtime during the survey program.

Cause of Downtime	Duration (hh:mm)	% of Overall Downtime
Replacement of Damaged PAM Equipment	01:04	1
Assessment and Adjustment to PAM Equipment	01:00	1
Seismic Gear Deployment/Retrieval/Maintenance	86:35	85
Vessel Engine Maintenance	13:39	13
Total Passive Acoustic Monitoring Downtime	102:18	100

4.4. SIMULTANEOUS VISUAL AND ACOUSTIC MONITORING SUMMARY

Simultaneous visual and acoustic monitoring was conducted to the maximum extent possible for a total of 365 hours 35 minutes. Of the overall simultaneous monitoring effort, 83% (301 hours 43 minutes) was conducted while the acoustic source was active (Table 14). Additional visual monitoring conducted during transit periods was not accompanied by acoustic monitoring as the increased vessel speed caused the hydrophone cable to migrate to the water surface, out of the ideal tow position, where the increased background noise impaired acoustic detection capabilities.

Table 14: Simultaneous visual and acoustic monitoring effort during the survey program.

Simultaneous Visual and Acoustic Monitoring	Duration (hh:mm)	% of Overall Downtime
Source Active	301:43	83
Source Silent	63:52	17
Overall Total	365:35	100

4.5. ENVIRONMENTAL CONDITIONS

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

Visibility was classified as ‘excellent’ if it extended to 10 kilometers or greater and ‘good’ if they were between six to nine kilometers. During the survey program, 65% and 17% of monitoring effort was undertaken at ‘excellent’ and ‘good’ visibility levels respectively (Table 15).

Table 15. Visibility during the survey program.

Total	<2 km	2-5 km	6-9 km	≥10 km
Duration (HH:MM)	30:52	65:11	93:22	349:13
% of effort	6	12	17	65

Reduced visibility was mainly attributed to periods of rain and fog, and the brief periods of reduced lighting before sunrise and after sunset. Precipitation was recorded during 18% of visual monitoring, for a total of 98 hours 10 minutes. The majority of the precipitation was fog (9.70%, 52 hours 19 minutes) (Table 16).

Table 16. Precipitation during the survey program.

Total	None	Light Rain	Heavy Rain	Squall	Fog
Duration (HH:MM)	441:03	42:33	03:18	00:00	52:19
% of effort	81.79	7.89	0.61	0	9.70

During visual monitoring, the entire predicted 160 decibel radius was not visible for 62 hours and nine minutes, due to precipitation. The entire 1,000-meter buffer zone was not visible for 17 hours 24 minutes, and the entire 500-meter exclusion zone was not visible for six hours 59 minutes. There was no time during the survey program where the entire 100-meter exclusion zone was not visible during visual monitoring efforts (Table 17).

Table 17. Duration radii were NOT fully visible during the survey program.

Total	160 dB	1000 m	500 m	100 m
Duration (HH:MM)	62:09	17:24	06:59	00:00
% of effort	12	3	1	0

The Beaufort Sea state recorded during visual monitoring ranged from level one to level five over the course of the survey program. The majority of visual observations (466 hours 27 minutes, 86.51%) were undertaken in conditions where the Beaufort state was level two or three, which were considered good conditions for the detection of protected species (Table 18).

Table 18. Beaufort Sea State during the survey program.

Total	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
Duration (HH:MM)	21:52	208:53	257:34	49:09	01:45	00:00	00:00	00:00	00:00	00:00
% of effort	4.06	38.74	47.77	9.12	0.32	0	0	0	0	0

The Beaufort wind force recorded during visual monitoring ranged from one (one to three knots) to six (22 to 27 knots). The majority of visual monitoring occurred during a recorded wind force of three (seven to ten knots) and four (11 to 16 knots), for a total of 372 hours 53 minutes (69.15% of all visual monitoring effort). The highest wind speeds, between 22 and 27 knots (level six), were recorded for a total of six

hours 24 minutes (1.19% of the overall project total) (Table 19).

Table 19. Beaufort Wind Force during the survey program.

Total	B1 (1-3 knots)	B2 (4-6 knots)	B3 (7-10 knots)	B4 (11-16 knots)	B5 (17-21 knots)	B6 (22-27 knots)	B7 (28-33 knots)	B8 (34-40 knots)	B9 (41-47 knots)	B10 (48-55 knots)
Duration (HH:MM)	10:06	100:35	191:15	181:38	49:15	06:24	00:00	00:00	00:00	00:00
% of effort	1.87	18.65	35.47	33.68	9.13	1.19	0	0	0	0

Swell heights during visual observations were generally low, with swells of less than two meters recorded for the majority of visual observations (516 hours 33 minutes, 96% of the total visual effort) (Table 20).

Table 20. Swell Height during the survey program.

Total	<2m	2-4m	>4m
Duration (HH:MM)	516:33	22:40	00:00
% of effort	96	4	0

The majority of visual monitoring effort was conducted while no glare was present, for a total of 258 hours 26 minutes (48%, Table 21). During times of moderate to severe glare, it is possible that the detection of protected species was hindered.

Table 21. Glare during the survey program.

Total	None	Little	Moderate	Severe
Duration (HH:MM)	258:26	63:06	80:36	137:05
% of effort	48	12	15	25

5. MONITORING AND DETECTION RESULTS

5.1. VISUAL DETECTIONS

Visual monitoring efforts resulted in a total of 98 visual detections of protected species. This included 86 detections of whales, five detections of dolphins, six detections of porpoises, and one detection of pinnipeds. Table 22 lists the total number of detections and total number of animals recorded for each protected species observed during the survey program. More detailed information about each sighting event can be found in Appendix I, and photographs taken of visual detections can be found in Appendix J.

Table 22. Number of visual detection records collected for each protected species during the survey program.

Species	Total Number Detection Records	Total Number Animals Recorded
Whales		
Blue Whale	7	14
Fin Whale	26	40
Humpback Whale	6	11
Minke Whale	1	1
Sei Whale	4	4
Sperm Whale	1	1
Pygmy Sperm Whale	1	2
Baird's Beaked Whale	1	8
Unidentified Whale	39	55
Dolphins		
Northern Right-Whale Dolphins	1*	20
Pacific White-Sided Dolphins	1*	5
Unidentified Dolphins	4	48
Porpoises		
Dall's Porpoise	4	14
Harbor Porpoise	2	3
Pinnipeds		
Unidentified Pinniped	1	1
TOTAL	98	229

*Detections occurred simultaneously with a detection of another species as a mixed pod and were not counted as separate detections towards the overall project total.

Unidentified whales were the most frequently and numerous observed species, followed by fin whales, totaling 39% and 26% of all visual protected species detections and 24% and 21% of the total individuals observed respectively. There were a few detections of large pods of dolphins; however, in general, most sightings consisted of four individuals or less. In addition, there were six calves observed during the survey program, including two blue whale calves, two fin whale calves, one pygmy sperm whale calf, and one harbor porpoise calf.

The majority of the protected species detections occurred within the survey area while the vessel was on a survey line (Figure 8). All of the detections within the survey area consisted of whales. All sightings of dolphins, porpoises, and pinnipeds occurred while the vessel was transiting to and from the survey area at the beginning and end of the survey program (Figure 9). There was some variability in weather conditions throughout the survey program, mainly with visibility due to precipitation. However, in general, days with high numbers of visual detections corresponded with days with high visibility, small swells, and calm seas (Figure 10).

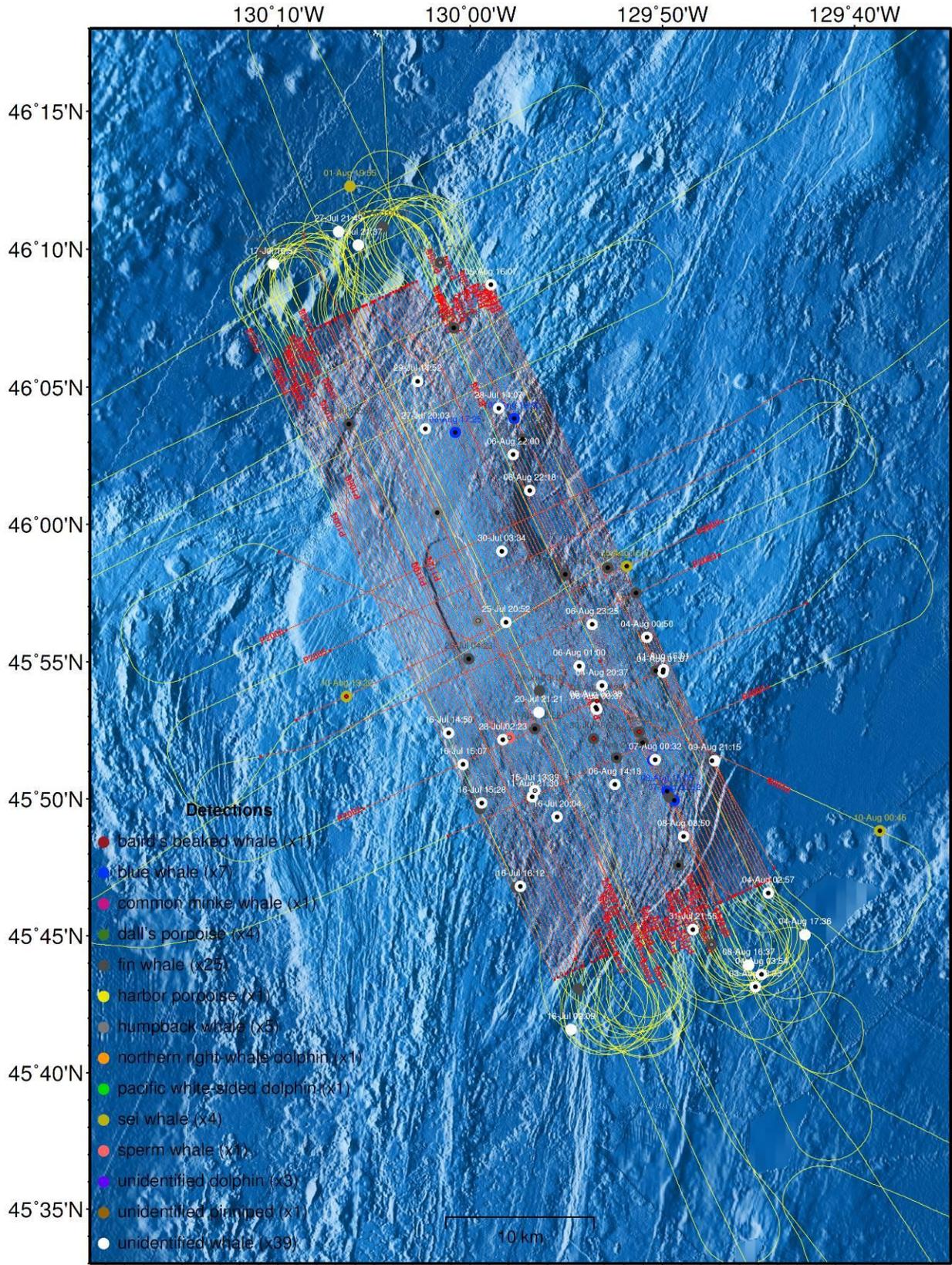


Figure 8: Protected species detections within the survey area.

MGL1905 protected species detections - sorted

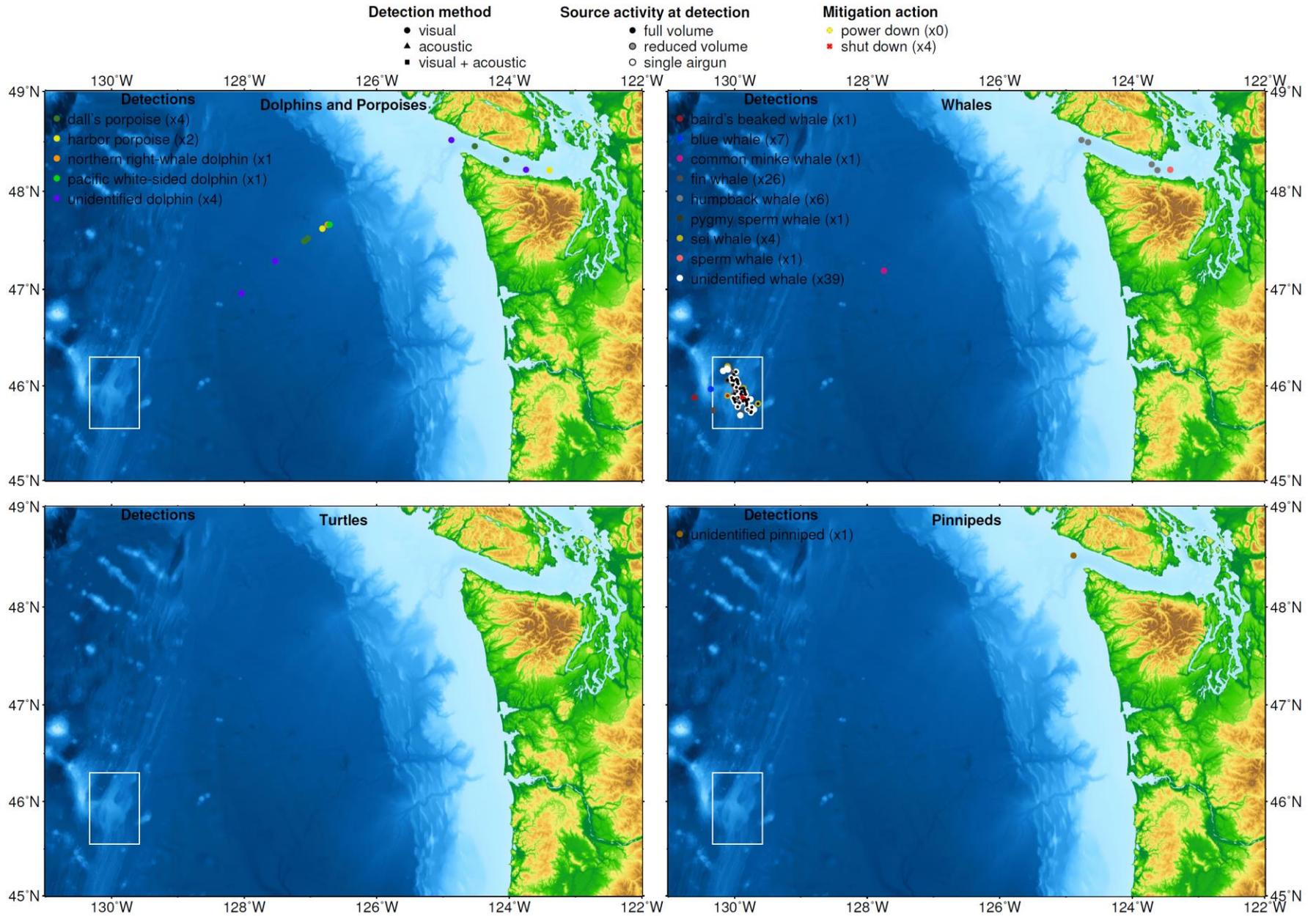


Figure 9: All protected species observed during the survey by species group.

Visual Detections and Weather Conditions During the Survey Program

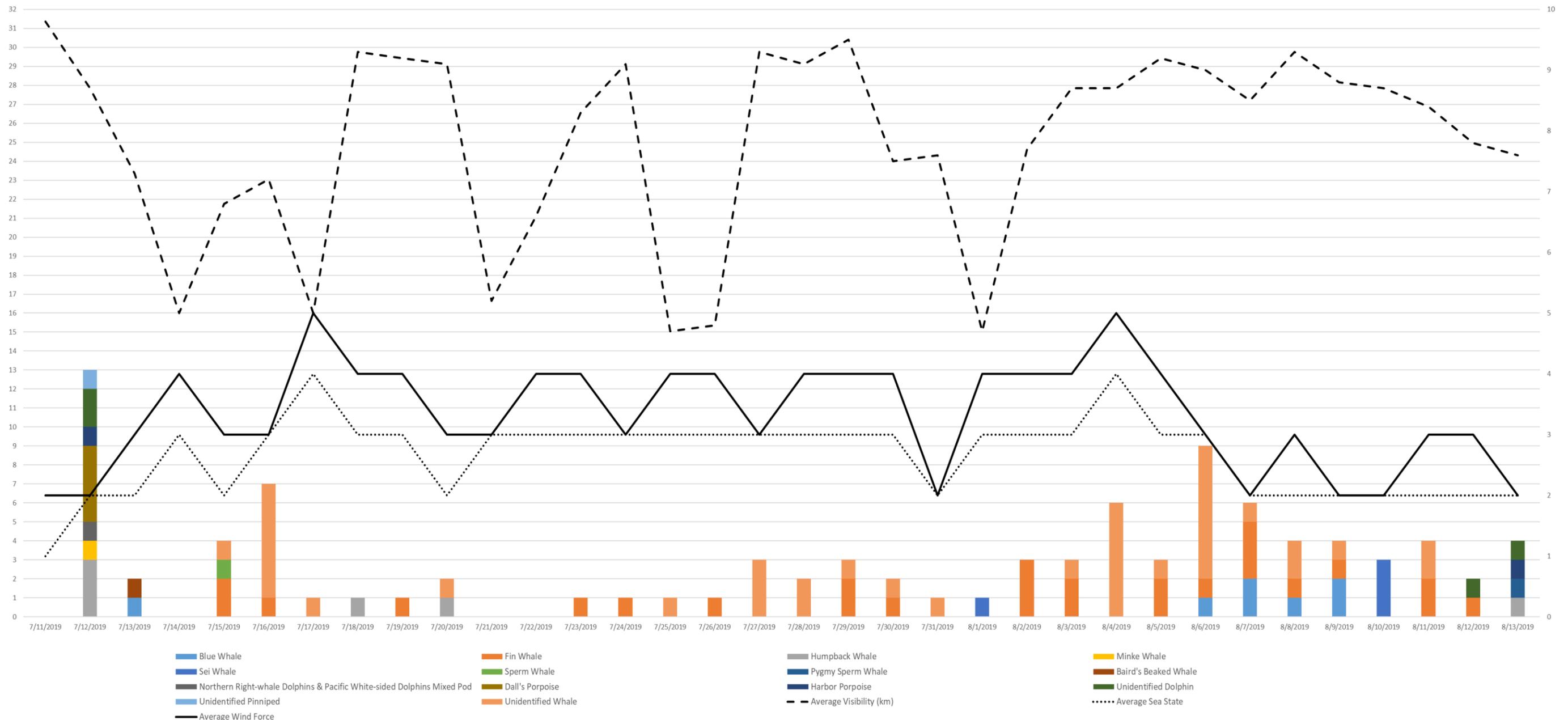


Figure 10: Number of protected species detections each day of the survey program and corresponding weather data for each day.

Of the 98 visual detections of protected species, 50 detections (51%) occurred/began while the acoustic source was active at full volume on a survey line, three detections (3%) occurred/began while the acoustic source was active at reduced volume on a survey line, six detections (6%) occurred/began while the acoustic source was active at full volume not on a survey line, two detections (2%) occurred/began while the acoustic source was being ramped-up, and 37 detections (38%) occurred/began while the acoustic source was silent (Table 23).

During full volume source operations on a survey line, there were five detections of blue whales, 16 detections of fin whales, one detection of humpback whales, two detections of sei whales, and 26 detections of unidentified whales. Of these species, sei whales had the closest approach to the source, with a distance of 438 meters. Fin whales had the second closest approach, with distance of 530 meters. There was one detection of a fin whale calf while the acoustic source was active at full volume on a survey line, and the calf and adult whales had a closest observed distance of 1,926 meters to the active source.

During reduced volume source operations on a survey line, there were one detection of a humpback whale, one detection of a sperm whale, and one detection of an unidentified whales. The sperm whale had the closest observed distance of 1,750 meters. During full volume source operations not on a survey line, there were one detection of a sei whale and five detections of unidentified whales. The sei whale had the closest observed distance of 1,047 meters. During ramp-up source operations, there were two detections of fin whales with closest observed distances of 1,060 meters and 2,967 meters.

While the acoustic source was silent, there were two sightings of blue whales, eight sightings of fin whales, four sightings of humpback whales, one sighting of a minke whale, one sighting of a sei whale, one sighting of pygmy sperm whales, one sighting of baird's beaked whales, one sighting of a mixed pod of northern right-whale dolphins and pacific white-sided dolphins, four sightings of Dall's porpoises, two sightings of harbor porpoises, four sightings of unidentified dolphins, one sighting of unidentified pinnipeds, and seven sightings of unidentified whales. For detections where the acoustic source was on board the vessel, the distance of the protected species to the source elements was calculated as if the arrays had been deployed.

There were six detections of protected species while the acoustic source was silent and deployed during a line change, with unidentified whales having the closest of the observed distances of 295 meters. One of these sightings included an adult and a calf fin whale, with a closest observed distance of 2,665 meters. There were two detections of protected species while the acoustic source was silent and deployed during a shut-down for another detections' mitigation action. This included one sighting of fin whales with a closest distance of 2,390 meters, and one sighting of blue whales, an adult and calf pair, with a closest observed distance of 1,319 meters. There were four detections of protected species while the acoustic source was silent and some arrays were deployed during deployment/retrieval operations, with fin whales having the closest of the observed distances at 130 meters. There were five detections of protected species while the acoustic source was silent and on board within the survey area for streamer or engine maintenance, and fin whales had the closest of the observed distances with 686 meters.

There were 20 detections of protected species while the acoustic source was silent and onboard while the vessel was transiting. Of these detections, Dall's porpoise and harbor porpoise had the closest observed distances of 150 meters and 165 meters respectively. Three of these detections include calves, including one sighting of blue whales at 5,659 meters, one sighting of pygmy sperm whales at 174 meters, and one sighting of harbor porpoises at 165 meters of closest observed distances.

Table 23. Average closest approach of protected species to the acoustic source at various volumes during the survey program.

Species Detected	Full Volume on a Survey Line		Reduced Volume on a Survey Line		Full Volume Not on a Survey Line		Ramp-up		Source Silent and Deployed		Source Silent and Onboard*	
	Number of detections	Average closest approach to source (meters)	Number of detections	Average closest approach to source (meters)	Number of detections	Average closest approach to source (meters)	Number of detections	Average closest approach to source (meters)	Number of detections	Average closest approach to source (meters)	Number of detections	Average closest approach to source (meters)
Blue Whale	5	3,188	-	-	-	-	-	-	1	1,319	1	5,659
Fin Whale	16	2,110	-	-	-	-	2	2,013	5	1,397	3	1,518
Humpback Whale	1	1,629	1	3,233	-	-	-	-	-	-	4	1,258
Minke Whale	-	-	-	-	-	-	-	-	-	-	1	449
Sei Whale	2	519	-	-	1	1,047	-	-	1	825	-	-
Sperm Whale	-	-	1	1,750	-	-	-	-	-	-	-	-
Pygmy Sperm Whale	-	-	-	-	-	-	-	-	-	-	1	174
Baird's Beaked Whale	-	-	-	-	-	-	-	-	-	-	1	654
Unidentified Whale	26	3,979	1	4,081	5	3,568	-	-	5	988	2	3,701
All Whales	50	3,116	3	3,021	6	3,148	2	2,013	12	1,173	13	1,840
Mixed Species Pod**	-	-	-	-	-	-	-	-	-	-	1	832
Unidentified Dolphins	-	-	-	-	-	-	-	-	-	-	4	1,128
All Dolphins	-	-	-	-	-	-	-	-	-	-	5	1,068
Dall's Porpoise	-	-	-	-	-	-	-	-	-	-	4	672
Harbor Porpoise	-	-	-	-	-	-	-	-	-	-	2	183
All Porpoises	-	-	-	-	-	-	-	-	-	-	6	509
Unidentified Pinniped	-	-	-	-	-	-	-	-	-	-	1	206
All Pinnipeds	-	-	-	-	-	-	-	-	-	-	1	206
All Protected Species	50	3,116	3	3,021	6	3,148	2	2,013	12	1,173	25	1,301

*For detections which occurred during acoustic source silence while the arrays were onboard during transits, the closest distance to the source was calculated as if the arrays had been deployed.

** Mixed species pod included northern right-whale dolphins and pacific white-sided dolphins.

5.1.1. Other Wildlife

Observations of other positively identified wildlife included 17 species of birds, five species of fish, and one species of marine invertebrates. A complete list of birds and other marine wildlife observed and identified can be found in Appendix K. No impacts to any other wildlife species as a result of research activities were observed during the survey program.

There were no detections of protected bird species during the survey program. There were several sightings of the black-footed albatross and the Laysan albatross during the survey. However, all sightings of the species were of individuals flying around the vessel, or small groups in the water outside of the exclusion zones. Therefore, no specific protected bird mitigation actions were required to be taken.

5.2. ACOUSTIC DETECTIONS

There were no acoustic detections of protected species during the survey.

6. MITIGATION ACTION SUMMARY

There were six mitigation actions implemented due to protected species being observed approaching, entering, or within their designated exclusion zones. This included two delayed ramp-ups and four shut-downs for whales. Overall, mitigation actions implemented during the survey program totaled four hours 56 minutes (Table 24). Four of the mitigation actions were implemented during acquisition of a survey line, which resulted in a total production loss of three hours 55 minutes during the survey program.

Table 24. Number and duration of mitigation actions implemented during the survey program.

Mitigation Action	Whales		Dolphins		Pinnipeds		Sea Turtles		Sea Birds	
	Number	Duration (hh:mm)	Number	Duration (hh:mm)	Number	Duration (hh:mm)	Number	Duration (hh:mm)	Number	Duration (hh:mm)
Delayed Operation	2	01:28	-	-	-	-	-	-	-	-
Power-down	-	-	-	-	-	-	-	-	-	-
Shut-down	4	03:28	-	-	-	-	-	-	-	-
Total	6	04:56	-	-	-	-	-	-	-	-

Of the total mitigation actions implemented, the majority (67%) were implemented for fin whales, with four mitigation actions implemented totaling four hours five minutes (83%). There was also one mitigation implemented for sei whales totaling 35 minutes and one mitigation action implemented for unidentified whales totaling 16 minutes (Table 25). Mitigation actions implemented during the survey program are summarized in

Table 26. While the mitigation action implemented for the sei whale occurred while the acoustic source was active at full volume on a survey line, acquisition of the line concluded at the same time the mitigation action was implemented, and therefore there was no production loss associated with the shut-down.

Table 25: Mitigation actions and downtime duration by species during the survey program.

Species	Number of Delayed Operations	Number of Power-downs	Number of Shut-downs	Duration of Mitigation action (h:mm)	Percentage of Mitigation Downtime
Fin Whale	1	-	3	04:05	83%
Sei Whale	-	-	1	00:35	17%
Unidentified Whale	1	-	-	00:16	16%

Table 26. Summary of each mitigation action implemented during the survey program.

Date	Visual Detection Number	Species	Group Size	Source Activity (initial detection)	Closest Approach to Source (m)/Activity	Mitigation Action	Total Duration of Mitigation Event	Total Duration of Production Loss
19 July 2019	29	Fin Whale (adult and calf)	2	Silent	2665m/Silent	Delayed Ramp-up	01:12	01:02
27 July 2019	38	Unidentified Whale	1	Silent	1032m/Silent	Delayed Ramp-up	00:16	00:00
20 July 2019	45	Fin Whale	1	Full Volume Online	530m/Full Volume Online and 338m/Silent	Shut-Down	00:30	00:30
02 August 2019	51	Fin Whale (adult and calf)	3	Full Volume Online	1926m/Full Volume Online and 1926m/Silent	Shut-Down	01:25	01:25
07 August 2019	75	Fin Whale	2	Full Volume Online	561m/Full Volume Online and 486m/Silent	Shut-Down	00:58	00:58
10 August 2019	88	Sei Whale	1	Full Volume Online	438m/Full Volume Online and 367m/Silent	Shut-Down	00:35	00:00

6.1. 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 several species listed as endangered or threatened under the ESA. Endangered marine mammal species include: blue whales, fin whales, humpback whales, sei whales, sperm whales, and Guadalupe fur seals. ESA-listed sea turtles included leatherback sea turtles, and listed seabirds included the short-tailed albatross and the Hawaiian petrel.

NMFS granted an IHA and ITS for the marine seismic survey authorizing Level B harassment takes for 38 marine mammal species during the survey program. Of these 38 species, seven of the species were also authorized for Level A harassment takes. No specific number of takes were authorized for sea turtles or protected sea birds. For sea turtles, behavioral harassment was expected to occur in the 175-decibel zone and auditory injury was expected to occur within the 195-decibel zone (100-meter (single source element and 3D survey) and 181-meter (2D survey) zones). No specific harassment zones were designated for sea birds; however, a mitigation action would have been implemented if the sea birds were observed diving or foraging within the 500-meter (power-down) and 100-meter (shut-down) zones.

A total of 5,926 individuals from 38 species (including five whale species and one pinniped species listed as endangered or threatened species) were authorized for takes in the IHA and ITS. Of this total, 5,865 individuals from all 38 species were authorized for Level B takes, and 61 individuals from only seven of these species were authorized for Level A takes. Takes for endangered species totaled 258 individuals, of which 14 individuals were authorized for Level A takes and 244 individuals were authorized for Level B takes. Specific take levels were authorized for one species of sea turtle, two takes for leatherback sea turtles. No specific take levels were authorized for protected sea birds.

55 protected species were observed within the Level B harassment zone while the acoustic source was active, including four blue whales, 24 fin whales, two humpback whales, three sei whales, one sperm whale, and 21 unidentified whales. No protected species were observed within the Level A harassment zone while the acoustic source was active (Table 27).

Table 27. Number of authorized and potential Level A and B Harassment Takes during the survey program.

Species	IHA Authorized Level A Takes	Potential Level A Takes / PTS During the Program	IHA Authorized Level B Takes	Potential Level B Takes During the Program	Total IHA Authorized Takes	Total Potential Takes During the Program
ESA Listed Species						
Blue Whale	2	-	19	4	21	4
Fin Whale	7	-	74	24	81	24
Humpback Whale	3	-	32	2	35	2
Sei Whale	2	-	6	3	8	3
Sperm Whale	-	-	48	1	48	1
Guadalupe Fur Seal	-	-	65	-	-	-
Non-Listed Species						
Minke Whale	2	-	23	-	25	-
Cuvier's and <i>Mesoplodon</i> Beaked Whales	-	-	138	-	138	-
Baird's Beaked Whales	-	-	15	-	15	-
<i>Kogia</i> spp.	2	-	29	-	31	-
Bottlenose Dolphin	-	-	13	-	13	-
Striped Dolphin	-	-	176	-	176	-
Short-beaked Common Dolphin	-	-	2,356	-	2,356	-
Pacific White-sided Dolphin	-	-	329	-	329	-
Northern Right-whale Dolphin	-	-	754	-	754	-
Risso's Dolphin	-	-	132	-	132	-
False Killer Whale	-	-	5	-	5	-
Killer Whale	-	-	17	-	17	-
Short-finned Pilot Whale	-	-	18	-	18	-
Dall's Porpoise	43	-	786	-	829	-
Northern Fur Seal	-	-	201	-	201	-
Northern Elephant Seal	-	-	629	-	629	-
Unidentified species						
Unidentified Whale	-	-	-	21	-	21
Unidentified Dolphin	-	-	-	-	-	-
Unidentified Pinniped	-	-	-	-	-	-
Unidentified Sea Turtle	-	-	-	-	-	-
Total for all species groups	61	-	5,800	55	5,861	55

The number of potential takes may be an underestimation and, therefore, may be a lower 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 animals not being seen or having moved away before they were observed. This is most likely to have occurred with sea turtles that were not close enough to the surface to be sighted from the vessel, large pods of dolphins where exact number of individuals is difficult to determine, and groups of whales where the individuals were close together, far away from the vessel, and only blows were observed, making the number of individuals difficult to determine. The Beaufort Sea state has a large impact on the ability to visibly detect many smaller or unobtrusive marine species such as beaked whales and sea turtles. During the survey program, there were a few days where Beaufort Sea states (level 4 or greater) may have resulted in some missed protected species detections. However, 90% of all visual monitoring observations throughout the survey program were conducted during Beaufort Sea states of level three or less.

Additionally, beyond hours of dawn, dusk and darkness, there were several occasions where the entire predicted 160 dB radii, 1,000-meter buffer zone, 500-meter exclusion zone were not fully visible, which would have prevented sightings of protected species within those areas around the vessel. Throughout

the survey program, the entirety of the 160-decibel radius was not visible for 62 hours nine minutes during visual monitoring efforts, the entire 1,000-meter buffer zone was not visible for 17 hours 24 minutes, and the entire 500-meter exclusion zone was not visible for six hours 59 minutes. There was no time where the entire 100-meter exclusion zone was not visible during visual monitoring efforts.

Previous analysis of R/V *Langseth* source received levels collected via hydrophone streamers in shallow waters (Crone 2014 and 2017), demonstrated that the measured mitigation zones were substantially smaller than those predicted. Therefore, animals observed within the predicted mitigation zones for this survey may similarly not have experienced received levels at those predicted levels. Furthermore, the mitigation zones actually implemented during operations, as required by the IHA and ITS, were significantly larger than the predicted mitigation zones, especially for most marine mammal functional hearing groups. As described in the PEIS, Lloyd's mirror and surface release effects also ameliorate the effects for animals at or near the sea surface.

Table 28 describes the behavior of all animals, including unidentified species, which were visually observed within the predicted Level A and Level B harassment zones during the survey program. While there were no highly distinctive behavioral reactions observed in relation to the vessel or acoustic source during the seismic survey, the majority of the protected species detected were last observed either not changing direction or changed direction to moving away from the vessel.

Table 28: Behavior of species visually observed to be exposed to sound pressure levels of 160 dB or greater during the survey program.

Species	Detection No.	No. of Animals	Highest Observed Sound Pressure Level (dB)	Initial behavior	Initial direction in relation to vessel	Subsequent and Final behavior	Subsequent and Final direction in relation to vessel
Sperm Whale	18	1	160	Blowing	Parallel to the vessel in the opposite direction	Blowing	Parallel to the vessel in the opposite direction
Unidentified Whale	23	1	160	Blowing	Unknown	Blowing	Unknown
Unidentified Whale	25	1	160	Blowing	Away from the vessel	Blowing	Away from the vessel
Humpback Whale	28	1	160	Blowing	Away from the vessel	Blowing	Away from the vessel
Humpback Whale	30	1	160	Blowing	Parallel to the vessel in the opposite direction	Blowing, diving	Parallel to the vessel in the opposite direction
Fin Whale	35	1	160	Blowing	Parallel to the vessel in the same direction	Blowing	Parallel to the vessel in the same direction
Unidentified Whale	36	1	160	Blowing	Away from the vessel	Blowing, fast travel	Away from the vessel
Unidentified Whale	44	2	160	Blowing	Parallel to the vessel in the opposite direction	Blowing, fast travel	Away from the vessel
Fin Whale	45	1	160	Blowing	Parallel to the vessel in the opposite direction	Blowing, fast travel	Parallel to the vessel in the opposite direction

Species	Detection No.	No. of Animals	Highest Observed Sound Pressure Level (dB)	Initial behavior	Initial direction in relation to vessel	Subsequent and Final behavior	Subsequent and Final direction in relation to vessel
Fin Whale	48	1	160	Blowing	Parallel to the vessel in the opposite direction	Blowing, fast travel	Away from the vessel
Fin Whale	49	1	160	Blowing	Crossing astern of the vessel	Blowing, fast travel	Away from the vessel
Fin Whale	50	2	160	Blowing	Crossing ahead of the vessel	Blowing, fast travel	Unknown
Fin Whale	51	3	160	Blowing	Parallel to the vessel in the opposite direction	Blowing, fast travel	Away from the vessel
Unidentified Whale	52	1	160	Blowing	Unknown	Blowing, fast travel	Unknown
Fin Whale	53	1	160	Blowing	Parallel to the vessel in the opposite direction	Blowing, fast travel	Parallel to the vessel in the opposite direction
Unidentified Whale	55	1	160	Blowing	Crossing astern of the vessel	Blowing, fast travel	Away from the vessel
Unidentified Whale	56	2	160	Blowing	Stationary	Blowing, slow travel	Stationary
Unidentified Whale	57	2	160	Blowing	Parallel to the vessel in the opposite direction	Blowing	Away from the vessel
Unidentified Whale	59	1	160	Blowing	Unknown	Blowing, slow travel	Unknown
Fin Whale	62	2	160	Blowing	Unknown	Blowing, fast travel	Away from the vessel
Unidentified Whale	63	1	160	Blowing	Crossing ahead of the vessel	Blowing	Away from the vessel
Unidentified Whale	64	1	160	Blowing	Unknown	Blowing	Away from the vessel
Unidentified Whale	66	4	160	Blowing	Variable	Blowing	Variable
Blue Whale	67	2	160	Blowing	Parallel to the vessel in the opposite direction	Blowing	Parallel to the vessel in the opposite direction
Fin Whale	68	2	160	Blowing	Crossing ahead of the vessel	Blowing, fast travel	Away from the vessel
Unidentified Whale	70	1	160	Blowing	Unknown	Blowing	Unknown

Species	Detection No.	No. of Animals	Highest Observed Sound Pressure Level (dB)	Initial behavior	Initial direction in relation to vessel	Subsequent and Final behavior	Subsequent and Final direction in relation to vessel
Fin Whale	74	1	160	Blowing	Parallel to the vessel in the opposite direction	Blowing	Away from the vessel
Fin Whale	75	2	160	Blowing	Crossing ahead of the vessel	Blowing, fast travel	Parallel to the vessel in the opposite direction
Fin Whale	79	4	160	Blowing	Away from the vessel	Blowing, milling, feeding	Variable
Blue Whale	82	1	160	Blowing	Parallel to the vessel in the opposite direction	Blowing, diving with fluke shown	Parallel to the vessel in the opposite direction
Fin Whale	83	2	160	Blowing	Parallel to the vessel in the opposite direction	Blowing	Parallel to the vessel in the opposite direction
Blue Whale	84	1	160	Blowing	Away from the vessel	Blowing, diving with fluke shown	Away from the vessel
Unidentified Whale	85	2	160	Blowing	Unknown	Blowing	Unknown
Sei Whale	86	1	160	Blowing	Crossing ahead of the vessel	Blowing, surface active	Away from the vessel
Sei Whale	87	1	160	Blowing	Towards the vessel	Blowing, fast travel	Away from the vessel
Sei Whale	88	1	160	Blowing	Parallel to the vessel in the same direction	Blowing, fast travel	Away from the vessel
Fin Whale	89	1	160	Blowing	Parallel to the vessel in the same direction	Blowing	Away from the vessel
Unidentified Whale	90	1	160	Blowing	Away from the vessel	Blowing	Away from the vessel
Fin Whale	91	1	160	Blowing	Away from the vessel	Blowing, fast travel	Parallel to the vessel in the opposite direction
Unidentified Whale	92	2	160	Blowing	Away from the vessel	Blowing	Away from the vessel

6.2. IMPLEMENTATION AND EFFECTIVENESS OF THE BIOLOGICAL OPINION'S ITS AND IHA

In order to minimize the potential impacts to marine mammals, sea turtles, and protected sea birds, LDEO and PSOs were prepared to implement mitigation measures whenever these protected species were detected approaching, entering, or within the exclusion zones designated in the IHA and ITS. There were four mitigation actions implemented for protected species during the survey program, including two delayed operations and four shut-downs, totaling four hours 56 minutes. The confirmation of the implementation of each Term and Condition of the Biological Opinion's Incidental Take Statement are described within this report.

As noted in Section 3.2, additional mitigation measures were required in the IHA and ITS.

One of these additional mitigation measures was implemented on two occasions during the survey program. On 12 July 2019, a ramp-up of the acoustic source was delayed for one hour 12 minutes, and on 03 August 2019, the acoustic source was shut-down for one hour five minutes due to the presence of fin whales with calves visually detected. For both sightings, ramp-up was not cleared to begin until 30 minutes following the final sighting of the whales. There was a third instance where this extra mitigation measure should have been implemented but was not. On 07 August 2019, an adult blue whale was sighted during a shut-down mitigation action implemented for a fin whale. The adult blue whale was outside of the exclusion zone, and the ramp-up was cleared to begin 30 minutes following the last sighting of the fin whale. However, when the detection pictures were reviewed a few hours later, a small calf was identified surfacing right next to the adult blue whale that was not observed during the detection. Had the calf been sighted during the detection, the ramp-up would have been delayed an additional time from the final sighting of the calf.

The IHA and ITS also waived the shut-down requirements for small dolphins of the genera *Tursiops*, *Delphinus*, *Stenella*, *Lagenorhynchus*, and *Lissodelphis*. If PSOs could positively identify the delphinids as one of these species upon their initial detection, the acoustic source could be powered-down instead of shut-down if the individuals were observed approaching, entering, or within the 500-meter exclusion zone. However, if there was any uncertainty to the species identification, the source would instead be shut-down. In addition, PSOs could elect to waive the power-down requirement as well if the delphinids of these genera appeared to be voluntarily approaching the vessel for the purpose of interacting with the vessel or with the towed gear. However, if any adverse reactions were observed from any of the individuals, then a power-down was required. During the survey program, there were no instances where the shut-down or power-down exemptions for these species was implemented/utilized.

In the event that an injured or dead protected species was discovered during the course of the survey program, and the lead visual observer determined that the cause of death was unknown or unrelated to the activities of the vessel, the incident was to be immediately reported. The report would include a detailed description of the incident, including pictures when possible, and information about the vessel's activities within the 24 hours prior to the discovery of the injured/dead protected species. Throughout the survey program, there was one sighting of a dead protected species. On 15 and 16 July 2019, the carcass of what appeared to be a dead whale was sighted nearby the vessel. A report for each sighting of the carcass on the two dates was created and provided to NMFS detailing this sighting.

Passive acoustic monitoring was conducted throughout the survey and the majority of acoustic monitoring was undertaken while the source was active. High levels of background noise on the hydrophone cable were experienced when the vessel traveled at higher speeds (greater than six knots), which made it impractical to conduct monitoring for baseline acoustic data collection while the vessel was in transit to and from the survey site. This prevented baseline acoustic data from being collected on the survey site and during transit while visual monitoring was ongoing for baseline data collection purposes. There were no acoustic detections of protected species during this survey program.

In order to prevent the occurrence of the vessel striking a marine mammal during transits, the vessel speed was reduced to 10 knots or less when adult/calf pairs or aggregations or any marine mammals were observed near the vessel. The vessel was required to maintain a minimum separation distance of

100 meters from large whales (i.e. sperm whales and all baleen whales), 50 meters from all other marine mammals, with the exception of those individuals that approach the vessel voluntarily, and 45 meters from sea turtles. The vessel was required to take action as necessary to avoid violating the relevant separation distances, including reducing speed, shifting the engines to neutral, and not engaging the engines until all of the animals were clear of the relevant area. These regulations did not apply when the vessel was towing gear. During the survey program, there were no occurrences where the vessel had to alter its speed or course to avoid interactions with marine mammals.

In the event of a live stranding (or near-shore atypical milling) event engaged within 50 kilometers of the survey operations, where the NMFS stranding network engaged in herding or other interventions to return animals to the water, L-DEO would be advised of the need to implement shut-down procedures for all acoustic sources within 50 kilometers of the stranding. The shut-down procedures would be implemented until all of the live animals have left the area, or until the marine mammals died or were euthanized. During the survey program, there were no instances of marine mammal stranding's near the survey area.

For the Axial Seamount survey program, a total of 5,926 individual marine mammals from 38 species (including five whale species and one pinniped species listed as endangered or threatened species) were authorized for takes in the IHA and ITS. Of this total, 5,865 individuals from all 38 species were authorized for Level B takes, and 61 individuals from only seven of these species were authorized for Level A takes. During the survey program, a total of 55 protected species were observed within the predicted Level B harassment radius. This total represents 1% of the authorized Level B takes, or less than 1% of authorized takes for the survey. No protected species were observed within the predicted Level A harassment zone during the survey program. The species composition of this total, in relation to the total allowed takes is shown in Table 27.

PSOs likely did not detect all animals present; however, it is highly unlikely that the actual number of animals present during survey operations reached anywhere near 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 IHA and ITS appear to have been an effective means to protect the marine species encountered during survey operations.

7. LITERATURE CITED

NOAA, 2019. Endangered Species Act Section 7 Consultation Biological Opinion for a marine seismic survey by Lamont-Doherty Earth Observatory in the Northeast Pacific Ocean and NFMS IHA issuance.

Crone, T.J., M. Tolstoy, and H. Carton. 2014. Estimating shallow water sound power levels and mitigation radii for the R/V Marcus G. Langseth using an 8 km long MCS streamer. *Geochem., Geophys., Geosyst.* 15(10):3793-3807.

Crone, T.J., M. Tolstoy, and H. Carton. 2017. Utilizing the R/V Marcus G. Langseth's streamer to measure the acoustic radiation of its seismic source in the shallow waters of New Jersey's continental shelf. *PLoS ONE* 12(8): e0183096. <http://doi.org/10.1371/journal.pone.0183096>

APPENDIX A: Incidental Harassment Authorization for the Northeast Pacific Ocean Axial Seamount Marine Geophysical Survey.



UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Silver Spring, MD 20910

JUL 10 2019

Sean Higgins
Director, Office of Marine Operations
Lamont-Doherty Earth Observatory
61 Rt. 9W
Palisades, NY 10964

Dear Mr. Higgins:

Enclosed is an Incidental Harassment Authorization (IHA) issued to Lamont-Doherty Earth Observatory, under the authority of Section 101(a)(5)(D) of the Marine Mammal Protection Act (16 U.S.C. 1361 *et seq.*) to take, by Level A harassment and Level B harassment only, small numbers of marine mammals incidental to a marine geophysical survey in the northeast Pacific Ocean, 2019.

You are required to comply with the conditions contained in the IHA, including all mitigation, monitoring and reporting requirements. Along with mitigation measures, the IHA requires monitoring for the presence and behavior of marine mammals during all activities associated with the project.

If you have any questions concerning the IHA or its requirements, please contact Amy Fowler, Office of Protected Resources, National Marine Fisheries Service, at (301) 427-8401.

Sincerely,

Donna S. Wieting, Director
Office of Protected Resources

Enclosure





INCIDENTAL HARASSMENT AUTHORIZATION

The Lamont-Doherty Earth Observatory of Columbia University (L-DEO) and 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 harass marine mammals incidental to a marine geophysical survey in the Northeast Pacific Ocean, when adhering to the following terms and conditions.

1. This Incidental Harassment Authorization (IHA) is valid for a period of one year from the date of issuance.
2. This IHA is valid only for marine geophysical activity as specified in L-DEO's IHA application and using an array aboard the R/V *Langseth* with characteristics specified in the IHA application, in the Northeast Pacific Ocean near the Axial volcano and seamount.
3. General Conditions
 - (a) A copy of this IHA must be in the possession of L-DEO, the vessel operator, the lead protected species observer (PSO) and any other relevant designees of L-DEO operating under the authority of this IHA.
 - (b) The species and numbers authorized for taking are listed in Table 1 (attached).
 - (c) The taking by serious injury, or death of any of the species listed in condition 3(b) of the Authorization or any taking of any other species of marine mammal is prohibited and may result in the modification, suspension, or revocation of this IHA.
 - (d) L-DEO or the vessel operator must conduct briefings between PSOs and vessel crew prior to the start of all seismic operations, and when new personnel join the work, in order to explain responsibilities, communication procedures, marine mammal monitoring protocol, and operational procedures.

4. Mitigation Measures

The holder of this Authorization is required to implement the following mitigation measures:

- (a) L-DEO must use at least five dedicated, trained, NMFS-approved Protected Species Observers (PSOs). The PSOs must have no tasks other than to conduct observational effort, record observational data, and communicate with and instruct relevant vessel crew with regard to the presence of marine mammals and mitigation requirements.

- (b) At least one of the visual and two of the acoustic PSOs aboard the vessel must have a minimum of 90 days at-sea experience working in those roles, respectively, during a deep penetration seismic survey, with no more than 18 months elapsed since the conclusion of the at-sea experience
- (c) Visual Observation
 - (i) During survey operations (*e.g.*, any day on which use of the acoustic source is planned to occur, and whenever the acoustic source is in the water, whether activated or not), a minimum of two visual PSOs must be on duty and conducting visual observations at all times during daylight hours (*i.e.*, from 30 minutes prior to sunrise through 30 minutes following sunset) and 30 minutes prior to and during ramp-up, including nighttime ramp-ups, of the airgun array. Visual monitoring of the exclusion and buffer zones must begin no less than 30 minutes prior to ramp-up and must continue until one hour after use of the acoustic source ceases or until 30 minutes past sunset.
 - (ii) Visual PSOs must coordinate to ensure 360° visual coverage around the vessel from the most appropriate observation posts, and must conduct visual observations using binoculars and the naked eye while free from distractions and in a consistent, systematic, and diligent manner.
 - (iii) Visual PSOs must immediately communicate all observations to the acoustic PSO(s) on duty, including any determination by the PSO regarding species identification, distance, and bearing and the degree of confidence in the determination.
 - (iv) During good conditions (*e.g.*, daylight hours; Beaufort sea state (BSS) 3 or less), visual PSOs must conduct observations when the acoustic source is not operating for comparison of sighting rates and behavior with and without use of the acoustic source and between acquisition periods, to the maximum extent practicable.
 - (v) Visual PSOs may be on watch for a maximum of four consecutive hours followed by a break of at least one hour between watches and may conduct a maximum of 12 hours of observation per 24-hour period. Combined observational duties (visual and acoustic but not at same time) may not exceed 12 hours per 24-hour period for any individual PSO
- (d) Acoustic Monitoring
 - (i) The source vessel must use a towed passive acoustic monitoring system (PAM) which must be monitored by, at a minimum, one on duty acoustic PSO beginning at least 30 minutes prior to ramp-up and at all times during use of the acoustic source.

- (ii) Acoustic PSOs must immediately communicate all detections to visual PSOs, when visual PSOs are on duty, including any determination by the PSO regarding species identification, distance, and bearing and the degree of confidence in the determination.
- (iii) Acoustic PSOs may be on watch for a maximum of four consecutive hours followed by a break of at least one hour between watches and may conduct a maximum of 12 hours of observation per 24-hour period. Combined observational duties may not exceed 12 hours per 24-hour period for any individual PSO.
- (iv) Survey activity may continue for 30 minutes when the PAM system malfunctions or is damaged, while the PAM operator diagnoses the issue. If the diagnosis indicates that the PAM system must be repaired to solve the problem, operations may continue for an additional five hours without acoustic monitoring during daylight hours only under the following conditions:
 - a. Sea state is less than or equal to BSS 4;
 - b. With the exception of delphinids, no marine mammals detected solely by PAM in the applicable exclusion zone in the previous two hours;
 - c. NMFS is notified via email as soon as practicable with the time and location in which operations began occurring without an active PAM system; and
 - d. Operations with an active acoustic source, but without an operating PAM system, do not exceed a cumulative total of five hours in any 24-hour period.
- (e) Exclusion zone and buffer zone
 - (i) PSOs must establish and monitor a 500-m exclusion zone and 1,000-m buffer zone. The exclusion zone encompasses the area at and below the sea surface out to a radius of 500 m from the edges of the airgun array (0–500 m). The buffer zone encompasses the area at and below the sea surface from the edge of the 0–500 m exclusion zone, out to a radius of 1,000 m from the edges of the airgun array (500–1,000 meters). PSOs must monitor beyond 1,000 m and enumerate any takes that occur beyond the buffer zone.
 - (ii) An extended 1,500-m exclusion zone must be established for all beaked whales, and dwarf and pygmy sperm whales.

- (f) Pre-clearance and Ramp-up
- (i) A ramp-up procedure must be followed at all times as part of the activation of the acoustic source, except as described under 4(f)(vi).
 - (ii) Ramp-up must not be initiated if any marine mammal is within the exclusion or buffer zone. If a marine mammal is observed within the exclusion zone or the buffer zone during the 30 minute pre-clearance period, ramp-up may not begin until the animal(s) has been observed exiting the zone or until an additional time period has elapsed with no further sightings (15 minutes for small odontocetes and pinnipeds, and 30 minutes for mysticetes and all other odontocetes, including sperm whales, pygmy sperm whales, dwarf sperm whales, beaked whales, pilot whales, and Risso's dolphins).
 - (iii) Ramp-up must begin by activating a single airgun of the smallest volume in the array and must continue in stages by doubling the number of active elements at the commencement of each stage, with each stage of approximately the same duration. Duration must not be less than 20 minutes.
 - (iv) PSOs must monitor the exclusion and buffer zones during ramp-up, and ramp-up must cease and the source must be shut down upon observation of a marine mammal within the exclusion zone. Once ramp-up has begun, observations of marine mammals within the buffer zone do not require shutdown or powerdown, but such observation must be communicated to the operator to prepare for the potential shutdown or powerdown.
 - (v) Ramp-up may occur at times of poor visibility, including nighttime, if appropriate acoustic monitoring has occurred with no detections in the 30 minutes prior to beginning ramp-up.
 - (vi) If the acoustic source is shut down for brief periods (i.e., less than 30 minutes) for reasons other than that described for shutdown and powerdown (e.g., mechanical difficulty), it may be activated again without ramp-up if PSOs have maintained constant visual and/or acoustic observation and no visual or acoustic detections of marine mammals have occurred within the applicable exclusion zone. For any longer shutdown, pre-clearance observation and ramp-up are required. For any shutdown at night or in periods of poor visibility (e.g., BSS 4 or greater), ramp-up is required, but if the shutdown period was brief and constant observation was maintained, pre-clearance watch of 30 min is not required.
 - (vii) Testing of the acoustic source involving all elements requires ramp-up. Testing limited to individual source elements or strings does not require ramp-up but does require pre-clearance of 30 min.

(g) Shutdown and Powerdown

- (i) Any PSO on duty has the authority to delay the start of survey operations or to call for shutdown or powerdown of the acoustic source if a marine mammal is detected within the 500-m exclusion zone (100 m when shutdown has been waived as described in 4(g)(viii)).
- (ii) The operator must establish and maintain clear lines of communication directly between PSOs on duty and crew controlling the acoustic source to ensure that shutdown and powerdown 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 powerdown) and (1) a marine mammal (excluding delphinids) appears within or enters the exclusion zone and/or (2) a marine mammal is detected acoustically and localized within the exclusion zone, the acoustic source must be shut down. When shutdown is called for by a PSO, the airgun array must be immediately deactivated. Any questions regarding a PSO shutdown must be resolved after deactivation.
- (iv) Shutdown must occur whenever PAM alone (without visual sighting), confirms presence of marine mammal(s) (other than delphinids) in the 500-m exclusion zone. During daylight hours, if the acoustic PSO cannot confirm presence within exclusion zone, visual PSOs must be notified but shutdown is not required.
- (v) The airgun array must be shut down if a marine mammal species for which take was not authorized, or a species for which authorization was granted but the takes have been met, approaches the Level A or Level B harassment zones.
- (vi) The airgun array must be shut down if a North Pacific right whale is observed at any distance.
- (vii) The airgun array must be shut down if any large whale (defined as a sperm whale or any mysticete species) with a calf (defined as an animal less than two-thirds the body size of an adult observed to be in close association with an adult) or an aggregation of six or more large whales is observed at any distance.
- (viii) The shutdown requirement shall be waived for small dolphins of the following genera: *Tursiops*, *Delphinus*, *Stenella*, *Lagenorhynchus*, and *Lissodelphis*.

- a. The acoustic source must be powered down to 40-in³ airgun if an individual belonging to these genera is visually detected within the 500-m exclusion zone.
 - b. When the acoustic source is powered down to the 40-in³ airgun due to the presence of dolphins specified in 4(g)(v), an exclusion zone of 100 m and Level B harassment zone of 430 m will be in effect for species other than specified dolphin genera that may approach the survey vessel.
 - c. Powerdown conditions must be maintained until delphinids, for which shutdown is waived, are no longer observed within the 500-m exclusion zone, following which full-power operations may be resumed without ramp-up. Visual PSOs may elect to waive the powerdown requirement if delphinids for which shutdown is waived appear to be voluntarily approaching the vessel for the purpose of interacting with the vessel or towed gear, and must use best professional judgment in making this decision.
 - d. If PSOs observe any behaviors in delphinids for which shutdown is waived that indicate an adverse reaction, then powerdown must be initiated.
 - e. Visual PSOs must use best professional judgment in making the decision to call for a shutdown if there is uncertainty regarding identification (i.e., whether the observed marine mammal(s) belongs to one of the delphinid genera for which shutdown is waived).
- (ix) Upon implementation of shutdown, the source may be reactivated after the marine mammal(s) has been observed exiting the applicable exclusion zone (i.e., animal is not required to fully exit the buffer zone where applicable) or following a clearance period (15 minutes for small odontocetes and pinnipeds, and 30 minutes for mysticetes and all other odontocetes, including sperm whales, pygmy sperm whales, dwarf sperm whales, beaked whales, pilot whales, and Risso's dolphins) with no further observation of the marine mammal(s).
- (h) Vessel operators and crews 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 mammal. A visual observer aboard the vessel must monitor a vessel strike avoidance zone around the vessel (specific distances detailed below), to ensure the potential for strike is minimized.
- (i) Vessel speeds must be reduced to 10 knots or less when mother/calf pairs, pods, or large assemblages of any marine mammal are observed near a vessel.

- (ii) Vessels must maintain a minimum separation distance of 100 m from large whales (i.e., sperm whales and all baleen whales).
 - (iii) Vessels must attempt to maintain a minimum separation distance of 50 m from all other marine mammals, with an exception made for those animals that approach the vessel.
 - (iv) When marine mammals are sighted while a vessel is underway, the vessel must take action as necessary to avoid violating the relevant separation distance. 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 recommendation does not apply to any vessel towing gear.
- (i) Actions to Minimize Additional Harm to Live Stranded (or Milling) Marine Mammals – In the event of a live stranding (or near-shore atypical milling) event within 50 km of the survey operations, where the NMFS stranding network is engaged in herding or other interventions to return animals to the water, the Director of OPR, NMFS (or designee) will advise L-DEO of the need to implement shutdown procedures for all active acoustic sources operating within 50 km of the stranding. Shutdown procedures for live stranding or milling marine mammals include the following:
- (i) If at any time, the marine mammal(s) die or are euthanized, or if herding/intervention efforts are stopped, the Director of OPR, NMFS (or designee) will advise the IHA-holder that the shutdown around the animals' location is no longer needed.
 - (ii) Otherwise, shutdown procedures will remain in effect until the Director of OPR, NMFS (or designee) determines and advises the IHA-holder that all live animals involved have left the area (either of their own volition or following an intervention).
 - (iii) If further observations of the marine mammals indicate the potential for re-stranding, additional coordination with the IHA-holder will be required to determine what measures are necessary to minimize that likelihood (e.g., extending the shutdown or moving operations farther away) and to implement those measures as appropriate.

5. Monitoring Requirements

The holder of this Authorization is required to conduct marine mammal monitoring during survey activity. Monitoring must be conducted in accordance with the following requirements:

- (a) The operator must provide PSOs with bigeye binoculars (e.g., 25 x 150; 2.7 view angle; individual ocular focus; height control) of appropriate quality (i.e., Fujinon

or equivalent) solely for PSO use. These must be pedestal-mounted on the deck at the most appropriate vantage point that provides for optimal sea surface observation, PSO safety, and safe operation of the vessel.

- (b) The operator must work with the selected third-party observer provider to ensure PSOs have all equipment (including backup equipment) needed to adequately perform necessary tasks, including accurate determination of distance and bearing to observed marine mammals. Such equipment, at a minimum, must include:
 - (i) PAM must include a system that has been verified and tested by the acoustic PSO that will be using it during the trip for which monitoring is required.
 - (ii) At least one night-vision device suited for the marine environment for use during nighttime pre-clearance and ramp-up that features automatic brightness and gain control, bright light protection, infrared illumination, and/or optics suited for low-light situations (e.g., Exelis PVS-7 night vision goggles; Night Optics D-300 night vision monocular; FLIR M324XP thermal imaging camera or equivalents).
 - (iii) Reticle binoculars (e.g., 7 x 50) of appropriate quality (i.e., Fujinon or equivalent) (at least one per PSO, plus backups).
 - (iv) Global Positioning Units (GPS) (at least one per PSO, plus backups).
 - (v) Digital single-lens reflex cameras of appropriate quality that capture photographs and video (i.e., Canon or equivalent) (at least one per PSO, plus backups).
 - (vi) Compasses (at least one per PSO, plus backups).
 - (vii) Radios for communication among vessel crew and PSOs (at least one per PSO, plus backups).
 - (viii) Any other tools necessary to adequately perform necessary PSO tasks.
- (c) Protected Species Observers (PSOs, Visual and Acoustic) Qualifications
 - (i) PSOs must be independent, dedicated, trained visual and acoustic PSOs and must be employed by a third-party observer provider.
 - (ii) PSOs must have no tasks other than to conduct observational effort (visual or acoustic), collect data, and communicate with and instruct relevant vessel crew with regard to the presence of protected species and mitigation requirements (including brief alerts regarding maritime hazards), and

- (iii) PSOs must have successfully completed an approved PSO training course appropriate for their designated task (visual or acoustic). Acoustic PSOs are required to complete specialized training for operating PAM systems and are encouraged to have familiarity with the vessel with which they will be working.
 - (iv) PSOs can act as acoustic or visual observers (but not at the same time) as long as they demonstrate that their training and experience are sufficient to perform the task at hand.
 - (v) NMFS must review and approve PSO resumes.
 - (vi) NMFS shall have one week to approve PSOs from the time that the necessary information is submitted, after which PSOs meeting the minimum requirements shall automatically be considered approved.
 - (vii) One visual PSO with experience as shown in 4(b) shall be designated as the lead for the entire protected species observation team. The lead must coordinate duty schedules and roles for the PSO team and serve as primary point of contact for the vessel operator. 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.
 - (viii) 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.
 - (ix) PSOs must have successfully attained a bachelor's degree from an accredited college or university with a major in one of the natural sciences, a minimum of 30 semester hours or equivalent in the biological sciences, and at least one undergraduate course in math or statistics.
 - (x) The educational requirements may be waived if the PSO has acquired the relevant skills through alternate experience. Requests for such a waiver must be submitted to NMFS and must include written justification. Requests must be granted or denied (with justification) by NMFS within one week of receipt of submitted information. Alternate experience that may be considered includes, but is not limited to (1) secondary education and/or experience comparable to PSO duties; (2) previous work experience conducting academic, commercial, or government-sponsored protected species surveys; or (3) previous work experience as a PSO; the PSO should demonstrate good standing and consistently good performance of PSO duties.
- (d) Data Collection

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

- (ii) At a minimum, the following information must be recorded:
 - a. Vessel names (source vessel and other vessels associated with survey) and call signs;
 - b. PSO names and affiliations;
 - c. Date and participants of PSO briefings (as discussed in General Requirement);
 - d. Dates of departures and returns to port with port name;
 - e. Dates and times (Greenwich Mean Time) of survey effort and times corresponding with PSO effort;
 - f. Vessel location (latitude/longitude) when survey effort began and ended and vessel location at beginning and end of visual PSO duty shifts;
 - g. Vessel heading and speed at beginning and end of visual PSO duty shifts and upon any line change;
 - h. Environmental conditions while on visual survey (at beginning and end of PSO shift and whenever conditions changed significantly), including BSS and any other relevant weather conditions including cloud cover, fog, sun glare, and overall visibility to the horizon;
 - i. Factors that may have contributed to impaired observations during each PSO shift change or as needed as environmental conditions changed (e.g., vessel traffic, equipment malfunctions); and
 - j. Survey activity information, such as acoustic source power output while in operation, number and volume of airguns operating in the array, tow depth of the array, and any other notes of significance (i.e., pre-clearance, ramp-up, shutdown, testing, shooting, ramp-up completion, end of operations, streamers, etc.).

- (iii) Upon visual observation of any protected species, the following information must be recorded:
- a. Watch status (sighting made by PSO on/off effort, opportunistic, crew, alternate vessel/platform);
 - b. PSO who sighted the animal;
 - c. Time of sighting;
 - d. Vessel location at time of sighting;
 - e. Water depth;
 - f. Direction of vessel's travel (compass direction);
 - g. Direction of animal's travel relative to the vessel;
 - h. Pace of the animal;
 - i. Estimated distance to the animal and its heading relative to vessel at initial sighting;
 - j. Identification of the animal (e.g., genus/species, lowest possible taxonomic level, or unidentified) and the composition of the group if there is a mix of species;
 - k. Estimated number of animals (high/low/best);
 - l. Estimated number of animals by cohort (adults, yearlings, juveniles, calves, group composition, etc.);
 - m. Description (as many distinguishing features as possible of each individual seen, including length, shape, color, pattern, scars or markings, shape and size of dorsal fin, shape of head, and blow characteristics);
 - n. Detailed behavior observations (e.g., number of blows/breaths, number of surfaces, breaching, spyhopping, diving, feeding, traveling; as explicit and detailed as possible; note any observed changes in behavior);
 - o. Animal's closest point of approach (CPA) and/or closest distance from any element of the acoustic source;
 - p. Platform activity at time of sighting (e.g., deploying, recovering, testing, shooting, data acquisition, other); and

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

6. Reporting

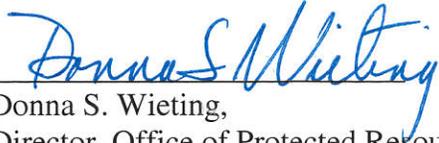
- (a) L-DEO must submit a draft comprehensive report to NMFS on all activities and monitoring results within 90 days of the completion of the survey or expiration of the IHA, whichever comes sooner. The draft report must include the following:
- (i) Summary of all activities conducted and sightings of protected species near the activities;
 - (ii) Full documentation of methods, results, and interpretation pertaining to all monitoring;
 - (iii) Summary of dates and locations of survey operations and all protected species sightings (dates, times, locations, activities, associated survey activities);
 - (iv) Geo-referenced time-stamped vessel tracklines for all time periods during which airguns were operating. Tracklines should include points recording any change in airgun status (e.g., when the airguns began operating, when they were turned off, or when they changed from full array to single gun or vice versa);
 - (v) GIS files in ESRI shapefile format and UTC date and time, latitude in decimal degrees, and longitude in decimal degrees. All coordinates must be referenced to the WGS84 geographic coordinate system;

- (vi) Raw observational data;
 - (vii) Summary of the information submitted in interim monthly reports as well as additional data collected as described above in Data Collection and the IHA;
 - (viii) Estimates of the number and nature of exposures that occurred above the harassment threshold based on PSO observations, including an estimate of those that were not detected in consideration of both the characteristics and behaviors of the species of marine mammals that affect detectability, as well as the environmental factors that affect detectability;
 - (ix) Certification from the lead PSO as to the accuracy of the report
 - a. The lead PSO may submit statement directly to NMFS concerning implementation and effectiveness of the required mitigation and monitoring.
 - (x) A final report must be submitted within 30 days following resolution of any comments on the draft report.
- (b) Reporting Injured or Dead Marine Mammals
- (i) Discovery of Injured or Dead Marine Mammal – In the event that personnel involved in the survey activities covered by the authorization discover an injured or dead marine mammal, L-DEO must report the incident to the Office of Protected Resources (OPR) (301-427-8401), NMFS and the NMFS West Coast Regional Stranding Coordinator (866-767-6114) as soon as feasible. The report must include the following information:
 - a. Time, date, and location (latitude/longitude) of the first discovery (and updated location information if known and applicable);
 - b. Species identification (if known) or description of the animal(s) involved;
 - c. Condition of the animal(s) (including carcass condition if the animal is dead);
 - d. Observed behaviors of the animal(s), if alive;
 - e. If available, photographs or video footage of the animal(s); and
 - f. General circumstances under which the animal was discovered.

- (ii) Vessel Strike – In the event of a ship strike of a marine mammal by any vessel involved in the activities covered by the authorization, L-DEO must report the incident to OPR, NMFS and to regional stranding coordinators as soon as feasible. The report must include the following information:
- a. Time, date, and location (latitude/longitude) of the incident;
 - b. Species identification (if known) or description of the animal(s) involved;
 - c. Vessel's speed during and leading up to the incident;
 - d. Vessel's course/heading and what operations were being conducted (if applicable);
 - e. Status of all sound sources in use;
 - f. Description of avoidance measures/requirements that were in place at the time of the strike and what additional measures were taken, if any, to avoid strike;
 - g. Environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover, visibility) immediately preceding the strike;
 - h. Estimated size and length of animal that was struck;
 - i. Description of the behavior of the marine mammal immediately preceding and following the strike;
 - j. If available, description of the presence and behavior of any other marine mammals immediately preceding the strike;
 - k. Estimated fate of the animal (e.g., dead, injured but alive, injured and moving, blood or tissue observed in the water, status unknown, disappeared); and
 - l. To the extent practicable, photographs or video footage of the animal(s).
- (iii) Additional Information Requests – If NMFS determines that the circumstances of any marine mammal stranding found in the vicinity of the activity suggest investigation of the association with survey activities is warranted (example circumstances noted below), and an investigation into the stranding is being pursued, NMFS will submit a written request to the IHA-holder indicating that the following initial available information must be provided as soon as possible, but no later than 7 business days after the request for information.

- a. Status of all sound source use in the 48 hours preceding the estimated time of stranding and within 50 km of the discovery/notification of the stranding by NMFS; and
 - b. If available, description of the behavior of any marine mammal(s) observed preceding (i.e., within 48 hours and 50 km) and immediately after the discovery of the stranding.
 - c. In the event that the investigation is still inconclusive, the investigation of the association of the survey activities is still warranted, and the investigation is still being pursued, NMFS may provide additional information requests, in writing, regarding the nature and location of survey operations prior to the time period above.
7. This Authorization may be modified, suspended or withdrawn if the holder fails to abide by the conditions prescribed herein, or if NMFS determines the authorized taking is having more than a negligible impact on the species or stock of affected marine mammals.
8. Renewals - On a case-by-case basis, NMFS may issue a one-year IHA renewal with an expedited public comment period (15 days) when 1) another year of identical or nearly identical activities as described in the Specified Activities section is planned or 2) the activities would not be completed by the time the IHA expires and a second IHA would allow for completion of the activities beyond that described in the Dates and Duration section, provided all of the following conditions are met:
 - (a) A request for renewal is received no later than 60 days prior to expiration of the current IHA.
 - (b) The request for renewal must include the following:
 - (i) An explanation that the activities to be conducted beyond the initial dates either are identical to the previously analyzed activities or include changes so minor (e.g., reduction in pile size) that the changes do not affect the previous analyses, take estimates, or mitigation and monitoring requirements.
 - (ii) A preliminary monitoring report showing the results of the required monitoring to date and an explanation showing that the monitoring results do not indicate impacts of a scale or nature not previously analyzed or authorized.
 - (iii) Upon review of the request for renewal, the status of the affected species or stocks, and any other pertinent information, NMFS determines that there are no more than minor changes in the activities, the mitigation and

monitoring measures remain the same and appropriate, and the original findings remain valid.



Donna S. Wieting,
Director, Office of Protected Resources,
National Marine Fisheries Service.

JUL 10 2019

Date

Table 1. Numbers of Incidental Take of Marine Mammals Authorized.

Species	Level B	Level A	Total Authorized Take
Humpback whale	32	3	35
Minke whale	23	2	25
Sei whale	6	2	8
Fin whale	74	7	81
Blue whale	19	2	21
Sperm whale	48	0	48
Cuvier's and <i>Mesoplodon</i> beaked whales	138	0	138
Baird's beaked whale	15	0	15
Bottlenose dolphin	13	0	13
Striped dolphin	176	0	176
Short-beaked common dolphin	2,356	0	2,356
Pacific white-sided dolphin	329	0	329
Northern right-whale dolphin	749	0	754
Risso's dolphin	132	0	132
False killer whale	5	0	5
Killer whale	17	0	17
Short-finned pilot whale	18	0	18
<i>Kogia</i> spp.	29	2	31
Dall's porpoise	786	43	829
Northern fur seal	201	0	201
Guadalupe fur seal	65	0	65
Northern elephant seal	629	0	629

APPENDIX B: Basic Data Summary Form

BASIC DATA FORM					
LDEO Project Number	MGL1905				
Seismic Contractor	L-DEO				
Area Surveyed During Reporting Period	Line Number	Start Latitude	Start Longitude	End Latitude	End Longitude
	3D Survey Area Corners				
	NE	46.14355°N	129.95739°W	-	-
	SE	46.81739°N	129.73997°W	-	-
	NW	46.07721°N	130.16186°W	-	-
	SW	45.75105°N	129.94350°W	-	-
	2D Survey Lines				
	2001	45.8543°N	130.0447°W	45.9380°N	129.7877°W
	2002	45.8806°N	130.0623°W	45.9643°N	129.8052°W
	2003	45.9051°N	130.0786°W	45.9887°N	129.8215°W
	2004	45.9317°N	130.0964°W	46.0153°N	129.8392°W
	2005	45.9519°N	130.1101°W	46.0356°N	129.8527°W
	2006	45.8282°N	129.9200°W	46.0402°N	130.0618°W
	2007	45.8318°N	129.9090°W	46.0438°N	130.0507°W
2008	45.8546°N	129.8389°W	46.0666°N	129.9804°W	
2009	45.8529°N	129.7640°W	45.9598°N	130.0926°W	
Survey Type	Combined 3D and 2D				
Vessel and/or Rig Name	R/V <i>Marcus G. Langseth</i>				
Permit Number	IHA and Biological Opinion Issued 10 July 2019				
Location / Distance of Airgun Deployment	280 meters astern (from the NRP in the PSO tower)				
Water Depth	Min	1,400			
	Max	2,800			
		11 July 2019	Through	13 August 2019	
Total time airguns operating – all power levels:	489:55				
Time airguns operating on survey lines:	385:28				
Time airguns operating not on a survey line:	88:41				
Amount of time mitigation gun (40 in³) operations:	00:00				
Amount of time in ramp-up:	15:44				
Number daytime ramp-ups:	44				
Number of night time ramp-ups:	5				
Number of ramp-ups from mitigation source:	0				
Amount of time conducted in airgun testing:	00:02				
Duration of visual observations:	539:13				
Duration of observations while source active:	303:35				
Duration of observation during source silence:	235:38				
Duration of acoustic monitoring:	563:29				
Duration of acoustic monitoring while source active:	487:51				
Duration of acoustic monitoring during source silence:	75:38				
Duration of simultaneous acoustic and visual monitoring:	365:35				
Lead Protected Species Observer:	Amanda Dubuque				
Protected Species Observers:	Bianca Mares, Lluvia Dorantes, Alejandra Ramos				
Lead Acoustic Observer:	Ana Salomon				
Number of Marine Mammals Visually Detected:	98				
Number of Marine Mammals Acoustically Detected:	0				

Number of Simultaneous Visual and Acoustic Detections:	0
Number of Sea Turtles detected:	0
Total Number of Protected Species Detections:	98
List Mitigation Actions	6 = 2 delayed ramp-ups and 4 shut-downs
Duration of operational downtime due to mitigation:	04:56 – 01:28 for delayed ramp-ups and 03:28 for shut-downs 03:58 was considered production loss

APPENDIX C: Passive Acoustic Monitoring System Specifications

1.1 Heavy Tow Cable with separate hydrophone array

Main Tow Cable serial number SM 4946 (damaged and replaced on 07 August 2019)

Spare Tow Cable serial number SM 6047

Mechanical Information

Length = 230 m

Outer diameter = 16.5 mm (+/- 0.5 mm)

Ship-side connector: ITT 19-way, male

Wet-end connector: Seiche, with 36-way Lemo insert, female.

Weight = approximately 94 kg (in air)

1.2 Hydrophone array cable

Main Cable serial number SM 4964

Spare Cable serial number SM 4073

Mechanical Information

Type = Detachable 20 m, 4-ch Array

Length = 20 m

Diameter = 17 mm (over cable), 32 mm (over mouldings), 65 mm (over connector)

Connector = Seiche connector with 36-way Lemo insert, male.

Weight = approximately 10 kg (in air)

Hydrophone elements

Array elements = four spherical hydrophones / preamplifiers, one depth sensor

Hydrophone 1 = 200-200,000 Hz (-3 dB), sensitivity -166dB re 1V/uPa; 0.00 m

Hydrophone 2 = 200-200,000 Hz (-3 dB), sensitivity -166dB re 1V/uPa; at 2.00 m

Hydrophone 3 = 2,000-200,000 Hz (-3 dB), sensitivity -166dB re 1V/uPa; at 15.00 m

Hydrophone 4 = 2,000-200,000 Hz (-3 dB), sensitivity -166dB re 1V/uPa; at 15.25 m

Depth sensor = 10-bar pressure rating.

1.3 Deck cable

Main Deck serial number SM 4952

Spare Deck serial number SM 3447

Mechanical Information

Length 100m

Diameter 14mm cable, 45mm at male connector, 65mm at female connector

Weight 25kg

Connectors ITT 19 pin

APPENDIX D: PAM Hydrophone Cable Deployment on the R/V *Marcus G. Langseth*

Deployment and retrieval of the hydrophone cable requires the PAM operator and at least one additional person to complete for the 2D survey deployment method and at least two additional persons to complete for the 3D survey deployment method.

Overview

Two identical hydrophone cables were supplied to the Langseth for this survey. The cables consisted of a 230-meter steel reinforced tow cable with a detachable 20 meter hydrophone array. The arrays consisted of two low-frequency hydrophones (200 Hz to 200 kHz), two high-frequency hydrophone elements (2 kHz to 200 kHz) and a depth gauge (100m capacity) potted directly into the cable. The four hydrophones have been positioned in two pairs, with the first pair positioned roughly 13m ahead of the second pair (Figure 1).

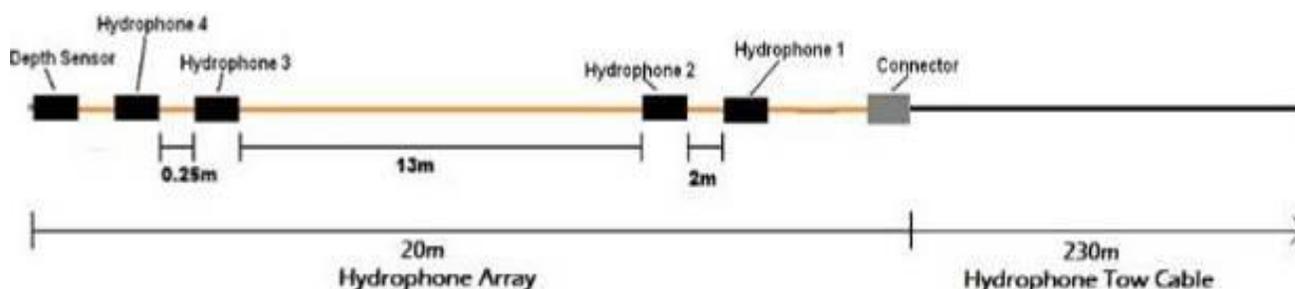


Figure 1: Two-part hydrophone cable with a 230-meter tow cable and detachable 20 meter hydrophone array

The hydrophone cable was spooled onto a hydraulic winch located on the port side of the gun deck (Figure 2). A 100-meter deck cable connects the hydrophone cable on the gun deck to the PAM station in the main science lab (Figure 3). Due to the structural design of the vessel, two 100-meter deck cables were installed in port, prior to the project. One of the deck cables was designated as the main cable and the other acted as a spare. The main deck cable was connected to an electronic processing unit (EPU) located, along with two monitors and other monitoring equipment, at the PAM station in the main science lab (Figure 4). The rack-mounted EPU was secured in the event of rough weather. A GPS feed (GNGGA string) was supplied to the system by the ship's navigation Seapath 200.

For the 3D survey of the program, the cable was deployed via roller from the lead-in of streamer four (Figure 5). A Chinese finger secured onto the tow cable approximately 30 meters from the end was attached to the roller and a second Chinese finger secured onto the tow cable approximately 110 meters from the end was attached to a tow point on the port stern of the vessel, which reduced the tension on the cable remaining on the winch after the cable was deployed. With this deployment method, approximately 110 meters of hydrophone cable was towed off the port of the vessel, with the last 30 meters flowing freely between streamers three and four. For the 2D survey of the program, the Chinese finger at 110 meters on the cable was attached, via Yales grip, to a lifting rope on the port side beam, which offset the towing point of the cable approximately two meters to port (Figure 6). With this deployment method, approximately 110 meters of hydrophone cable were towed freely off the port stern of the vessel. Both deployment methods were utilized to minimize the risk of entanglement with the seismic gear which had different deployment configurations for the different survey methods. A one-meter chain length weighing approximately 12 kilograms was taped onto the two cable approximately five meters ahead of the connector to the hydrophone array. For the 3D survey deployment method, the extra weight assisted the roller in moving down the streamer and into the water. For the 2D survey deployment method, the extra weight assisted in increasing the tow depth of the cable.



Figure 2: PAM cable spooled onto the winch.



Figure 3: Hydrophone cable on the winch connected to the main deck cable.

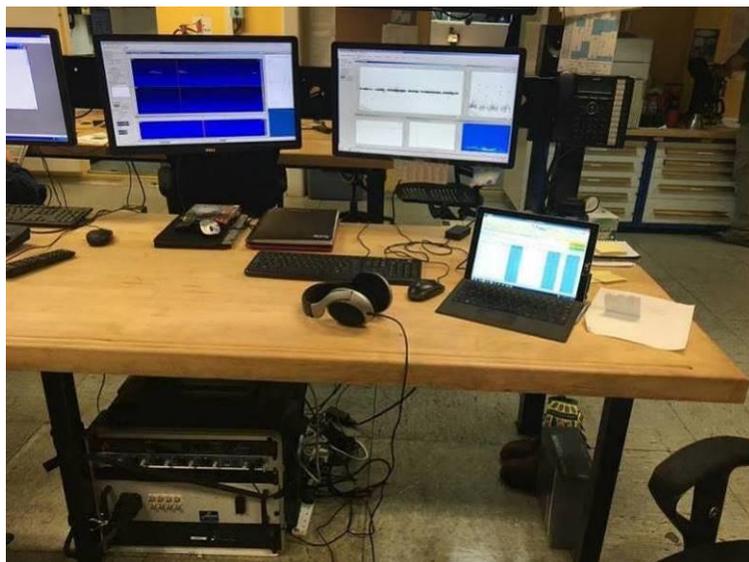


Figure 4: Passive Acoustic Monitoring Station in the Main Science Lab



Figure 5: Hydrophone cable connected to the roller on the lead-in for streamer four.



Figure 6: PAM cable connecting to the offset rope via shackle.

Deployment Tasks

- Ensure that the data processing unit is powered down.
- Alert the bridge of the pending hydrophone deployment.
- Ensure that the deck cable was disconnected from the hydrophone tow cable. Do not allow connectors to rotate with the winches unless they are strapped down as they can impact or snag and snap.
- Power on the winch.
- Avoid excess tension on the cable.
- Deploy in a slow controlled manner to prevent crossover on the winch.
- Respect the cables minimum bend angles and ensure are not bent on either side of cable mouldings/pottings.
- Protect cable from abrasions and chaffing.
- Let out the proper length of hydrophone cable off the winch for the deployment method used.
- Connect the hydrophone cable to any needed sliding collars, offset ropes, etc. used for the deployment method via Chinese fingers.
- Power off the winch.
- Connect the hydrophone tow cable to the deck cable.
- Power on the data processing unit.

Retrieval Tasks

- Ensure that the data processing unit is powered down.
- Alert the bridge of the pending hydrophone cable retrieval.
- Disconnect the hydrophone cable from the tow cable. Tape the connectors and ensure they are stowed/secured clear of the moving winch.
- Power on the winch.
- Disconnect the Chinese fingers on the cable from any utilized sliding collars or offset ropes.
- Retrieve the cable in a slow controlled manner to prevent crossover on the winch.
- Power off the winch.

Always ensure that if the winch is powered on that the tow cable is disconnect from the deck cable and the connectors properly stowed.

Health Safety and Environment (HSE) Requirements

Normal working deck Personal Protective Equipment (PPE) was required (hard hat, boots, gloves, eye protection). A life vest was required for any work involving items going over the side. The operation carried relatively low risk. Hazards included working close to the side of the vessel, trip hazards, and pinch points at the winch.

A Job Safety Analysis (JSA) was completed for this task. Further review of JSA was required in the event of modifications to the procedures.

APPENDIX E: Survey Lines Acquired

Survey Line	Date Acquisition Commenced	Time Acquisition Commenced (UTC)	Date Acquisition Completed	Time Acquisition Completed (UTC)	Comments
3D Survey Lines					
MGL1905-P1004	2019-07-15	06:28	2019-07-15	10:21	Source active for night-time line change
MGL1905-P1116	2019-07-15	12:27	2019-07-15	17:34	Source silent for day-time line change
MGL1905-P1012	2019-07-15	19:19	2019-07-15	21:11	Line aborted due to engine issues.
MGL1905-P1124	2019-07-16	07:19	2019-07-16	09:26	Source active for night-time line change
MGL1905-P1020	2019-07-16	11:34	2019-07-16	17:01	Source silent for day-time line change
MGL1905-P1132	2019-07-16	19:05	2019-07-17	00:33	Source silent for day-time line change
MGL1905-P1028	2019-07-17	02:33	2019-07-17	08:00	Source active for night-time line change
MGL1905-P1140	2019-07-17	10:15	2019-07-17	16:00	Source silent for day-time line change
MGL1905-P1036	2019-07-17	18:03	2019-07-17	23:01	Source silent for day-time line change
MGL1905-P1148	2019-07-18	01:24	2019-07-18	06:51	Source active for night-time line change
MGL1905-P1044	2019-07-18	09:08	2019-07-18	14:10	Source silent for day-time line change
MGL1905-P1156	2019-07-18	16:46	2019-07-18	22:17	Source silent for day-time line change
MGL1905-P1052	2019-07-19	00:36	2019-07-19	05:52	Source active for night-time line change
MGL1905-P1164	2019-07-19	07:59	2019-07-19	13:45	Source silent for day-time line change
MGL1905-P1060	2019-07-19	16:52	2019-07-19	21:24	Source silent for day-time line change
MGL1905-P1172	2019-07-19	23:17	2019-07-20	05:19	Source active for night-time line change
MGL1905-P1068	2019-07-20	07:16	2019-07-20	12:43	Source silent for day-time line change
MGL1905-P1076	2019-07-21	03:26	2019-07-21	09:21	A technical issue with streamer four caused recording gaps from 03:39-03:42 UTC, 03:44-03:55 UTC, 04:11-04:26 UTC, and 05:55-06:21 UTC while the issue was corrected. The source remained active at full volume during these times. The source also remained active after the end of the line for the night-time line change.
MGL1905-P1080	2019-07-21	11:18	2019-07-21	17:06	Source silent for line change.
MGL1905-P1084	2019-07-21	19:01	2019-07-22	00:43	Source silent for line change.
MGL1905-I1180	2019-07-22	02:40	2019-07-22	08:49	Source active for line change
MGL1905-P1092	2019-07-22	10:44	2019-07-22	15:59	Source silent for line change.
MGL1905-P1188	2019-07-22	18:19	2019-07-23	00:13	Source silent for line change
MGL1905-I1092	2019-07-23	02:32	2019-07-23	07:57	Source silenced at end of line and operations suspended for maintenance of streamer four, and then for repair of the vessel's engines.
MGL1905-P1100	2019-07-25	12:31	2019-07-25	16:03	Source silent for line change
MGL1905-P1196	2019-07-25	18:12	2019-07-25	23:39	Source silent for line change
MGL1905-P1108	2019-07-26	01:27	2019-07-26	06:52	Source active for line change
MGL1905-P1204	2019-07-26	09:13	2019-07-26	14:48	Source silent for line change
MGL1905-I1076	2019-07-26	17:11	2019-07-26	21:54	Source active for line change
MGL1905-I1124	2019-07-27	00:06	2019-07-27	05:57	Source active for line change
MGL1905-I1060	2019-07-27	08:10	2019-07-27	13:49	Source silent for line change
MGL1905-P1212	2019-07-27	15:48	2019-07-27	21:08	Source silent for line change
MGL1905-I1100	2019-07-27	22:56	2019-07-28	04:17	Source active for line change
MGL1905-P1220	2019-07-28	06:02	2019-07-28	11:21	Source active for line change
MGL1905-P2348	2019-07-28	13:17	2019-07-28	18:09	Source active for line change
MGL1905-P1228	2019-07-28	20:10	2019-07-29	01:27	Source silent for line change
MGL1905-P1356	2019-07-29	02:55	2019-07-29	08:14	Source active for line change
MGL1905-P1236	2019-07-29	10:14	2019-07-29	15:35	Source silent for line change
MGL1905-P1364	2019-07-29	17:35	2019-07-29	22:26	Source silent for line change
MGL1905-P1244	2019-07-30	00:23	2019-07-30	05:47	Source active for line change

Survey Line	Date Acquisition Commenced	Time Acquisition Commenced (UTC)	Date Acquisition Completed	Time Acquisition Completed (UTC)	Comments
MGL1905-P1372	2019-07-30	07:56	2019-07-30	13:04	Source active for line change due to fog and rain greatly reducing visibility around vessel.
MGL1905-P1252	2019-07-30	15:03	2019-07-30	20:56	Acquisition suspended from 16:56 to 17:26 UTC due to a mitigation shut-down for a whale. Source silent for line change.
MGL1905-P1380	2019-07-30	22:33	2019-07-31	04:13	Source silenced from 04:42 to 04:46 UTC for a mechanical/technical shut-down due to engine issues causing compressors to shut-down. Source active for line change.
MGL1905-P1260	2019-07-31	07:22	2019-07-31	13:06	Source silent for line change
MGL1905-P1388	2019-07-31	15:04	2019-07-31	20:06	Source silent for line change
MGL1905-P1268	2019-07-31	22:05	2019-08-01	03:35	Source active for line change
MGL1905-P1396	2019-08-01	05:24	2019-08-01	11:13	Source active for line change. Streamer number four failed at 07:30 UTC.
MGL1905-P1276	2019-08-01	13:18	2019-08-01	18:56	Source silenced at end of line and further source operations suspended to conduct maintenance and repairs on streamer four.
MGL1905-P1284	2019-08-02	10:47	2019-08-02	14:24	Source silent for line change
MGL1905-P1404	2019-08-02	16:16	2019-08-02	21:19	Source silent for line change
MGL1905-P1292	2019-08-02	23:19	2019-08-03	05:08	Acquisition suspended from 02:01 to 03:06 UTC due to a mitigation shut-down for large whale and calf. Source active for line change
MGL1905-P1412	2019-08-03	07:19	2019-08-03	12:24	Source active for line change
MGL1905-I1292	2019-08-03	14:31	2019-08-03	20:05	Source silent for line change
MGL1905-I1412	2019-08-03	22:00	2019-08-04	02:51	Source active for line change
MGL1905-P1300	2019-08-04	04:41	2019-08-04	10:12	Source active for line change
MGL1905-P1420	2019-08-04	12:07	2019-08-04	16:58	Survey line began at full volume and switched to reduced volume at 12:21 UTC for the remainder of the line. Source silent for line change. Sub-array one retrieved for maintenance during the line change.
MGL1905-P1308	2019-08-04	19:06	2019-08-05	00:15	Source silent for line change
MGL1905-P1428	2019-08-05	02:07	2019-08-05	07:02	Source active for line change
MGL1905-P1316	2019-08-05	09:05	2019-08-05	14:14	Source silent for line change
MGL1905-P1436	2019-08-05	16:08	2019-08-05	21:01	Source silent for line change. Sub-array one retrieved for maintenance to fix air leak.
MGL1905-R1284	2019-08-05	22:54	2019-08-06	04:14	Source active for line change
MGL1905-I1348	2019-08-06	06:05	2019-08-06	11:14	Source active for line change
MGL1905-I1252	2019-08-06	13:10	2019-08-06	18:36	Source silent for line change
MGL1905-A1348	2019-08-06	20:38	2019-08-07	01:41	Source silent for five minutes then resumed at full volume for remainder of the line change due to fog reducing visibility
MGL1905-P1324	2019-08-07	04:43	2019-08-07	06:57	Survey line aborted – streamer four lead-in broke requiring retrieval
MGL1905-B1348	2019-08-07	18:20	2019-08-07	22:57	Source silent for line change. Mitigation shut-down for whale from 21:27 to 22:01 UTC
MGL1905-R1324	2019-08-08	03:09	2019-08-08	08:36	Source active for line change
MGL1905-C1348	2019-08-08	11:04	2019-08-08	16:01	Last 3D survey line of the project. Source silenced at end of line to retrieve gear to re-configure for 2D survey deployment
2D Survey Lines					
MGL1905-P2007	2019-08-09	08:27	2019-08-09	09:07	First 2D survey line. Source active for line change.

Survey Line	Date Acquisition Commenced	Time Acquisition Commenced (UTC)	Date Acquisition Completed	Time Acquisition Completed (UTC)	Comments
MGL1905-B2007	2019-08-09	09:11	2019-08-09	15:01	Source active for line change
MGL1905-P2008	2019-08-09	16:44	2019-08-09	22:16	Source active for line change
MGL1905-P2009	2019-08-10	01:43	2019-08-10	06:09	Source active for line change
MGL1905-P2006	2019-08-10	09:19	2019-08-10	13:59	Source active for line change
MGL1905-P2004	2019-08-10	15:59	2019-08-10	19:49	Source silenced at end of line for a mitigation shut-down for a whale.
MGL1905-P2005	2019-08-10	23:04	2019-08-11	02:53	Source active for line change
MGL1905-P2003	2019-08-11	05:46	2019-08-11	09:52	Source active for line change.
MGL1905-P2002	2019-08-11	12:19	2019-08-11	16:17	Source active for line change.
MGL1905-P2001	2019-08-11	19:24	2019-08-11	22:14	Source silenced at end of line – survey completed.

APPENDIX F: Acoustic Source Ramp-up Operations

Date	Time Ramp-up Initiated (UTC)	Time Ramp-up Completed (UTC)	Final Source Volume (in ³)	Reason for Ramp-up/Comments
3D Survey Ramp-ups				
2019-07-15	05:52	06:22	3300/3240	Begin source operations for the survey program. Port array at full volume (3300 in ³ with 18 elements) starboard array at reduced volume (3240 in ³ with 17 elements).
2019-07-15	18:57	19:18	3300/3240	Resume operations after a day-time line change. Port array at full volume (3300 in ³ with 18 elements) starboard array at reduced volume (3240 in ³ with 17 elements).
2019-07-16	06:58	07:19	3300	Resume operations after they had been suspended due to an issue with the vessel's engines. Both arrays at full volume.
2019-07-16	18:23	18:43	3300	Ramp-up after source silenced for line change
2019-07-17	01:42	02:02	3300	Ramp-up after source silenced for line change
2019-07-17	17:40	18:00	3300	Ramp-up after source silenced for line change
2019-07-18	01:04	01:24	3300	Ramp-up after source silenced for line change
2019-07-18	16:00	16:13	n/a	Ramp-up after source silenced for line change and then aborted due to technical issue
2019-07-18	16:14	16:20	n/a	Ramp-up aborted due to technical issue
2019-07-18	16:26	16:46	3300/3260	Starboard array at full volume (3300 in ³ with 18 elements) and port array at reduced volume (3240 in ³ with 17 elements).
2019-07-18	23:58			Ramp-up after source silenced for line change
2019-07-19		00:18	3300/3260	Starboard array at full volume (3300 in ³ with 18 elements) and port array at reduced volume (3240 in ³ with 17 elements).
2019-07-19	16:22	16:23	n/a	Ramp-up started without being cleared due to a miscommunication, but was quickly stopped after one shot of a single 40 in ³ element.
2019-07-19	16:32	16:52	3300	Ramp-up after source silenced for line change. Delayed due to protected species sighting.
2019-07-19	22:54	23:14	3300	Ramp-up after source silenced for line change
2019-07-21	01:49	02:09	3300	Ramp-up conducted for source test after streamer maintenance.
2019-07-21	03:02	03:22	3300	Ramp-up after source silenced for line change
2019-07-21	18:40	19:01	3300	Ramp-up after source silenced for line change
2019-07-22	02:19	02:39	3300	Ramp-up after source silenced for line change
2019-07-22	17:58	18:18	3300	Ramp-up after source silenced for line change
2019-07-23	01:41	02:01	3300	Ramp-up after source silenced for line change
2019-07-25	12:10	12:30	3300	Ramp-up after extended downtime for streamer maintenance, then seismic gear retrieval for engine repairs, and then re-deployment of the seismic gear. The ramp-up was delayed for approximately five hours as PSOs could not give clearance due to dense fog limiting visibility for several hours.
2019-07-25	17:43	18:03	3300	Ramp-up after source silenced for line change
2019-07-26	00:55	01:15	3300	Ramp-up after source silenced for line change
2019-07-26	16:51	17:11	3300	Ramp-up after source silenced for line change; ramp-up delayed for 51 minutes as PSOs could not clear EZ due to fog
2019-07-27	15:18	15:38	3300	Ramp-up after source silenced for line change
2019-07-27	22:36	22:56	3300	Ramp-up after source silenced for line change. Ramp-up was delayed 16 minutes while PSOs confirmed that a whale ahead of the vessel was clear of the buffer zone.
2019-07-29	02:34	02:55	3300	Ramp-up after source silenced for line change
2019-07-29	17:07	17:27	3300	Ramp-up after source silenced for line change
2019-07-30	00:03	00:23	3300	Ramp-up after source silenced for line change
2019-07-30	17:06	17:26	3300	Ramp-up after source silenced for a mitigation shut-down
2019-07-30	22:04	22:25	3300	Ramp-up after source silenced for line change
2019-07-31	14:30	14:50	3300	Ramp-up after source silenced for line change
2019-07-31	21:34	21:55	3300	Ramp-up after source silenced for line change

Date	Time Ramp-up Initiated (UTC)	Time Ramp-up Completed (UTC)	Final Source Volume (in ³)	Reason for Ramp-up/Comments
2019-08-02	10:26	10:46	3300	Night-time ramp-up after suspended operations for streamer maintenance. Ramp-up delayed several hours due to fog.
2019-08-02	15:47	16:08	3300	Ramp-up after source silenced for line change
2019-08-02	22:57	23:18	3300	Ramp-up after source silenced for line change
2019-08-03	03:06	03:26	3300	Ramp-up after source silenced for a mitigation shut-down
2019-08-03	21:40	22:00	3300	Ramp-up after source silenced for line change
2019-08-04	18:45	19:06	3300	Ramp-up after source silenced for line change.
2019-08-05	01:46	02:07	3300	Ramp-up after source silenced for line change.
2019-08-05	15:46	16:06	3300	Ramp-up after source silenced for line change.
2019-08-05	22:33	22:54	3300	Ramp-up after source silenced for line change.
2019-08-06	20:09	20:29	3300	Ramp-up after source silenced for line change.
2019-08-07	18:00	18:20	3300	Ramp-up to resume source activity after operations had been suspended for a broken streamer.
2019-08-07	22:01	22:04	200	Ramp-up to resume source activity after a mitigation shut-down for a whale. Ramp-up aborted at 200 in ³ with four active elements due to technical issue with source controller system.
2019-08-07	22:05	22:25	3300	Ramp-up to resume source activity after a mitigation shut-down and an aborted ramp-up.
2019-08-08	02:49	03:09	3300	Ramp-up after source silenced for line change. Last ramp-up to this source volume for acquisition of final 3D survey line.
2D Survey Ramp-ups				
2019-08-09	07:01	07:21	6600	Night-time ramp-up to begin acquisition of the first 2D survey line.
2019-08-10	20:04	20:24	6600	Ramp-up to resume source activity after a mitigation shut-down.

APPENDIX G: Changes in Acoustic Source Volume During Survey Operations

Date	Time (UTC)	Start Volume (in ³)	Start Active Elements	End Volume (in ³)	End Active Elements	Comments
3D Survey						
2019-07-18	13:58	3300/3300	18/18	3300/3260	18/17	Volume on port array reduced. Starboard array still at full volume.
2019-08-04	12:21	3300/3300	18/18	3300/2940	18/17	Volume on starboard array reduced. Port array still at full volume
2019-08-04	12:25	3300/2940	18/17	3300/3120	18/18	Volume on starboard array increased. Port array still at full volume.

APPENDIX H: Acoustic Monitoring Downtime

Acoustic Monitoring Stopped		Acoustic Monitoring Resumed		Total Downtime	Total Downtime with Source Active	Total Downtime with Source Silent	Reason/Comment
Date	Time (UTC)	Date	Time (UTC)				
3D Survey							
2019-07-15	06:55	2019-07-15	07:03	00:08	00:08	-	Adjust cable deployment length
2019-07-15	21:16	2019-07-16	06:21	09:05	-	09:05	Source arrays and PAM cable retrieved for engine repairs/maintenance
2019-07-20	13:04	2019-07-21	01:19	12:15	-	12:15	Source arrays and PAM cable retrieved for streamer repairs/maintenance
2019-07-23	07:57	2019-07-23	21:37	13:40	-	13:40	Source arrays and PAM cable retrieved for streamer repairs/maintenance
2019-07-23	22:59	2019-07-25	06:23	31:24	-	31:24	All towed gear retrieved for engine repairs/maintenance
2019-08-01	05:22	2019-08-01	05:26	00:04	00:04	-	PAM system briefly stopped to re-start the computer and switch to back-up configuration file – system froze
2019-08-01	18:57	2019-08-02	06:13	11:16	-	11:16	Streamer maintenance
2019-08-06	16:11	2019-08-06	17:15	01:04	01:04	-	Replace hydrophone array with spare
2019-08-07	07:06	2019-08-07	17:29	10:23	-	10:23	Streamer four lead-in broke – replaced tow cable during the downtime
2019-08-08	16:01	2019-08-09	04:12	12:11	-	12:11	Seismic gear re-configured for 2D survey lines
2D Survey							
2019-08-10	00:33	2019-08-10	01:21	00:48	00:48	-	Adjustment to the PAM cable – added extra layer of protection between the tow cable and the chain weight

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position	Source Activity Initial Detection	Movement/ Behavior		CPA Source / Source Activity	Mitigation Action	Comments
48	2019-08-02	18:39	Fin Whale	1	45.97143 °N 129.87951 °W	Full Volume Online	PV/OD; AV	BV, FT	2629m/Full Volume Online	None	Whale first observed within and last observed outside of the 160 dB radius. Whale was a potential Level B take
49	2019-08-02	19:31	Fin Whale	1	45.90962 °N 129.83810 °W	Full Volume Online	PE(BH); AV	BV, FT	1665m/Full Volume Online	None	Whale first and last observed within 160 dB radius and was a potential Level B take.
50	2019-08-02	23:12	Fin Whale	2	45.74617 °N 129.79200 °W	Ramp-up	PE(AH); UN	BV, FT	1060m/Full Volume Online	None	Detection began during ramp-up and concluded with the source at full volume online. Whales first and last sighted in 160 dB radius, and were potential Level B takes
51	2019-08-03	01:25	Fin Whale	3	45.89280°N 129.89008°W	Full Volume Online	PV/OD; AV	BV, FT	1926m/Full Volume Online and 1926m/Silent	Shut-down	Sighting was two adults and a calf. Mitigation action was one hour 25 minutes (one hour five minutes for the shut-down and 20 minutes for the ramp-up). Whales initially observed in 160 dB radius before the shut-down and were potential Level B takes
52	2019-08-03	13:34	Unidentified Whale	1	45.71917°N 129.75500°W	Full Volume Offline	UN	BV, FT	1479m/Full Volume Offline	None	Whale first and last observed within 160 dB radius. Whale was a potential Level B take.
53	2019-08-03	14:47	Fin Whale	1	45.79439°N 129.82056°W	Full Volume Online	PV/OD	BV, FT	889m/Full Volume Online	None	Whale first and last observed within 160 dB radius. Whale was a potential Level B take.
54	2019-08-04	00:50	Unidentified Whale	2	45.93067°N 129.84650°W	Full Volume Online	PV/SD	BV	10,050m/Full Volume Online	None	Whales were not observed approaching or entering any radii or exclusion zones.

APPENDIX I: Summary of Visual Detections of Protected Species during the Axial Seamount Seismic Survey Program

Movement Codes: **TV:** towards vessel; **AV:** away from vessel; **PV/SD:** parallel vessel, same direction; **PV/OD:** parallel vessel, opposite direction; **PE (AH/BH):** perpendicular (crossing ahead or behind); **MI:** milling; **SA:** stationary; **V:** variable, **UN:** unknown; **OM:** other movement

Behavioral Codes: **NS:** normal swimming; **FT:** fast travel; **ST:** slow travel; **PO:** porpoising; **SS:** swimming below surface; **MI:** milling; **BR:** bow/wake riding; **BA:** resting/basking at surface; **FL:** floating; **SA:** surface active (lob tailing/pectoral slapping, full/partial breaching); **R:** rolling; **DI:** dive; **DF:** dive with fluke; **FF:** feeding/foraging; **SB:** social behavior; **MT:** mating behavior; **BV:** blow visible (whale); **SV:** only splashes visible (dolphins); **DV:** dorsal fin visible; **OB:** other behavior

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position	Source Activity Initial Detection	Movement/ Behavior	CPA Source / Source Activity	Mitigation Action	Comments
1	2019-07-12	00:00	Humpback Whale	1	48.27267°N 123.70300°W	Not Firing/Silent	PV/SD BV, FT	1735m/Silent	None	Acoustic source silent and on-board during transit.
2	2019-07-12	01:16	Dall's Porpoise	3	48.32592°N 124.05859°W	Not Firing/Silent	PV/OD NS	1553m/Silent	None	Acoustic source silent and on-board during transit.
3	2019-07-12	03:09	Dall's Porpoise	3	48.45590°N 124.52354°W	Not Firing/Silent	PV/OD NS, PO, DI	652m/Silent	None	Acoustic source silent and on-board during transit.
4	2019-07-12	03:48	Humpback Whale	1	48.49683°N 124.67550°W	Not Firing/Silent	PV/OD; AV NS, BV	1361m/Silent	None	Acoustic source silent and on-board during transit.
5	2019-07-12	04:13	Humpback Whale	5	48.51505°N 124.77073°W	Not Firing/Silent	PV/OD SA, BV, FF, DF	1211m/Silent	None	Acoustic source silent and on-board during transit.
6	2019-07-12	04:39	Unidentified Dolphin	40	48.51519°N 124.87230°W	Not Firing/Silent	PV/OD; AV FT, SR	1575m/Silent	None	Acoustic source silent and on-board during transit.
7	2019-07-12	04:43	Unidentified Pinniped	3	48.51531°N 124.88635°W	Not Firing/Silent	V SA, FT	206m/Silent	None	Acoustic source silent and on-board during transit.
8	2019-07-12	14:09	Northern Right-Whale Dolphins and Pacific White-Sided Dolphins	20 (NRWD) and 5 (PWSD)	47.66150°N 126.73967°W	Not Firing/Silent	PE(AH); AV FT, PO	832m/Silent	None	Detection was a mixed pod of two species. Acoustic source silent and on-board during transit.

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position	Source Activity Initial Detection	Movement/ Behavior		CPA Source / Source Activity	Mitigation Action	Comments
9	2019-07-12	14:33	Harbour Porpoise	1	47.62450°N 126.82067°W	Not Firing/Silent	PV/OD; AV	NS	200m/Silent	None	Acoustic source silent and on-board during transit.
10	2019-07-12	16:06	Dall's Porpoise	4	47.52117°N 127.04383°W	Not Firing/Silent	TV; AV	SR, FT	150m/Silent	None	Acoustic source silent and on-board during transit.
11	2019-07-12	16:27	Dall's Porpoise	4	47.49585°N 127.09871°W	Not Firing/Silent	TV, AV	SR, FT	336m/Silent	None	Acoustic source silent and on-board during transit.
12	2019-07-12	18:36	Unidentified Dolphins	3	47.29020°N 127.53740°W	Not Firing/Silent	PV/OD	NS, MI	850m/Silent	None	Acoustic source silent and on-board during transit.
13	2019-07-12	19:40	Minke Whale	1	47.19029°N 127.75067°W	Not Firing/Silent	AV	SR, NS	449m/Silent	None	Acoustic source silent and on-board during transit.
14	2019-07-13	14:40	Blue Whale	5	45.96690°N 130.36266°W	Not Firing/Silent	AV	BV, MI, SR	5659m/Silent	None	Acoustic source silent and on-board during streamer deployment in the survey area.
15	2019-07-13	17:30	Baird's Beaked Whale	8	45.87630°N 130.60835°W	Not Firing/Silent	TV; AW	BV, FT, SA	654m/Silent	None	Acoustic source silent and on-board during streamer deployment in the survey area.
16	2019-07-15	03:42	Fin Whale	1	46.16388°N 130.18340°W	Silent	PV/OD	BV	1390m/Silent	None	Acoustic source arrays silent during source array deployment operations.
17	2019-07-15	13:40	Unidentified Whale	1	45.84033°N 129.94533°W	Reduced Volume Online	PV/OD	BV	4081m/Reduced Volume Online	None	Whale did not enter any radii or EZ. Port array at FV and Stbd array at RV. No potential takes.
18	2019-07-15	14:07	Sperm Whale	1	45.87917°N 129.97133°W	Reduced Volume Online	PV/OD	BV	1750m/Reduced Volume Online	None	Whale last sighted in 160 dB radius. Potential Level B take. Port array at FV and Stbd array at RV
19	2019-07-15	23:45	Fin Whale	1	45.82717°N 129.99117°W	Silent	PV/OD	BV	2117m/Silent	None	Source silent and on-board d/t vessel engine issues/maintenance.

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position	Source Activity Initial Detection	Movement/ Behavior		CPA Source / Source Activity	Mitigation Action	Comments
20	2019-07-16	00:36	Fin Whale	1	45.77936°N 129.96013°W	Silent	PV/OD; AV	BV	1752m/Silent	None	Source silent and on-board d/t vessel engine issues/maintenance.
21	2019-07-16	02:10	Unidentified Whale	2	45.69231°N 129.90961°W	Silent	PE(BH)	BV	5620m/Silent	None	Source silent and on-board d/t vessel engine issues/maintenance.
22	2019-07-16	14:50	Unidentified Whale	1	45.87322°N 130.01860°W	Full Volume Online	AV	BV	5926m/Full Volume Online	None	Whale did not approach or enter 500m EZ or 160 dB radius.
23	2019-07-16	15:07	Unidentified Whale	1	45.85413°N 130.00581°W	Full Volume Online	UN	BV	2884m/Full Volume Online	None	Whale last sighted within the 160 dB radius. Potential Level B take.
24	2019-07-16	15:28	Unidentified Whale	1	45.83028°N 129.98993°W	Full Volume Online	AV	BV	4357m/Full Volume Online	None	Whale did not approach or enter 500m EZ or 160 dB radius.
25	2019-07-16	16:13	Unidentified Whale	1	45.77849°N 129.95539°W	Full Volume Online	AV	BV	2831m/Full Volume Online	None	Whale last observed outside of 160 dB radius. Potential Level B take.
26	2019-07-16	20:05	Unidentified Whale	1	45.82574°N 129.92720°W	Full Volume Online	UN; AV	BV	5754m/Full Volume Online	None	Whale did not approach or enter 500m EZ or 160 dB radius.
27	2019-07-17	16:58	Unidentified Whale	1	46.15642°N 130.17268°W	Silent	UN; TV; PV/OD	BV, FT	295m/Silent	None	Source deployed and silent on a line change.
28	2019-07-18	19:25	Humpback Whale	1	45.94183°N 129.99317°W	Reduced Volume Online	AV	BV, FT	3233m/Reduced Volume Online	None	Whale briefly entered 160 dB radius. Port array at RV and stbd array at FV
29	2019-07-19	14:20	Fin Whale	2	46.16490°N 130.12687°W	Silent	PE(AH); UN	BV, MI, ST	2665m/Silent	Delayed Ramp-up	Delayed ramp-up due to large whale with a calf sighted at any distance from the vessel, per IHA. Ramp-up was delayed 01:12, with a production loss of 01:02.

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position	Source Activity Initial Detection	Movement/ Behavior		CPA Source / Source Activity	Mitigation Action	Comments
30	2019-07-20	3:27	Humpback Whale	1	46.00871 °N 130.02979 °W	Full Volume Online	PV/OD	BV, NS, DI	1629m/Full Volume Online	None	Whale last sighted in 160 dB radius. Potential Level B take.
31	2019-07-20	21:21	Unidentified Whale	1	45.88659°N 129.94084°W	Silent	AV	BV	1782m/Silent	None	Source silent and on-board during streamer maintenance.
32	2019-07-23	02:58	Fin Whale	2	46.06051°N 130.10510°W	Full Volume Online	AV	BV, NS	4352m/Full Volume Online	None	Whales did not enter or approach 160 dB radius or 500 meter EZ.
33	2019-07-24	23:10	Fin Whale	2	46.90083°N 129.94100°W	Silent	AV; PV/OD, PV/AD	BV, FT	686m/Silent	None	Source arrays silent and on-board during streamer deployment operations within the survey area.
34	2019-07-25	20:53	Unidentified Whale	1	45.94183°N 129.96975°W	Full Volume Online	UN	BV	4077m/Full Volume Online	None	Whale did not enter or approach 160 dB radius or 500 meter EZ.
35	2019-07-26	04:23	Fin Whale	1	45.91783°N 130.01333°W	Full Volume Online	PV/SD	BV	1144m/Full Volume Online	None	Whale first and last observed within 160 dB radius. Potential Level B take.
36	2019-07-27	20:04	Unidentified Whale	1	46.05968°N 130.03992°W	Full Volume Online	AV	BV, FT	2596m/Full Volume Online	None	Whale last sighted within the 160 dB radius. Potential Level B take.
37	2019-07-27	21:37	Unidentified Whale	1	46.17507°N 130.10654°W	Silent	PV/SD	BV	217m/Silent	None	Source was silent during a line change.
38	2019-07-27	21:50	Unidentified Whale	1	46.17790°N 130.12026°W	Silent	UN; PE(AH)	BV	1032m/Silent	Delayed Ramp-up	Source was silent during a line change. Ramp-up was delayed for 16 minutes while PSOs confirmed the distance of the whale from the source at the time that clearance was requested.
39	2019-07-28	02:24	Unidentified Whale	1	45.86773°N 129.97093°W	Full Volume Online	PV/OD	BV	6054m/Full Volume Online	None	Whale was not observed approaching or entering any relevant radii or zones.

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position	Source Activity Initial Detection	Movement/ Behavior		CPA Source / Source Activity	Mitigation Action	Comments
40	2019-07-28	14:07	Unidentified Whale	1	46.06967°N 129.97482°W	Full Volume Online	AV	BV	4205m/Full Volume Online	None	Whale was not observed approaching or entering any relevant radii or zones.
41	2019-07-29	14:52	Unidentified Whale	1	46.08779°N 130.04614°W	Full Volume Online	UN	BV	5166m/Full Volume Online	None	Whale was not observed approaching or entering any relevant radii or zones.
42	2019-07-29	17:19	Fin Whale	1	46.15664°N 130.02465°W	Ramp-up	PV/SD; UN	BV	3967m/ Ramp-up	None	Whale was not observed approaching or entering any relevant radii or zones. Detection began during ramp-up with source volume at 2220 in ³ with 15 active elements, and concluded with source active online at full volume
43	2019-07-29	18:46	Fin Whale	1	46.04948°N 129.95300°W	Full Volume Online	UN; PV/AD	BV	5625m/Full Volume Online	None	Whale was not observed approaching or entering any relevant radii or zones.
44	2019-07-30	03:35	Unidentified Whale	2	45.98917°N 129.97383°W	Full Volume Online	PV/OD; AV	BV, FT	2942m/Full Volume Online	None	Whales last sighted in 160 dB radius and were potential Level B takes
45	2019-07-30	16:54	Fin Whale	1	45.87167 °N 129.89383 °W	Full Volume Online	PV/OD	BV, FT	530m/Full Volume Online and 338m/Silent	Shut-down	Whale observed entering and exiting the 500m EZ and last observed in the 160 dB radius. Mitigation action was 30 minutes (10 minutes for shut-down and 20 minutes for ramp-up). Whale was a potential Level B take
46	2019-07-31	21:57	Unidentified Whale	1	45.75537°N 129.80791°W	Full Volume Offline	UN	BV	5687m/Full Volume Offline	None	Whale not observed approaching or entering any radii or EZ.
47	2019-08-01	19:55	Sei Whale	1	46.20523°N 130.10429°W	Silent	AV; TV; PV/OD	BV, FT	825m/Silent	None	Source was silent and arrays were being retrieved for streamer maintenance.

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position	Source Activity Initial Detection	Movement/ Behavior		CPA Source / Source Activity	Mitigation Action	Comments
55	2019-08-04	01:07	Unidentified Whale	1	45.90950°N 129.83233°W	Full Volume Online	PE(BH); AV	BV, FT	697m/Full Volume Online	None	Whale was first and last observed within 160 dB radius and was a potential Level B take.
56	2019-08-04	02:57	Unidentified Whale	2	45.77543°N 129.74073°W	Full Volume Offline	SA	BV, ST	2740m/Full Volume Offline	None	Whales were first and last observed within 160 dB radius and were potential Level B takes.
57	2019-08-04	03:54	Unidentified Whale	2	45.72633°N 129.74907°W	Full Volume Offline	PV/OD; AV	BV	1799m/Full Volume Offline	None	Whales were first and last observed within 160 dB radius and were potential Level B takes.
58	2019-08-04	17:36	Unidentified Whale	1	45.74976°N 129.70968°W	Silent	UN	BV, ST	2405m/Silent	None	Source was silent during a line change.
59	2019-08-04	20:38	Unidentified Whale	1	45.90688°N 129.88902°W	Full Volume Online	UN	BV, ST	3121m/Full Volume Online	None	Whale was first and last observed within 160 dB radius and was a potential Level B take.
60	2019-08-05	60	Fin Whale	2	46.18052°N 130.07557°W	Silent	TV; PE(BH)	BV	414 meters/Silent	None	Source was silent during a line change.
61	2019-08-05	16:07	Unidentified Whale	1	46.14479°N 129.98162°W	Full Volume Offline	UN	BV	6136m/Full Volume Offline	None	Whale was not observed approaching or entering any radii or exclusion zones.
62	2019-08-05	18:39	Fin Whale	2	45.95592°N 129.85471°W	Full Volume Online	UN; AV	BV, FT	1272m/Full Volume Online	None	Both whales initially sighted in 160 dB radius and were potential Level B takes. One whale last sighted within and one whale last sighted outside of the 160 dB radius.

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position	Source Activity Initial Detection	Movement/ Behavior		CPA Source / Source Activity	Mitigation Action	Comments
63	2019-08-06	00:37	Unidentified Whale	1	45.89115°N 129.89242°W	Full Volume Online	PE(AH); AV	BV	1290m/Full Volume Online	None	Whale was first and last observed within 160 dB radius and was a potential Level B take. Occurred simultaneously with VD#64.
64	2019-08-06	00:38	Unidentified Whale	1	45.89115°N 129.89242°W	Full Volume Online	UN; AV	BV	2676m/Full Volume Online	None	Whale was first and last observed within 160 dB radius and was a potential Level B take. Occurred simultaneously with VD#63.
65	2019-08-06	01:00	Unidentified Whale	1	45.90869°N 129.90305°W	Full Volume Online	UN	BV	6210m/ Full Volume Online	None	Whale was not observed approaching or entering any radii or exclusion zones.
66	2019-08-06	14:18	Unidentified Whale	4	45.84251°N 129.87486°W	Full Volume Online	V	BV	2141m/Full Volume Online	None	Only one of the whales entered the 160 dB radius and was a potential Level B take
67	2019-08-06	17:25	Blue Whale	2	46.05929°N 130.01505°W	Full Volume Online	PV/OD	BV	3041m/Full Volume Online	None	Whales were first and last observed within 160 dB radius and were potential Level B takes.
68	2019-08-06	20:56	Fin Whale	2	46.11863°N 130.01418°W	Full Volume Online	PE(AH); AV	BV, FT	1400m/Full Volume Online	None	Both whales initially sighted in 160 dB radius and were potential Level B takes. One whale last sighted within and one whale last sighted outside of the 160 dB radius.
69	2019-08-06	22:00	Unidentified Whale	1	46.05433°N 129.97100°W	Full Volume Online	PV/SD	BV	4368m/Full Volume Online	None	Whale was not observed approaching or entering any radii or exclusion zones.
70	2019-08-06	22:18	Unidentified Whale	1	46.01967°N 129.94750°W	Full Volume Online	UN	BV	2614m/Full Volume Online	None	Whale first and last observed within 160 dB radius and was a potential Level B take.

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position	Source Activity Initial Detection	Movement/ Behavior		CPA Source / Source Activity	Mitigation Action	Comments
71	2019-08-06	23:25	Unidentified Whale	1	45.93917°N 129.89417°W	Full Volume Online	UN	BV	3825m/Full Volume Online	None	Whale was not observed approaching or entering any radii or exclusion zones.
72	2019-08-07	00:32	Unidentified Whale	3	45.85592°N 129.83873°W	Full Volume Online	SA	BV	4002m/Full Volume Online	None	Whales were not observed approaching or entering any radii or exclusion zones.
73	2019-08-07	00:52	Blue Whale	2	45.85592°N 129.83873°W	Full Volume Online	PV/SD	BF, DF	4020m/Full Volume Online	None	Whales were not observed approaching or entering any radii or exclusion zones.
74	2019-08-07	19:57	Fin Whale	1	45.96833°N 129.91633°W	Full Volume Online	PV/OD; AV	BV	2675m/Full Volume Online	None	Whale first and last observed within 160 dB radius and was a potential Level B take.
75	2019-08-07	21:14	Fin Whale	2	45.87342°N 129.85315°W	Full Volume Online	PE(AH); PV/OD	BV, FT	561m/Full Volume Online and 486m/Silent	Shut-down	Both whales first observed within 160 dB radius and were potential Level B takes. One whale last observed within 160 dB radius. Second whale enter and was last sighted in 500m EZ. Mitigation action was 58 minutes (34 minutes for the shut-down and 24 minutes for the ramp-up).
76	2019-08-07	21:29	Blue Whale	2	45.85842°N 129.84312°W	Silent	PV/OD	BV, DF	1319m/Silent	None	Detection of adult with a calf, but calf was not identified until review of the detection pictures several hours later. Occurred during the shut-down for VD#75, and blue whales were first sighted before that detection concluded. The ramp-up from that shut-down should have been delayed five more minutes for the calf in this sighting, but it was not observed during the detection.

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position	Source Activity Initial Detection	Movement/ Behavior		CPA Source / Source Activity	Mitigation Action	Comments
77	2019-08-07	21:49	Fin Whale	1	45.83047°N 129.82447°W	Silent	AV	BV	2390m/Silent	None	Source was silent for the shut-down for VD#75.
78	2019-08-08	03:50	Unidentified Whale	3	45.81173°N 129.81561°W	Full Volume Online	AV	BV	4359m/Full Volume Online	None	Whales were not observed approaching or entering any radii or exclusion zones.
79	2019-08-08	14:42	Fin Whale	4	45.86531°N 129.84881°W	Full Volume Online	AV; V	BV, MI, FF	2576m/Full Volume Online	None	Only three of the whales were observed entering and then exiting the 160 dB radius and were potential Level B takes.
80	2019-08-08	15:06	Blue Whale	1	45.83634°N 129.82808°W	Full Volume Online	AV	BV, FT	4091m/Full Volume Online	None	Blue whale sighted during VD#79, near the three fin whales being observed. Blue whale was not observed approaching or entering any radii or exclusion zones.
81	2019-08-08	16:38	Unidentified Whale	1	45.73072°N 129.75745°W	Silent	UN	BV, FT	995m/Silent	None	Source silent and arrays being retrieved along with streamers to re-configure deployment for 2D survey lines.
82	2019-08-09	18:01	Blue Whale	1	46.06167°N 129.95983°W	Full Volume Online	PV/OD	BV, DF	1803m/Silent	None	Whale first and last observed within 160 dB radius and was a potential Level B take
83	2019-08-09	21:16	Fin Whale	2	45.85505°N 129.78901°W	Full Volume Online	PV/OD	BV	3005m/Silent	None	Whales were first and last observed within 160 dB radius and were potential Level B takes. Simultaneous with VD#84 and VD#85.
84	2019-08-09	21:16	Blue Whale	1	45.85505°N 129.78901°W	Full Volume Online	AV	BV, DF	2985m/Silent	None	Whale first and last observed within 160 dB radius and was a potential Level B take. Simultaneous with VD#83 and VD#85.

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position	Source Activity Initial Detection	Movement/ Behavior		CPA Source / Source Activity	Mitigation Action	Comments
85	2019-08-09	21:16	Unidentified Whale	2	45.85505°N 129.78901°W	Full Volume Online	UN	BV	4443m/Silent	None	Whales were first and last observed within 160 dB radius and were potential Level B takes. Simultaneous with VD#83 and VD#84.
86	2019-08-10	00:45	Sei Whale	1	45.81400°N 129.64500°W	Full Volume Offline	PE(AH); AV	BV, NS, SA	1047m/Full Volume Offline	None	Whale first and last observed within 160 dB radius and was a potential Level B take.
87	2019-08-10	16:51	Sei Whale	1	45.97467°N 129.86450°W	Full Volume Online	TV; AV	BV, FT	600m/Full Volume Online	None	Whale first and last observed within 160 dB radius and was a potential Level B take.
88	2019-08-10	19:23	Sei Whale	1	45.89470°N 130.11061°W	Full Volume Online	PV/SD; TV; AV	BV, FT	438m/Full Volume Online and 367m/Silent	Shut-down	Whale first and last observed within 160 dB radius and was a potential Level B take. Whale observed entering and exiting 500m EZ, but did not enter the Level A harassment radius while source was active. Mitigation action was 35 minutes, including 15 minutes for the shut-down and 20 minutes for the ramp-up.
89	2019-08-11	13:52	Fin Whale	1	45.87601°N 129.94353°W	Full Volume Online	PV/SD; AV	BV	1569m/Full Volume Online	None	Whale was first and last sighted within 160 dB radius and was a potential Level B take.
90	2019-08-11	15:02	Unidentified Whale	1	45.91257°N 129.83088°W	Full Volume Online	AV	BV	4094m/Full Volume Online	None	Whale was first and last sighted within 160 dB radius and was a potential Level B take.
91	2019-08-11	20:45	Fin Whale	1	45.85817°N 129.87350°W	Full Volume Online	AV; PV/OD	BV, FT	1956m/Full Volume Online	None	Whale was first and last sighted within 160 dB radius and was a potential Level B take.

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position	Source Activity Initial Detection	Movement/ Behavior		CPA Source / Source Activity	Mitigation Action	Comments
92	2019-08-11	21:31	Unidentified Whale	2	45.83367°N 129.94883°W	Full Volume Online	AV	SA, BV, FT	4202m/Full Volume Online	None	Whales were first and last sighted within 160 dB radius and were potential Level B takes.
93	2019-08-12	03:33	Fin Whale	1	45.74458°N 130.31772°W	Silent	PE(BH)	SR	130m/Silent	None	Whale initially sighted incidentally off the stern by crew retrieving streamer at the end of the project. Source silent and on board.
94	2019-08-12	16:27	Unidentified Dolphins	3	46.96467°N 128.03517°W	Silent	AV	SR	1765m/Silent	None	Source silent and on board during transit back to dock at the end of the project.
95	2019-08-13	13:17	Unidentified Dolphin	2	48.21853°N 123.74133°W	Silent	PV/OD	SR, NS	331m/Silent	None	Source silent and on board during transit back to dock at the end of the project.
96	2019-08-13	14:04	Humpback Whale	2	48.21632°N 123.61301°W	Silent	PV/OD	SR, BV, ST, DF	727m/Silent	None	Source silent and on board during transit back to dock at the end of the project.
97	2019-08-13	15:08	Pygmy Sperm Whale	2	48.21744°N 123.42107°W	Silent	AV	SR, NS, DI	174m/Silent	None	Source silent and on board during transit back to dock at the end of the project.
98	2019-08-13	15:18	Harbour Porpoise	2	48.21499°N 123.38469°W	Silent	PV/SD' AV	SR, NS	165m/Silent	None	Source silent and on board during transit back to dock at the end of the project.

APPENDIX J: Photographs of Identified Protected Species Visually Detected during the Axial Seamount Seismic Survey Program.



Figure 7: Visual Detection #1; Humpback Whale; 12 July 2019



Figure 8: Visual Detection #2; Dall's Porpoise; 12 July 2019



Figure 9: Visual Detection #3; Dall's Porpoise; 12 July 2019



Figure 10: Visual Detection #4; Humpback Whale; 12 July 2019



Figure 11: Visual Detection #5; Humpback Whales; 12 July 2019.



Figure 12: Visual Detection #7; Unidentified Pinniped; 12 July 2019



Figure 13: Visual Detection #8; Mixed pod of Northern Right-Whale Dolphins and Pacific White-Sided Dolphins; 12 July 2019



Figure 14: Visual Detection #10; Dall's Porpoise; 12 July 2019



Figure 15: Visual Detection #11; Dall's Porpoise; 12 July 2019.



Figure 16: Visual Detection #13; Minke Whale; 12 July 2019.



Figure 17: Visual Detection #14; Blue Whales (adults and calf); 13 July 2019.



Figure 18: Visual Detection #15; Baird's Beaked Whales; 13 July 2019



Figure 19: Visual Detection #19; Fin Whale; 15 July 2019



Figure 20: Visual Detection #20; Fin Whale; 15 July 2019



Figure 21: Visual Detection #28; Humpback whale; 18 July 2019



Figure 22: Visual Detection #29; Fin whales – adult and calf; 19 July 2019



Figure 23: Visual Detection #32; Fin Whales; 23 July 2019



Figure 24: Visual Detection #33; Fin Whales; 24 July 2019



Figure 25: Visual Detection #42; Fin Whale; 29 July 2019



Figure 26: Visual Detection #47; Sei Whale; 01 August 2019



Figure 27: Visual Detection #48; Fin Whale; 02 August 2019



Figure 28: Visual Detection #50; Fin Whales; 02 August 2019



Figure 29: Visual Detection #51; Fin Whales (Right: adult and calf); 03 August 2019



Figure 30: Visual Detection #53; Fin Whale; 03 August 2019



Figure 31: Visual Detection #60; Fin Whale; 5 August 2019



Figure 32: Visual Detection #62; Fin Whale; 5 August 2019



Figure 33: Visual Detection #67; Blue Whale; 6 August 2019



Figure 34: Visual Detection; #68 Fin Whales; 6 August 2019



Figure 35: Visual Detection #74; Fin Whale; 7 August 2019



Figure 36: Visual Detection #75; Fin Whales; 7 August 2019



Figure 37: Visual Detection #76; Blue Whale and Calf; 7 August 2019



Figure 38: Visual Detection #79; Fin Whales; 8 August 2019



Figure 39: Visual Detection #86; Sei Whale; 10 August 2019



Figure 40: Visual Detection #87; Sei Whale; 10 August 2019



Figure 41: Visual Detection #88; Sei Whale; 10 August 2019



Figure 42: Visual Detection #89; Fin Whale; 11 August 2019



Figure 43: Visual Detection #91; Fin Whale; 11 August 2019



Figure 44: Visual Detection #92; Fin Whale; 12 August 2019



Figure 45: Visual Detection #96; Humpback Whale; 13 August 2019



Figure 46: Visual Detection #97; Pygmy Sperm Whale (adult and calf); 13 August 2019



Figure 47: Visual Detection #97; Harbour Porpoise (adult and calf); 13 August 2019



Figure 48: Dead marine mammal sighted on 15 and 16 July 2019

Appendix K: Species of Birds and Other Wildlife Observed during the Axial Seamount Seismic Survey Program

Birds: Common Name	Family	Genus	Species	Approximate Number Individuals Observed	Approximate Number of Days Species Was Observed
Artic tern	Laridae	<i>Synthliboramphus</i>	<i>antiquus</i>	4	3
Black-footed albatross	Diomedidae	<i>Phoebastria</i>	<i>nigripes</i>	48	23
Black-legged kittiwake	Laridae	<i>Rissa</i>	<i>tridactyla</i>	1	1
Black storm-petrel	Hydrobatidae	<i>Oceanodroma</i>	<i>melania</i>	3	1
Common murre	Alcidae	<i>Uria</i>	<i>aalge</i>	81	3
Fork-tailed storm-petrel	Hydrobatidae	<i>Oceanodroma</i>	<i>furcata</i>	1	1
Glaucous gull	Laridae	<i>Larus</i>	<i>hyperboreus</i>	1	1
Glaucous-winged gull	Laridae	<i>Larus</i>	<i>glaucescens</i>	4	2
Laysan Albatross	Diomedidae	<i>Phoebastria</i>	<i>immutabilis</i>	15	5
Leach's storm petrel	Hydrobatidae	<i>Oceanodroma</i>	<i>leucorhoa</i>	6	5
Long-tailed jaegar	Stecorariidae	<i>Stercorarius</i>	<i>longicaudus</i>	9	7
Murphy's petrel	Procellariidae	<i>Pterodroma</i>	<i>ultima</i>	1	1
Pigeon guillemot	Alcidae	<i>Cephus</i>	<i>columba</i>	4	1
Red-necked Phalarope	Scolopacidae	<i>Phalaropes</i>	<i>lobatus</i>	2	1
Red phalarope	Scolopacidae	<i>Phalaropes</i>	<i>fulicarius</i>	5	3
Ring-billed gull	Laridae	<i>Larus</i>	<i>delawarensis</i>	1	1
Slaty-backed gull	Laridae	<i>Larus</i>	<i>schistisagus</i>	4	3

Fish: Common Name	Family	Genus	Species	Approximate Number of Individuals Observed	Approximate Number of Days Species Was Observed
Blue Shark	Carcharhinidae	<i>Prionace</i>	<i>glauca</i>	12	6
Manta ray	Mobulidae	<i>Mobula</i>	<i>birostris</i>	1	1
Ocean sunfish	Molidae	<i>Mola</i>	<i>mola</i>	4	4
Salmon Shak	Lamnidae	<i>Lamna</i>	<i>ditropis</i>	5	4
Shortfin Mako shark	Lamnidae	<i>Isurus</i>	<i>oxyrinchus</i>	5	3

Marine Invertebrates: Common Name	Family	Genus	Species	Approximate Number of Individuals Observed	Approximate Number of Days Species Was Observed
Sea nettle jellyfish	Pelagiidae	<i>Chrysaora</i>	<i>fuscescens</i>	1	1