# Protected Species Mitigation and Monitoring Report

## Shillington

## Aleutian Islands

### 27 June 2011- 05 August 2011

### R/V *Marcus G. Langseth*

**Prepared for**

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# ACRONYMNS AND ABBREVIATIONS

| | |
|---|---|
| ADCP | Acoustic Doppler Current Profiler |
| BO | Biological Opinion |
| BOEMRE | Bureau of Ocean Energy, Management, Regulation and Enforcement |
| CPA | Closest Point of Approach |
| CZMA | Coastal Zone Management Act |
| dB | decibel |
| EA | Environmental Assessment |
| EEZ | Exclusive Economic Zone |
| EFH | Essential Fish Habitat |
| ESA | (U.S.) Endangered Species Act |
| FFT | Fourier Transform Filter |
| GOA | Gulf of Alaska |
| GPS | Global Positioning System |
| HF | High Frequency |
| Hz | Hertz |
| IHA | Incidental Harassment Authorization (under U.S. MMPA) |
| in | inch |
| ITS | Incidental Take Statement |
| kHz | kilohertz |
| L-DEO | Lamont-Doherty Earth Observatory of Columbia University |
| *Langseth* | R/V *Marcus G. Langseth* |
| MBES | Multibeam echosounder |
| MCS | Multi-channel seismic |
| MMPA | (U.S.) Marine Mammal Protection Act |
| ms | millisecond |
| M/V | Marine Vessel |
| NEPA | (U.S.) National Environmental Policy Act |
| NHPA | (U.S.) National Historic Preservation Act |
| NMFS | (U.S.) National Marine Fisheries Service |
| NOAA | (U.S.) National Oceanic and Atmospheric Administration |
| NRC | (U.S.) National Research Council |
| NSF | (U.S.) National Science Foundation |
| NVD | Night Vision Device |
| OBS | Ocean-bottom seismometer |
| PAM | Passive Acoustic Monitoring |
| psi | pounds per square inch |
| PSO | Protected Species Observer |
| PTS | Permanent Threshold Shift |
| RL | Received Level |
| R/V | Research Vessel |
| SBP | Sub-Bottom Profiler |
| SE | southeast |
| SEL | Sound Exposure Level (a measure of acoustic energy) |
| SL | Source Level |
| SPL | sound pressure level |
| TTS | Temporary Threshold Shift |
| U.S. | United States of America |

# 1. EXECUTIVE SUMMARY

The National Science Foundation (NSF) owned research vessel (R/V), *Marcus G. Langseth* (*Langseth*), operated by Lamont-Doherty Earth Observatory (L-DEO), a part of Columbia University, was contracted to conduct the Shillington Aleutian Megathrust two-dimensional (2D) marine seismic program in the Aleutian Islands of Alaska between Kodiak Island and Dutch Harbor between 30 June and 5 August 2011. The survey was conducted to image the subduction megathrust zone in the Gulf of Alaska (GOA) and correlate its slip history with its reflection signature to test the hypothesis that the megathrust has a distinctive reflection image which could be mapped with a high degree of spatial accuracy.

L-DEO submitted an application to the National Marine Fisheries Service (NMFS) for a permit to harass marine mammals that are incidental to the marine geophysical survey. An Incidental Harassment Authorization (IHA) was granted with several mitigation measures that stipulated Level B harassment to marine mammals and sea turtles (Appendix A). Mitigation measures were implemented to minimize potential impacts to marine mammals and sea turtles through the acquisition of the survey. Mitigation measures included, but were not limited to, the use of NMFS qualified Protected Species Observers (PSOs) for both visual and acoustic monitoring, establishment of safety radii, and implementation of ramp-up, power-down and shut-down procedures.

RPS was contracted by L-DEO to provide continuous protected species observation coverage and to fulfill the environmental regulatory requirements and reporting mandated by NMFS in the IHA. Four PSOs and one dedicated PAM Operator were present on board the *Langseth* throughout the survey in this capacity.

PSOs undertook a combination of visual and acoustic watches, accumulating a total of 635 hours and 07 minutes of visual observations and 417 hours and 40 minutes of acoustic monitoring over the course of the survey project (Appendix B).

The visual monitoring effort produced a total of 201 protected species detection records of marine mammals (no marine turtles were observed), which were all detected visually (no acoustic detections made through monitoring of the PAM system): 184 cetacean records, 14 records for pinniped species and three fissiped records (all fissipeds were observed in transit from the port of Kodiak and not on the survey site). Of the 184 cetacean records collected, 152 consisted of mysticetes observed with the remaining 28 records collected for odontocete species in addition to four records collected for unidentified cetaceans (Appendix B).

These detections of marine mammals resulted in the implementation of 50 mitigation actions during 44 detections events with a total duration of 40 hours and 36 minutes: 39 power-downs, 37 of which were implemented for cetaceans and two for pinnipeds, four shut-downs and seven delayed ramp-ups of the acoustic source, all of which were implemented for cetaceans.

A known 146 cetaceans of three species and two pinnipeds, both northern fur seals were exposed to received sound levels equal to or greater than 160dB of sound from the acoustic source, constituting a Level B harassment take as defined by NMFS. Level B harassment takes included 46 fin whales, 84 humpback whales, 16 Dall's porpoise and two northern fur seals. An additional 37 unidentified baleen whales and unidentified cetaceans were also exposed to 160dB received sound level.

# 2. INTRODUCTION

The following report details protected species monitoring and mitigation and seismic survey operations undertaken as part of the Shillington Aleutian two-dimensional marine seismic survey on board the *Langseth* from 30 June to 5 August of 2011 inside exclusive economic zone (EEZ) of the United States (U.S.) in the Gulf of Alaska (GOA) along the Aleutian Island Chain.

This document serves to meet the reporting requirements dictated in the IHA issued to L-DEO by NMFS on 24 June 2011. The IHA (Appendix A) authorized Level B harassment of specific marine mammals incidental to a marine seismic survey program. NMFS has stated that seismic source received sound levels greater than 160dB could potentially disturb marine mammals, temporarily disrupting behavior, such that they could be considered non-lethal “takes” of these exposed animals. Potential consequences of Level B harassment taking could include effects such as temporary hearing threshold shifts, behavior modification and other reactions. It is unknown to what extent cetaceans exposed to seismic noise of this level would express these effects, and in order to take a precautionary approach, NMFS requires that provisions such as safety radii, power-downs and shut-downs be implemented to mitigate for these potential effects.

A Biological Opinion (BO) was also issued in conjunction with the IHA where NMFS anticipates that the Shillington Aleutian marine seismic survey will also take sea turtles in the form of harassment as a result of exposure to acoustic energy. To minimize incidental sea turtle takes by harassment, the NMFS mandated that mitigation measures also be applied to sea turtles observed within the 180dB isopleths.

## 2.1. SURVEY PROGRAM OVERVIEW AND LOCATION

The Shillington Aleutian Megathrust survey program took place in the Gulf of Alaska (GOA) inside the U.S. EEZ along the Aleutian Island Chain between the Kodiak and Dutch Harbor (Figure 1). The *Langseth* was utilized as the source and acquisition vessel to conduct the Shillington Aleutian marine seismic survey. The vessel departed the Port of Kodiak on 30 June 2011 and, returned to the port of Dutch Harbour upon completion of the survey on 05 August 2011.

The survey plan included ocean-bottom seismometer (OBS) refraction survey lines and multi-channel seismic (MCS) survey lines. Survey lines were oriented both north to south and east to west through a wide range of water depths from less than 25 meters to greater than 6000 meters. Survey lines varied in length from approximately 20 to 400 kilometres.

The two OBS survey lines oriented in a north-south direction were acquired first after the vessel’s departure from the Port of Kodiak along with one test OBS line. The *Langseth* scouted for optimal OBS deployment locations on 1 July and began deployment of 21 OBSs on 2 July, completing deployment on 3 July. Acquisition of the first OBS line was undertaken followed by retrieval of the OBSs. All 21 OBSs were deployed along the second OBS survey line, followed by acquisition which was completed at 08:37 UTC on 10 July. The OBSs were retrieved and the vessel went to Sand Point to allow for the departure of the OBS technicians.

The MCS portion of the survey began as the vessel departed Sand Point on 12 July at 09:37 UTC and commenced the deployment of the seismic equipment. A total of 23 MCS survey lines in addition to two test lines were acquired beginning in the east and working westward starting on 15 July with the last survey line completed at 22:55 UTC on 3 August.

To acquire the Shillington Aleutian Megathrust marine seismic survey in the Aleutian Islands, the *Langseth* towed four airgun sub-arrays. The sub-arrays were deployed astern of the vessel as a single acoustic source with each array separated by eight meters. The airguns were towed at a depth of 12 meters approximately 181 meters off the stern of the vessel (Figure 2). The center of the source (COS) was located approximately 223 meters from the Navigational Reference Point (NRP), which was located on the PSO observation tower. The acoustic source remained active between survey lines, discharging at full or partial volume as line changes were very short in duration. The energy source and two additional acoustical data acquisition systems were configured and used as stated in the IHA Application. The IHA Application can be found online at http://www.nmfs.noaa.gov/pr/permits/incidental.htm#applications.

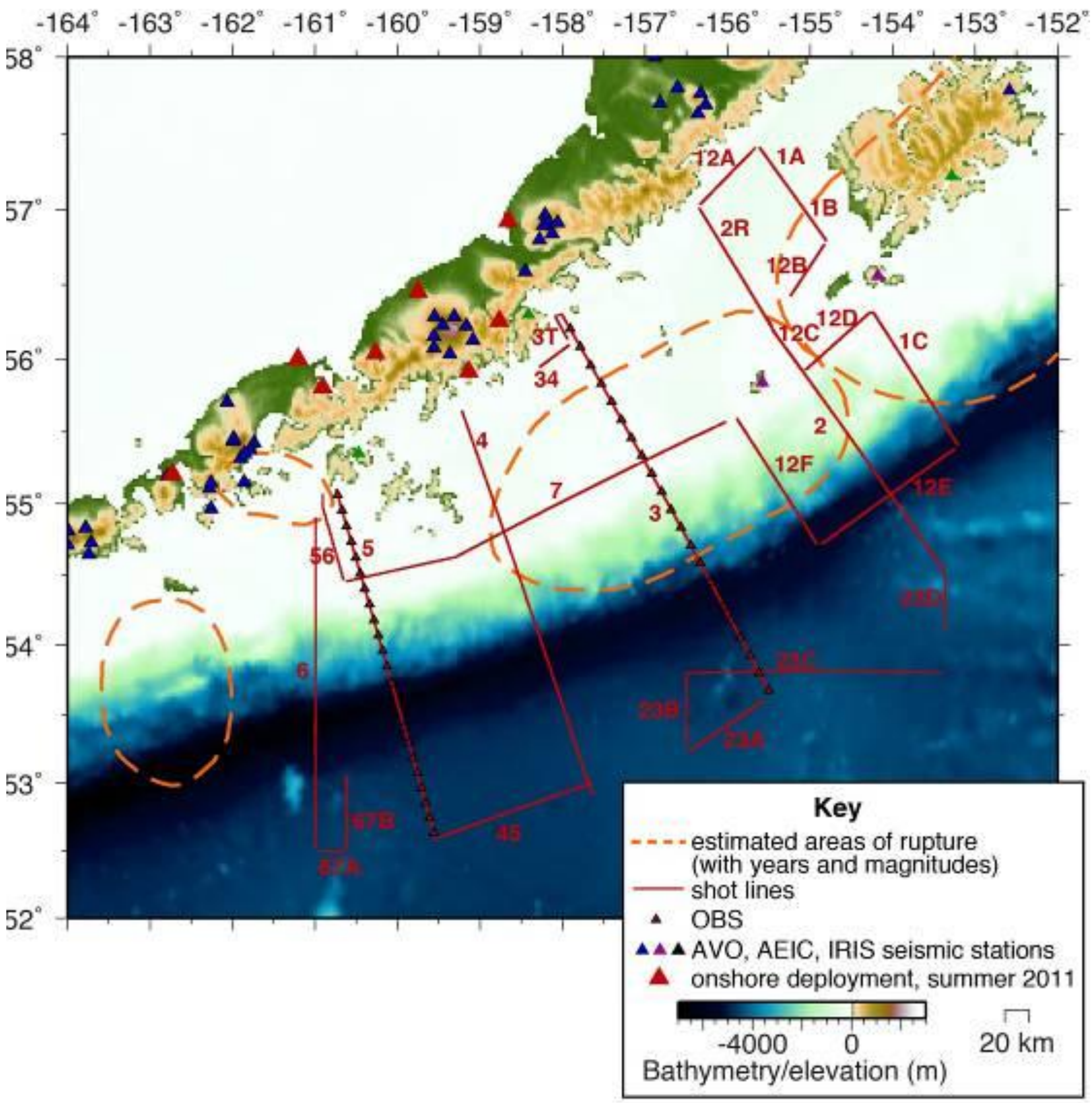


**Figure 1: Location of the Shillington Aleutian survey in the Gulf of Alaska along the Aleutian Islands Chain**

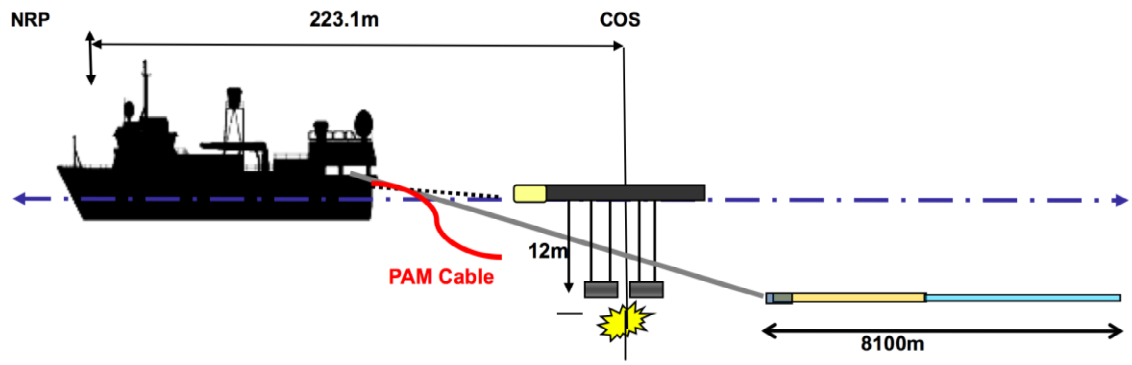


**Figure 2: Towing configuration of seismic equipment during MCS portion of the Shillington Aleutian marine seismic survey**

## 2.2. MONITORING PROGRAM CONFIGURATION

### 2.2.1. Visual Observer Personnel and Equipment

Four Bureau of Ocean Energy Management Regulation and Enforcement (BOEMRE) certified and NMFS-approved PSOs and one trained biologist from L-DEO were on board the *Langseth* for the duration of the survey to conduct the marine mammal monitoring program. In addition, a biologist employed by the NSF was on board for the initial OBS portion of the survey, assisting with PSO monitoring and mitigation duties.

Visual observation watches were established to fulfill the requirements specified by the IHA and are discussed in this report in Section 3.1: Visual Monitoring Methodology. Visual monitoring was primarily carried out from an observation tower located 19 meters above the water surface, which afforded the PSOs a 360-degree viewpoint around the acoustic source.

The tower was equipped with two big-eye binoculars (12 X 150), one located on the port side and the other on the starboard side. A tent in the center of the tower was set-up to facilitate data collection and communication. A monitor displayed the vessel position, water depth, vessel speed and heading, source activity, wind speed and direction and provided camera views of the stern of the vessel. A telephone was provided in addition to a UHF radio in order to allow communication between the PSOs in the tower and the PAM station and the science lab. Observations were also carried out from the bridge, catwalk or back decks for safety reasons or during periods when weather conditions were poor or severe. Fujinon 7X50 binoculars were available for daytime observations and night-vision devices, ITT Industries Night Quest NQ2200 Night Vision Viewers, were available to be utilized during night-time observations conducted during night-time ramp-ups of the acoustic source.

### 2.2.2. Passive Acoustic Monitoring Personnel and Equipment

A trained and experienced PAM operator was present throughout the cruise to oversee and conduct the PAM operations. The lead PSO was also trained and experienced in the use of PAM. PAM was used to augment visual monitoring efforts and was not used to execute any mitigation actions without a concurrent visual sighting that required mitigation. PAM was also used during periods of darkness or low visibility when visual monitoring might not be applicable or effective. The PAM system was monitored to the maximum extent possible, 24-hours a day during seismic operations, and the times when monitoring was possible while the airguns were not in operation. To achieve 24-hours of monitoring, the PSOs and the PAM operator rotated through acoustic monitoring shifts with each PSO conducting four to five hours of acoustic monitoring a day and the PAM operator monitoring many of the night time hours when PSOs were not making visual observations and PAM was the only system in use for detecting cetaceans. All PSOs completed a basic PAM training provided by the PAM Operator onboard in the initial days of the hydrophone deployment.

Acoustic monitoring was carried out using a system developed by Seiche Measurements Ltd (PAM system specifications can be found in Appendix C). The system was comprised of 250 meters of hydrophone cable deployed from a deckhead winch at the port stern of the gun deck connected via 100 meters of deck cable to electronic processing modules located in the main science lab.

The hydrophone cable consists of a five-meter linear array of four hydrophones (three broadband and one low frequency) pre-amplifiers and a depth gauge. Three hydrophones (hydrophone number one, two and three) were broadband elements, sampling mid-range frequencies of two kilohertz to 200 kilohertz. Hydrophone number four was a lower frequency hydrophone with a range of 75 hertz to 30 kilohertz. One spare tow array, also 250 meters with the same hydrophone configuration, and a spare 100 meters of deck cable were also supplied and available on board the vessel.

The electronic processing unit contained a buffer processing unit with USB output, an RME *Fireface 800 ADC* processing unit with firewire output, a *Behringer Ultralink Pro mixer*, a *Behringer Ultralink Pro graphic equalizer* and a Sennheiser radio headphone transmitter. Two laptops were set-up in the main lab next to the electronic processing unit to display a high frequency range on one laptop (hereafter referred to as the HF laptop), using the signal from two hydrophones, and the low frequency on the other laptop (LF laptop) receiving signal from all four hydrophones. A GPS feed of INGGA strings was supplied from the ship's navigation system and connected to the LF laptop, reading data every 20 seconds.

The high frequency (HF) system was used to detect and localize ultrasonic pulses used by some dolphins, beaked whales and *Kogia* species. The signal from two hydrophones was digitized using an analogue-digital National Instruments data acquisition (DAQ) soundcard at a sampling rate of 500 kilohertz, then processed and displayed on a laptop computer using the program *PAMguard version 1.9.01* via USB connection. The amplitude of clicks detected at the front hydrophone was measured at 5th order Butterworth band-pass filters ranging from 35 kilohertz to 120 kilohertz with a high pass digital pre-filter set at 35 kilohertz (Butterworth 2nd order). *PAMguard* used the difference between the time that a sound signal arrived at each of the two hydrophones to calculate and display the bearing to the source of the sound. A scrolling bearing time display in *PAMGuard* also displayed the detected clicks within the HF envelope band pass filter in real time, allowing the identification and directional mapping of detected animal click trains.

The low frequency (LF) system was used to detect sounds produced by marine mammals in the human audible band between approximately four kilohertz and 24 kilohertz. The low frequency system used four hydrophones; the signal was interfaced via a firewire cable to a laptop computer, where it was digitized at 48 kilohertz per channel. The LF hydrophone signal was further processed within the *PAMguard* monitoring software by applying Engine Noise Fast Fourier Transform (FFT) filters including click suppression and spectral noise removal filters (median filter, average subtraction, Gaussian kernel smoothing and thresholding). In addition to the Spectrogram available for each of the four hydrophones, modules for Click Detector, Mapping, Sound Recording and Radar displays for bearings of whistles and moans were configured. The bearings and distance to detected whistles and moans were calculated using the 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. The vessel's GPS connected to the LF laptop via serial USB and allowed delphinid whistles and other cetacean vocalizations to be plotted onto a map module where bearing and range to the vocalizing animal's actual position could be obtained. Typical screenshots from the HF and LF laptop PAMguard program can be found in Appendix D.

A mixer unit enabled the operator to adjust stereo signal levels from each of the four hydrophones. The PAM Operator monitored the hydrophone signals aurally using headphones.

#### 2.2.2.1. Hydrophone Deployment

The vessel had a winch installed on the port stern deckhead of the gun deck for deployment of the PAM hydrophone cable. Two deck cables, the main cable and a spare, were installed along the gun deck deckhead running from the winch to the main science lab. Several configurations of hydrophone deployment have been tested during previous cruises on board the *Langseth*. The preferred method devised from this experimentation involves the hydrophone cable being deployed directly astern from the dedicated winch without any attachment to the streamer lead-ins. The hydrophone cable tows alongside and below the port side gun umbilicals sinking to a depth of 18 meters (+/- 3 to 4 meters) at the average survey speed of 4.5 to 5.5 knots with minimal weighting to the cable from three sets of chains taped to the hydrophone cable in three positions (10, 20 and 70 meters ahead of the first hydrophone element).

Figure 3 shows the position of the hydrophone deployments in relation to the vessel and seismic equipment. Photos of the hydrophone deployment methods and equipment discussed below can be found in Appendix E.

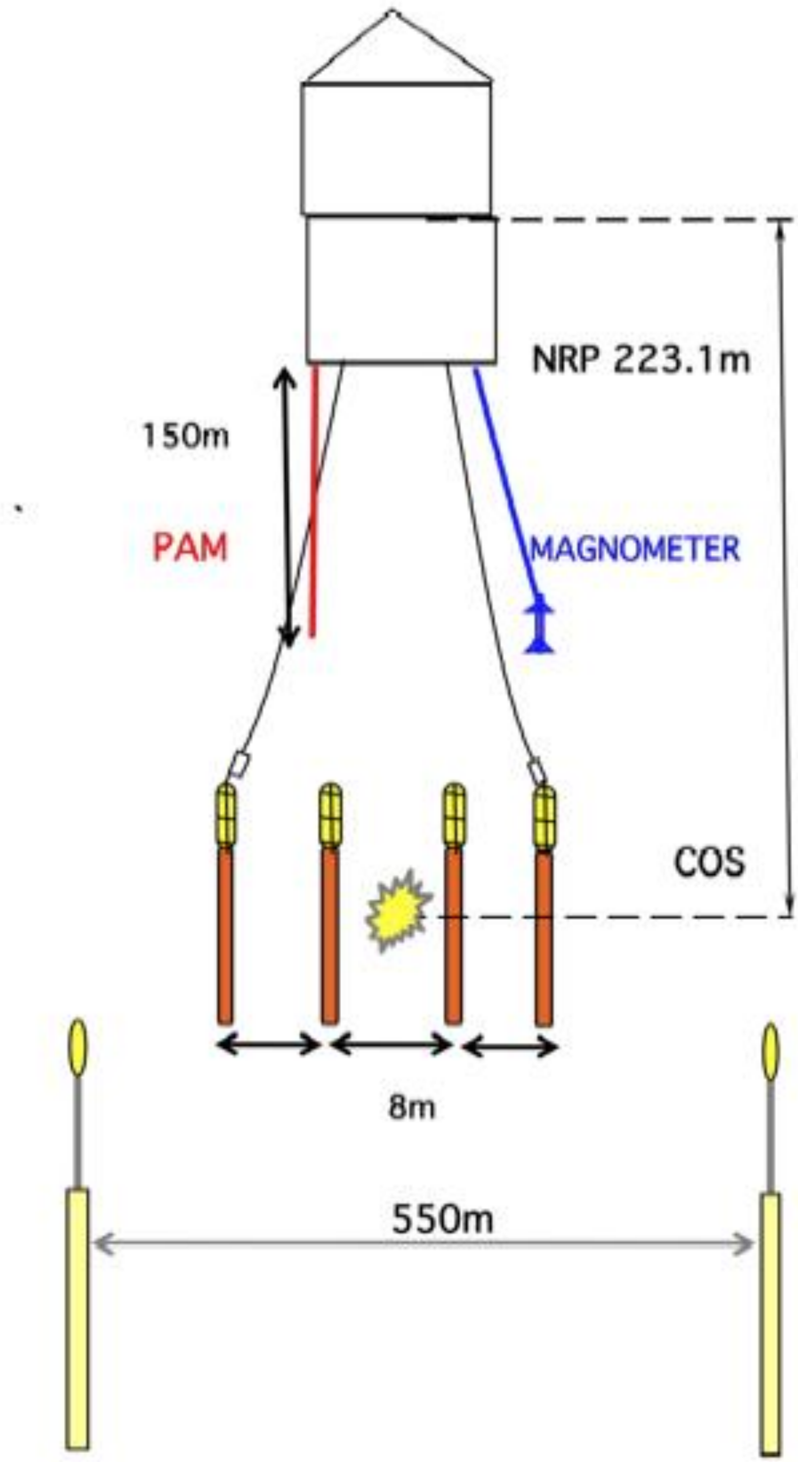


**Figure 3: Location of the hydrophone deployment**

# 3. MITIGATION AND MONITORING METHODS

The PSO monitoring system based on the *Langseth* was established to meet the IHA requirements that were issued to the L-DEO by NMFS including both monitoring and mitigation objectives. The survey mitigation program was produced to minimize potential impacts of the *Langseth*'s seismic program on marine mammals, marine turtles and other protected species of interest and is outlined in detail in Section 3.3 of this report and in the IHA found in Appendix A. The following monitoring protocols were followed to meet these objectives.

- Visual observations were established to provide real-time sighting data, allowing for the implementation of mitigation procedures as necessary
- Operation of a Passive Acoustic Monitoring system to compliment visual observations and provide additional marine mammal detection data
- Ascertain the effects of marine mammals and marine turtles exposed to sound levels constituting a "take"

In addition to achieving the mitigation objectives outlined in the IHA, PSOs collected and analyzed necessary data mandated by the IHA for this report including but not limited to:

- Dates, times and locations, heading, speed, weather, sea conditions (including Beaufort sea state and wind force), and related activities during all seismic operations and marine mammal detections.
- Species, number, location, distance from the vessel, and behavior of any marine mammals, as well as associated seismic activity including the number of power downs and shut downs, were observed and logged throughout all monitoring actions.
- An estimate of the number, decided by species, of marine mammals that: (A) are known to have been exposed to the seismic activity (based on visual observation) at received levels greater than or equal to 160 dB re 1 μPa (rms), 180 dB re 1 μPa (rms) and/or 190 dB re 1 μPa (rms) along with a discussion of any specific behaviors those individuals exhibited; and (B) may have been exposed (based on modelling results) to the seismic activity at received levels greater than or equal to 160 dB re 1 μPa (rms), 180 dB re 1 μPa (rms) and/or 190 dB re 1 μPa (rms) along with a discussion of the plausible consequences of that exposure on the individuals that were within the safety radii.
- A description of the implementation and effectiveness of the: (A) terms and conditions of the ITS and (B) mitigation measures of the IHA.

## 3.1. VISUAL MONITORING SURVEY METHODOLOGY

Visual monitoring methods were implemented in accordance with the survey requirements outlined in the IHA. Two NMFS-approved PSOs conducted observations throughout all daytime operations of the acoustic source including while the single 40 $in^3$ gun was active and all ramp-ups of the acoustic source including those conducted at night. When the acoustic source was activated from silence, PSOs maintained a two-person watch for 30 minutes prior to the activation of the source. Visual watches commenced each day before sunrise, beginning as soon as the entire safety radius was visible, and continued past sunset until the safety radius became obscured, from between approximately 05:30 until 23:45 local time, approximately 17 hours minimum every day. Start of watch and end of watch times varied as the vessel transited from the northernmost survey lines to survey lines farther south and was dependant on cloud cover.

A visual monitoring schedule was established by the lead PSO where each PSO completed visual observations watches varying in length from between two to four hours, two to three times a day for a total of seven to nine hours of visual monitoring watches per day. This schedule was arranged such that two PSOs were on visual observation duty at all times except during meal breaks when up to 45 minutes only one PSO would stand watch so that the entire team could eat while maintaining both visual and acoustic monitoring. This schedule was adhered to during OBS deployment and retrieval when the acoustic source was not active in order to collect baseline data.

Observations were focused forward of the vessel and to the sides but with regular sweeps through the area around the active acoustic source. PSOs searched for indications of the presence of a protected species including blows, splashes or disturbances to the sea surface, the presence of large flocks of feeding seabirds and other sighting cues. Upon the visual detection of a protected species, PSOs concentrated first on initiating any necessary mitigation action, identifying the animal's range to the acoustic source, the activity of the acoustic source (full power firing, single mitigation gun of 40 $in^3$ firing) and the type of animal present (cetacean, pinniped, or sea turtle) in order to determine which safety radius to apply. The science lab was informed of any necessary mitigation actions by telephone to the PAM Operator who would relay the message and record the necessary data. The seismic technician's desk was located next to the PAM station to facilitate communication. The PAM Operator was also notified of all marine mammal sightings as soon as possible in order to enable recordings so that the recordings could be archived for quality control or to later be reviewed a second time in case a detection was overlooked.

Range estimations upon the initial sighting of a protected species, the closest point of approach (CPA) of animals to the acoustic source, and the distance to the animal(s) when last sighted were determined using the naked eye, assessed by use of reticule binoculars, or applied using the known towing distances of the source and streamer head float.

Specific species identifications were made whenever distance, length of sighting and visual observation conditions allowed. PSOs observed anatomical features of animals sighted with the naked eye and through the big-eyes and reticule binoculars and noted behavior of the animal or group. Photographs were taken during each sighting, when possible in conjunction with other higher priority tasks, using a Canon EOS 60D with a 300 millimeter telephoto lens. Marine mammal and sea turtle identification manuals were consulted and photos were examined during visual watch breaks to confirm identifications.

During or immediately after each sighting event PSOs or PAM Operators recorded the position, time at first and last sighting, number of animals present (adults and juveniles), the initial and any subsequent behaviors observed, the initial range, bearing and movement of the animal(s), the source activity at the initial and final detections and any mitigation measures that were applied. Specific information regarding the animal(s) closest approach to the vessel, acoustic source and the acoustic source output at the closest approach were recorded to allow the lead PSO to determine if the animals had been exposed to 160 dB, 180 dB and/or 190 dB of sound from the source during the sighting event.

In addition, the vessel position, water depth, vessel heading and speed, the wind speed and direction, Beaufort sea state, swell level, visibility and glare were recorded every half an hour at minimum or every time conditions changed, environmental conditions or vessel or seismic activity changes. Each sighting event was linked to an entry on this datasheet such that environmental conditions were available for each sighting event.

## 3.2. ACOUSTIC MONITORING SURVEY METHODOLOGY

Acoustic monitoring operators vigilantly analyzed the LF and HF laptops visually while listening to the hydrophone output through headphones connected to the Sennheiser transmitter unit. Monitoring shifts lasted two to five hours. During daylight hours acoustic operators were in communication with visual PSOs in the tower relaying sighting information. At the time of any visual sighting of a marine mammal, the acoustic operator was notified and sound recordings were made for later analysis by one of the experienced PAM Operators.

Vessel position, water depth, heading and speed, vessel and airgun activity were recorded by the PAM Operator every hour using the vessel's instrumentation that was available in the main lab along with rating the background noise level on the Gannier scale (Gannier, 2002). The LF Spectrogram was monitored for delphinid whistles, sperm whale clicks, and baleen whale vocalizations while the Click Detectors on the HF and LF system were monitored for indications of echolocation clicks. The Spectrogram's amplitude range and appearance were adjusted as needed to suit the operator's preference so as to maximize the vocalizations appearance above the pictured background noise.

## 3.3. MITIGATION METHODS

The following mitigation measures were implemented during the Shillington Aleutian marine seismic survey as mandated by the IHA granted by NMFS on 24 June 2011 and found in Appendix A.

### 3.3.1. Safety Radii

L-DEO conducted multiple acoustic calibration studies in the Gulf of Mexico in 2003 and again in 2007/2008 to obtain measurements of seismic sounds at varying distances from seismic source in order to verify safety radii estimated in past acoustical models. Although analysis continues, it was determined that the safety radii around airgun arrays vary with water depth (Shillington Environmental Assessment, 2011). Safety radii for the Shillington Aleutian survey program were established using conservative distances and are outlined in Table 1 below.

**Table 1: Predicted distances that 160, 180 and 190 dB re 1μPa sound levels could be received and which will be used as safety radii for a 36 gun source and a single airgun (towed at a 12 meter depth) during the Shillington Aleutian survey program**

| Source and Volume | Water Depth (m) | Predicted RMS Distances (m) | | |
|---|---|---|---|---|
| | | **190 dB** (Pinnipeds) | **180 dB** (Cetaceans) | **160 dB** (Level-B Harassment Radius) |
| Single Airgun (40 in$^3$) | > 1000 | 12 | 40 | 385 |
| | 100 to1000 | 18 | 60 | 578 |
| | < 100 | 150 | 296 | 1050 |
| 4 Strings 36 Airgun source (6,600 in$^3$) | > 1000 | 460 | 1100 | 4400 |
| | 100 to 1000 | 615 | 1810 | 13395 |
| | < 100 | 770 | 2520 | 23470 |

### 3.3.2. Ramp-ups and Visual Pre-searches

Ramp-ups, also known as soft starts, of the acoustic source were conducted prior to the commencement of any seismic activity from silence or reduced power that lasted for a period greater than nine minutes. This was done by activation of the smallest airgun in the array (40 $in^3$) followed by airguns added in a sequence such that the source level of the array increased in steps not exceeding 6 dB per five-minute period over a total duration of approximately 30 minutes.

PSOs monitored the safety radii throughout ramp-ups, including day and night, and if marine mammals or turtles were sighted inside the safety radii a power-down or shut-down was implemented as though the full array were fully operational.

Night time ramp-ups were to be conducted only when a single airgun had been active during the period prior and PSOs conducted visual observations throughout the ramp-up using night vision devices.

Daytime ramp-ups could be conducted from airgun silence if PSOs had maintained continuous visual observation during the silent period prior to the ramp-up commencement or, if observations had not been continuous, a 30 minute pre-ramp-up survey of the safety radii was conducted. If no protected species were observed inside the exclusion zones then ramp-up could proceed. Ramp-up was delayed if a protected species was detected inside the larger safety radius and could proceed only when:

1. The animal was visually observed to have left the safety zone
2. The animal had not been seen within the zone for 15 minutes, in the case of small odontocetes, or 30 minutes, in the case of mysticetes and large odontocetes, including sperm, pygmy sperm, dwarf sperm, and beaked whales
3. The vessel had moved outside the zone for marine turtles, which were treated as stationary objects

### 3.3.3. Power-down Procedures

A power-down was implemented by decreasing the number of active airguns to a single 40 $in^3$ airgun such that the size of the 160 dB, 180 dB, or 190 dB safety radius (depending on marine mammal/turtle present) was decreased, placing marine mammals or turtles in the vicinity safely outside the exclusion zone. A single airgun was operated throughout a power-down rather than shutting down the source entirely in order to alert marine mammals of seismic activity or presence.

Power-down procedures were conducted for protected species detected inside the 160 dB (‘zero-take’ animals), 180 dB (cetaceans and marine turtles) and 190 dB (pinnipeds) safety radii as well as for animals detected prior to imminently entering the safety radii. Seismic operations were resumed after a power-down only when the protected species had cleared the safety zone, as determined by:

1. The animal was visually observed leaving the safety zone
2. The animal had not been sighted inside the safety zone for 15 minutes in the case of small odontocetes or 30 minutes in the case of large mysticetes or large odontocetes
3. Satisfactory time had passed to allow the vessel to move past a stationary animal, such as a turtle, that it could be considered to be outside the safety radius.

If a power-down lasted longer than nine minutes then a ramp-up procedure was required to resume seismic operations.

### 3.3.4. Shut-down Procedures

The seismic source was shut-down if a marine mammal or sea turtle was observed inside or approaching the safety radius for the single 40 $in^3$ airgun, either after a power-down had already been initiated or if the animal was initially detected within the safety radius of the single airgun.

Additionally, the IHA mandated that the positive identification of the following ‘zero-take’ marine mammals would result in an immediate shut-down of the seismic source regardless of the animal’s distance to the source: North-Pacific right whale, sei whale, blue whale and beluga whale.

Seismic operations were resumed following a shut-down under the same criteria outlined for resumption of operations following a power-down.

# 4. MONITORING EFFORT SUMMARY

## 4.1. SURVEY OPERATIONS SUMMARY

The *Langseth* departed the Port of Kodiak for the survey site at 01:45 UTC on 30 June 2011. The survey was acquired in phases, beginning with the ocean-bottom seismometer survey lines followed by the multi-channel seismic survey lines.

After departing the port of Kodiak, the vessel began to scout the survey area for the optimal locations for deployment of the ocean bottom seismometers. Deployment of the OBSs began at 08:28 UTC on 2 July 2011 and was completed at 05:31 on 3 July 2011, at which time the vessel began acquisition of the first OBS survey line. Retrieval of the OBSs began on 5 July 2011 at 03:46 UTC upon completion of acquisition of the first OBS line. The OBSs were then re-deployed in preparation to acquire the second OBS survey line. Acquisition of the second and final OBS survey line was completed at 08:37 UTC on 10 July 2011. All 21 OBSs were retrieved successfully following the completion of acquisition of each OBS survey line. Following the completion of the OBS phase of the survey project, the *Langseth* travelled to the port of Sand Point for a personnel transfer prior to beginning the final phase of the survey.

On 12 July 2011 at 11:45 UTC the vessel began deploying streamer cable for the MCS portion of the survey, and completed deployment of the first guns strings at 14:07 UTC on 15 July 2011. A mitigation gun was enabled at 14:26 UTC followed by a ramp-up of the acoustic source which was completed at 15:29 UTC. Once acquisition of survey lines began, the acoustic source remained active, with the source operating on full power during most line changes. The source volume was reduced to one gun string (1,800 $in^3$), two gun strings (3,300 $in^3$), or three gun strings (4,950 $in^3$) as operationally required in order for gun maintenance to be performed on the arrays. Acquisition of MCS survey lines continued until 3 August 2011 at 22:55 UTC when the last shot was fired on the final MCS survey line. A total of 27 line sequences were acquired, two OBS survey lines and 25 MCS line sequences (Table 2). Each OBS line sequence was also acquired as an MCS survey line. Several MCS survey lines were acquired more than once, (labelled using the same line sequence number with an alphabetic suffix (A,B,C,D,E,F)) when there were gaps in the data due to mechanical or technical problems or when marine mammal mitigation actions were sufficiently large to require a re-shoot.

**Table 2: Shillington Aleutian OBS and MCS survey lines acquired**

| Survey Line | Date Acquisition Commenced | Time Acquisition Commenced (UTC) | Date Acquisition Completed | Time Acquisition Completed (UTC) |
|---|---|---|---|---|
| MGL1110OBS03 | 3 July | 10:57 | 5 July | 03:46 |
| MGL1110OBS05 | 8 July | 21:58 | 10 July | 08:37 |
| MGL1110MCS05 | 16 July | 07:22 | 17 July | 20:56 |
| MGL1110MCS45 | 17 July | 21:01 | 18 July | 14:27 |
| MGL1110MCS04 | 18 July | 17:33 | 20 July | 10:48 |
| MGL1110MCS34 | 20 July | 23:30 | 21 July | 03:09 |
| MGL1110MCS03 | 21 July | 07:12 | 23 July | 02:32 |
| MGL1110MCS23A | 23 July | 03:59 | 23 July | 13:14 |
| MGL1110MCS23B | 23 July | 13:45 | 23 July | 22:14 |
| MGL1110MCS23C | 23 July | 22:16 | 25 July | 00:45 |

| Survey Line | Date Acquisition Commenced | Time Acquisition Commenced (UTC) | Date Acquisition Completed | Time Acquisition Completed (UTC) |
|---|---|---|---|---|
| MGL1110MCS23D | 25 July | 05:23 | 25 July | 11:15 |
| MGL1110MCS02 | 25 July | 11:23 | 26 July | 17:23 |
| MGL1110MCS02R | 26 July | 22:05 | 27 July | 10:55 |
| MGL1110MCS12A | 27 July | 11:16 | 27 July | 18:49 |
| MGL1110MCS01A | 27 July | 19:09 | 27 July | 23:31 |
| MGL1110MCS01B | 28 July | 00:13 | 28 July | 05:38 |
| MGL1110MCS12B | 28 July | 05:57 | 28 July | 11:48 |
| MGL1110MCS12C | 28 July | 14:31 | 28 July | 20:25 |
| MGL1110MCS12D | 28 July | 20:43 | 29 July | 05:06 |
| MGL1110MCS01C | 29 July | 06:02 | 29 July | 21:04 |
| MGL1110MCS12E | 29 July | 21:23 | 30 July | 12:44 |
| MGL1110MCS12F | 30 July | 13:10 | 31 July | 02:49 |
| MGL1110MCS07 | 31 July | 03:41 | 01 August | 17:23 |
| MGL1110MCS56 | 01 August | 17:37 | 02 August | 03:55 |
| MGL1110MCS06 | 02 August | 05:02 | 03 August | 12:11 |
| MGL1110MCS67A | 03 August | 12:39 | 03 August | 15:15 |
| MGL1110MCS67B | 03 August | 15:30 | 03 August | 22:55 |

Full power source operations accounted for 89% of airgun activity during the survey project. Survey acquisition accounted for most full power seismic activity, totalling 436 hours and 47 minutes (84% of full source airgun activity). The vessel continued to fire the source at full or partial power on most line changes resulting in an additional 24 hours and 29 minutes of full or partial power source operations throughout the survey (Table 3).

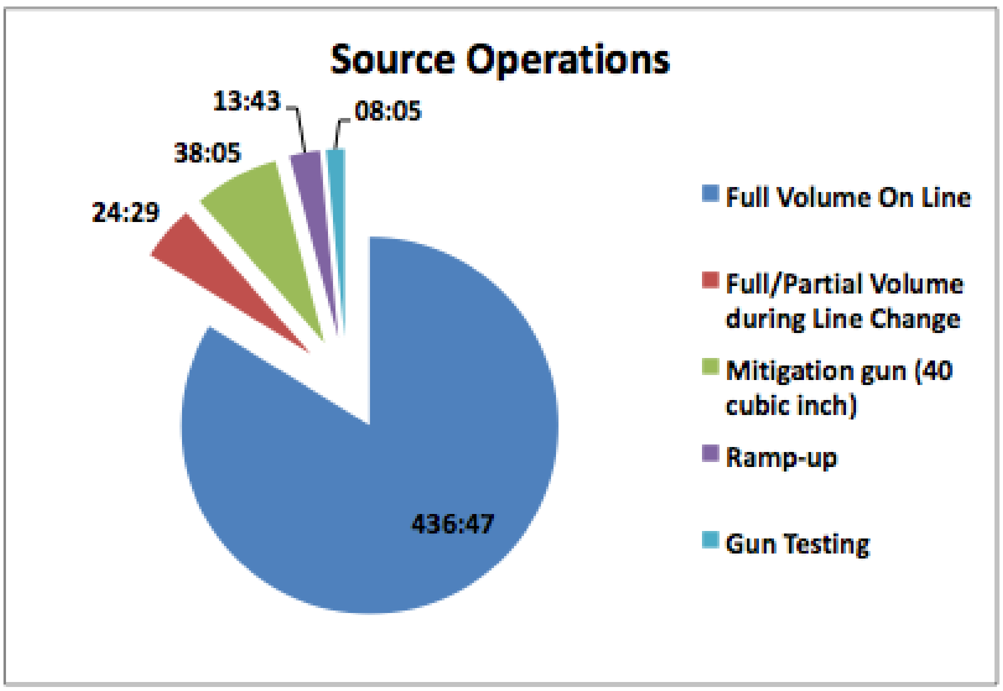


**Figure 4: Source operations as a percentage of total acoustic source activity.**

**Table 3: Source operations during Shillington Aleutian marine seismic survey**

| Acoustic Source Operations | Number | Duration (hh:mm) |
|---|---|---|
| Gun Tests | - | 08:05 |
| Ramp-ups | 39 | 13:43 |
| Day time ramp-ups from silence | 2 | 01:18 |
| Day time ramp-ups from mitigation | 35 | 11:22 |
| Night time ramp-ups (from mitigation source) | 2 | 01:03 |
| Survey Acquisition | - | 436:47 |
| Full power/Partial power line changes | - | 24:29 |
| Single 40 $in^3$ airgun | - | 38:05 |
| Total time acoustic source was active | | 521:09 |

The airguns were ramped up 39 times over the course of the survey in order to commence full power survey operations in compliance with the IHA, accounting for 3% (13 hours and 43 minutes) of the project's total source activity (Figure 4). Most ramp-ups were conducted during the day with only two night time ramp-ups performed, beginning from the active mitigation source (40 in3). The majority of ramp-ups conducted during the daytime were also initiated with the mitigation source already active, with only two daytime ramp-ups initiated from complete source silence (Figure 5).

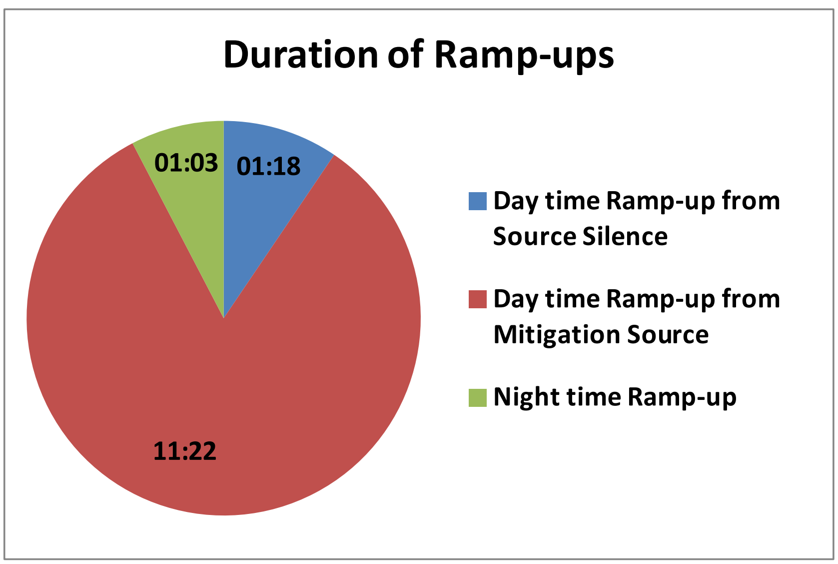


**Figure 5: Duration of all source ramp-ups conducted during the Shillington survey during the day and at night and from the mitigation source**

Each ramp-up was conducted over approximately 25 to 30 minutes, where the NMFS approved automated gun controller program DigiShot added guns sequentially to achieve full source over the required period of time. In order to perform partial ramp-ups where multiple airguns were already active, an operator, beginning with the smaller guns and gradually increasing the volume, activated the remaining guns sequentially and manually.

Between 24 and 30 July 2011 several ramp-ups were conducted over too short of a duration to meet the IHA requirement that guns be added sequentially "such that the source level of the array shall increase in steps not exceeding approximately 6 dB per 5 minutes" (15 minutes being the shortest ramp-up conducted to full source volume of 6,420 $in^3$). Due to the exponential relationship between the volume of the source and the decibel level of the received sound, and the lack of precise gun modelling available to seismic operators, some of the new operators lacked a full understanding of how to modify the automated NMFS-approved ramp-up program in the Beaufort gun controller to account for varying vessel speed and the shortened shot interval utilized during the MCS portion of the survey. This only became apparent when the large number of ramp-ups implemented during that period meant that new operators were initiating ramp-ups that were later discovered to be too short in duration. Once the problem was discovered, additional training in implementation of ramp-up procedures for all gun controller operators.

Ramp-ups were conducted, as mandated by the IHA, during daytime and night-time operations during the Shillington Aleutian survey project, although the majority of ramp-ups conducted occurred during daylight hours. Of the 39 ramp-ups conducted throughout the survey project, only 2 were conducted at night. All remaining 37 ramp-ups were daytime ramp-ups. Daytime ramp-ups could begin from airgun silence if a 30 minute pre-survey was conducted by PSOs on watch and 2 ramp-ups were conducted from airgun silence. The remaining 35 daytime ramp-ups were initiated from the already active 40 $in^3$ mitigation gun.

The single mitigation source (one gun 40 $in^3$) was active during mitigation power-downs initiated for protected species inside the safety radii as well as during mechanical or technical power-downs for a total of 38 hours and 05 minutes over the course of the survey.

## 4.2. ENVIRONMENTAL CONDITIONS

The majority of visual monitoring effort was conducted during average to good observations conditions, where visibility was good, extending to several kilometers such that the entire safety radii for 180dB could be observed. There were brief but regular periods of obscured and/or reduced visibility in combination with high Beaufort sea state (Beaufort level 5 or above) but often not lasting more than several hours at a time.

Visibility varied greatly over the survey project, ranging from 50 meters to nine kilometers, however the majority (62%) of visual monitoring effort was conducted while visibility extended to six kilometers (Figure 6). Brief and regular periods of fog and rain obscured visibility but on only ten occasions (7, 9 to 11, 13, 16, 18 to 20, and 30 July) did visibility decrease to the extent that the safety radii were not visible.

PSOs undertook visual observations during periods of rain on 26 of the 38 days during which visual monitoring was conducted, performing a total of 140 hours of monitoring effort during periods of rain, 30 hours of which occurred during heavy rain (Figure 6).

Fog impacted visibility during 25 days of visual observations with a total of 210 hours and 30 minutes of visual monitoring conducted during fog. There were few periods of glare due to the consistent heavy cloud cover observed throughout the project.

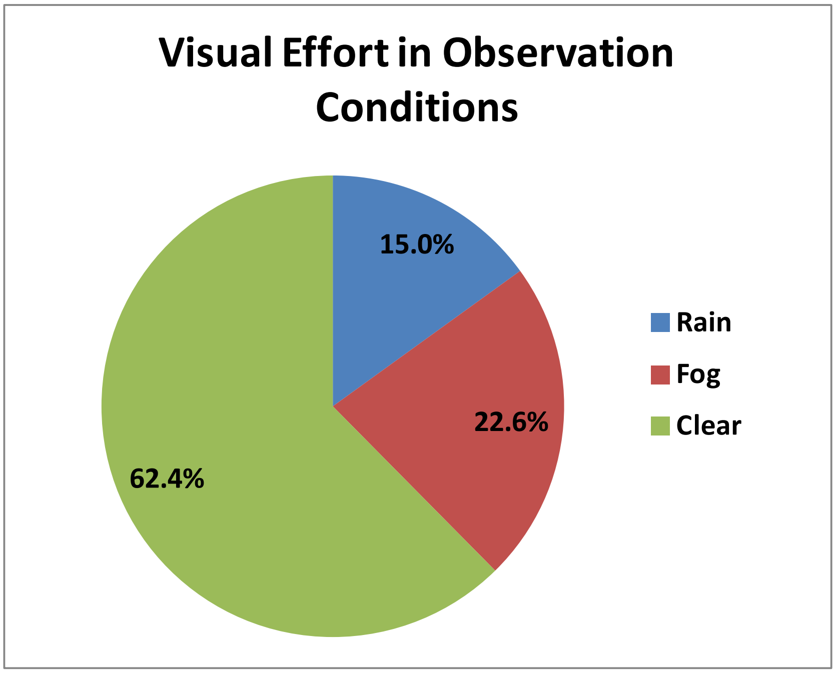


**Figure 6: Percentage of visual monitoring effort conducted during environmental conditions affecting visibility during the Shillington survey**

The majority of visual monitoring effort was conducted at a Beaufort sea state level three, characterized as "large wavelets, crests begin to break, foam of glassy appearance, occasional scattered white horses" (Appendix F). Beaufort sea states recorded during visual monitoring effort varied from a low of level one to a high of level six on 4 August 2011, although these extremes corresponded to short periods of visual observation effort. On only twelve days during which visual monitoring was conducted did the sea state increase to level five, a Beaufort level at which PSO's ability to detect obscure species could have been hindered (Figure 7).

Wind force varied from no recorded wind speed (close to zero knots) to a high of 38 knots (4 August). Wind force generally averaged around 14 knots with wind forces greater than 20 knots only recorded on 18 days during the project. These high wind forces corresponded to the highest Beaufort sea states recorded during the survey. Wind direction was highly variable throughout the survey.

As the wind force did not increase above 20 knots for more than several hours on most days, the swell also remained low, recorded as less than two meters on most days. Swells reached a high of four meters after sustained periods of high wind speeds on several days.

Water clarity was low throughout the project due in part to the heavy cloud cover and rough seas.

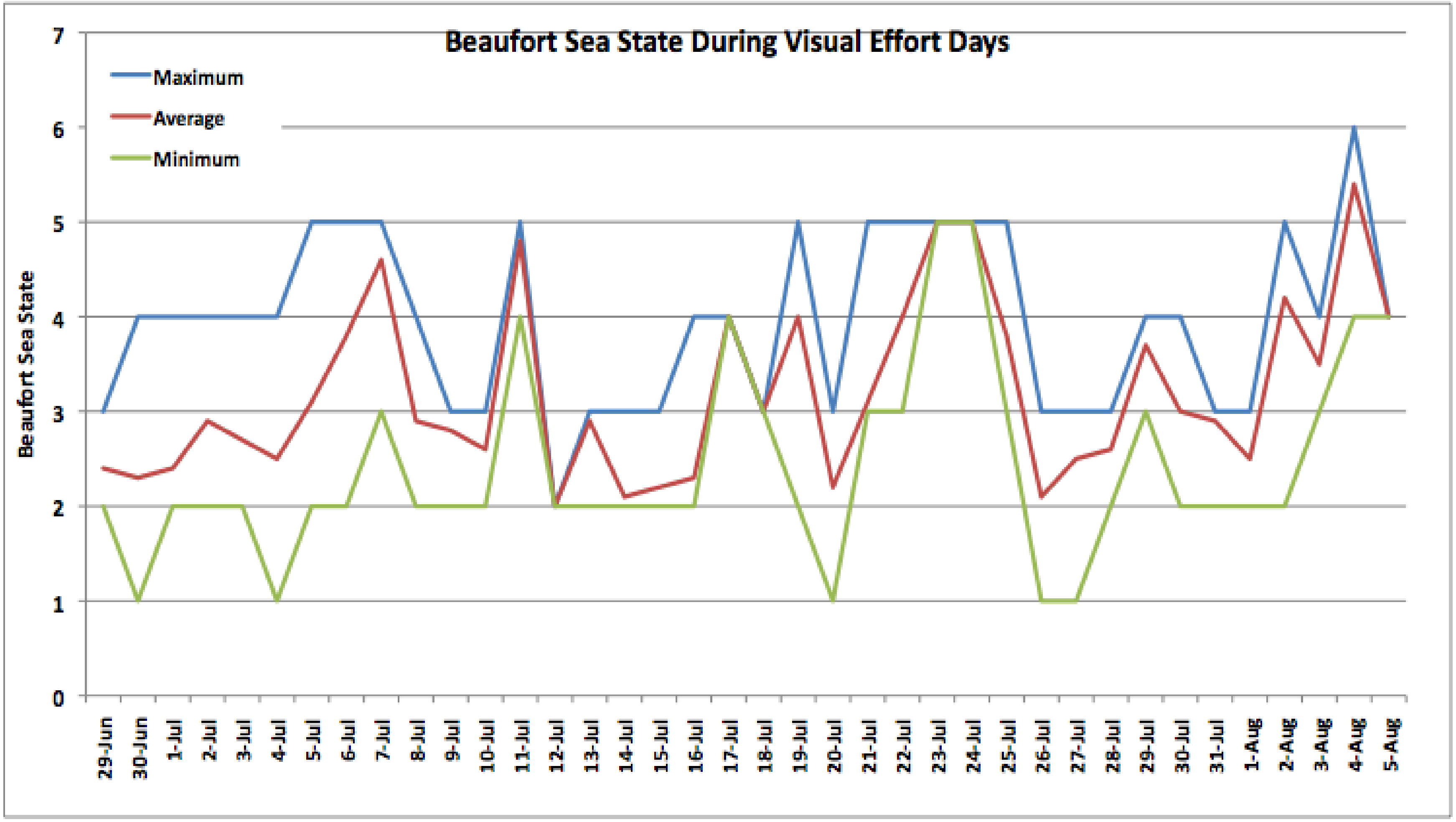


**Figure 7: Maximum, minimum and average Beaufort sea state each day visual monitoring observations were conducted during the survey.**

## 4.3. MONITORING SUMMARY

Monitoring was conducted over a period of 37 days (30 June through 05 August 2011 UTC) within and adjacent to the Shillington Aleutian survey lines, with PSOs achieving a total of 1,052 hours and 47 minutes of visual and acoustic monitoring hours for protected species. Observations were undertaken while the vessel engaged in any seismic operations in addition to throughout the deployment and retrieval of seismic equipment, on transit to and from the survey site, during periods of technical downtime and while maintenance was performed on airguns or streamers.

Of the total observation effort achieved by PSOs, visual monitoring accounted for the majority of the effort, 635 hours and 07 minutes. An additional 417 hours and 47 minutes of acoustic monitoring effort were accumulated, 320 hours and 41 minutes of which were conducted with simultaneous visual observations completed (Figure 8).

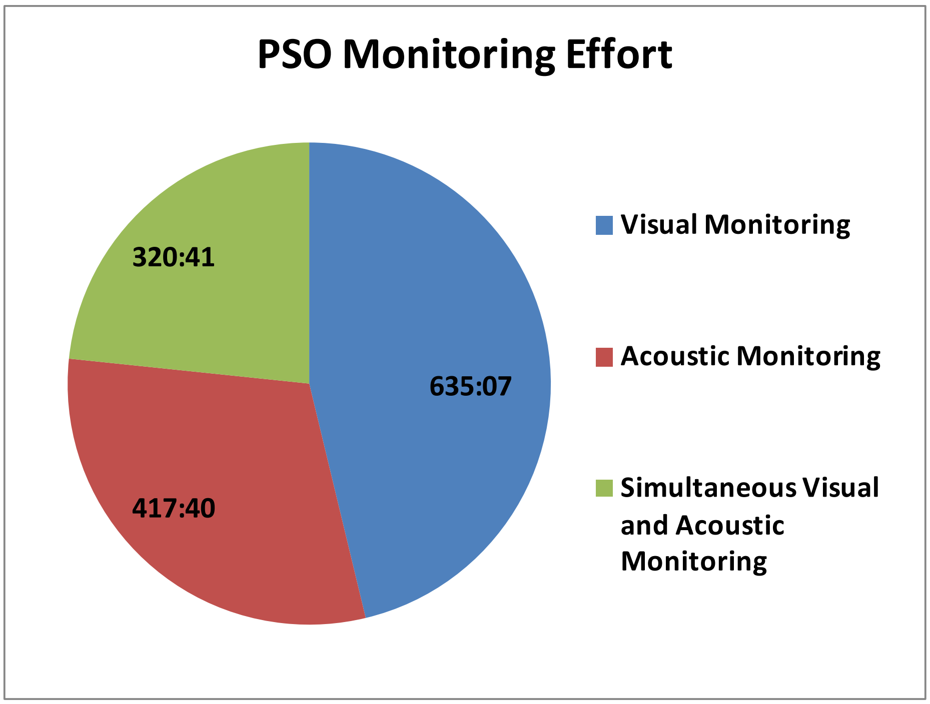


**Figure 8: Duration of the type of monitoring shown as a percentage of total PSO monitoring effort over the survey**

Airguns were active throughout the majority of visual and acoustic monitoring effort as once survey acquisition began, the source was only disabled for protected species mitigation shut-down procedures and when mechanical complications arose requiring the survey to be suspended (Figure 9).

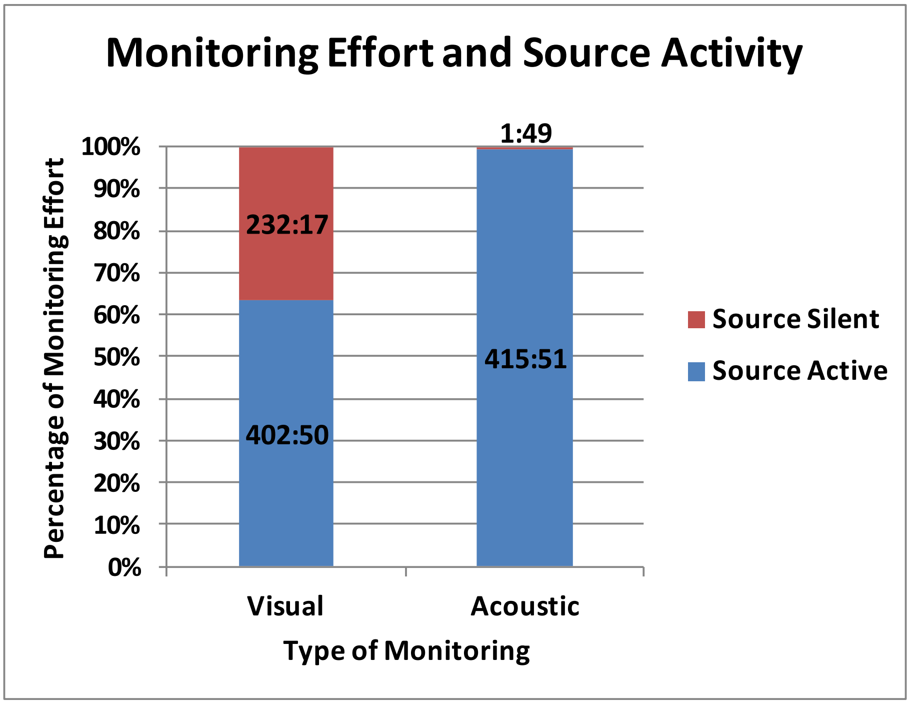


**Figure 9: Duration of visual and acoustic monitoring effort while the acoustic source was active and silent shown as a percentage of the total monitoring effort**

### 4.3.1. Visual Monitoring Survey Summary

Visual monitoring began on 30 June 2011 as the vessel departed the Port of Kodiak and began the transit to the survey area and continued until 05 August (UTC) when the vessel returned to port in Dutch Harbor at the completion of the survey project. Monitoring was conducted by two PSOs every day between just before dawn until just after dusk (approximately 12:00 to 13:30 UTC to 23:00 to 00:00 UTC), which averaged between 17.5 to 19 hours of visual observations per day. The start and end of visual observation times varied based on sunrise and sunset times and cloud cover. Sunrise and sunset times changed as the vessel transited from north to south on survey lines. Observations ended when it became too dark for the entire safety radius to be visible.

On 30 June 2011 and 1 July 2011, prior to the start of survey acquisition while the vessel was scouting for deployment locations of the OBSs, a single PSO continued visual observations. Additionally, during lunch and dinner scheduled meal hours on the vessel, a single PSO continued visual monitoring in addition to acoustic monitoring conducted by the PAM operator on duty while each PSO rotated for a meal break. Single PSO visual observations during these periods lasted a maximum of 45 minutes. When single monitoring happened concurrently with a detection a second PSO resumed visual observations immediately for assistance.

Of the total 635 hours and 07 minutes of visual monitoring conducted, 63% (402 hours and 50 minutes) occurred while the source was active (including the single 40 $in^3$ mitigation gun, ramp-up of the source and full volume activity) (Figure 12 above, Table 4).

**Table 4: Visual monitoring effort during the Shillington Aleutian survey**

| Visual Monitoring | Duration (hh:mm) |
|---|---|
| Monitoring during full volume operations | 321:28 |
| Monitoring during partial volume operations | 33:13 |
| Monitoring during ramp-up | 12:57 |
| Monitoring during mitigation gun operation | 35:12 |
| Total monitoring while airguns active | 402:50 |
| Total monitoring during airgun silence | 232:17 |
| Total visual monitoring | 635:07 |

The largest percentage of visual monitoring effort was accumulated during full source operations (51%, 321 hours and 28 minutes). The acoustic source was considered to be at full volume when all four strings were active consisting of 36 airguns. The preferred full source volume for the Shillington survey was 6,600 $in^3$, but on occasions when one airgun had to be substituted for another, the volume decreased to 6,270, 6,420, 6,470 or 6,560 $in^3$. Partial volume operations were recorded on occasions when less than four gun strings were operational: two gun strings of 18 airguns at a volume of 3,300 $in^3$ or three gun strings of 27 airguns at a volume of 4,950 $in^3$. Partial volume source activity was being conducted during only 5% (33 hours and 13 minutes) of visual observations (Figure 10). The mitigation gun, a single 40 $in^3$ airgun was also active for 5% of visual monitoring effort (35 hours and 12 minutes).

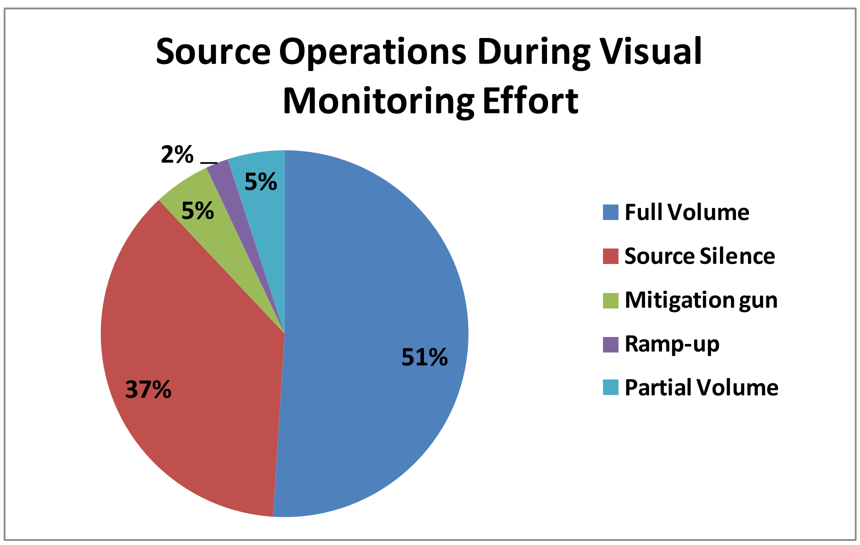


**Figure 10: Percentage of visual monitoring effort conducted at acoustic source operation levels during the Shillington Aleutian survey**

More visual observation effort was undertaken in water depths greater than 1000 meters (305 hours and 27 minutes of the total 635 hours and 07 minutes of visual observation effort) than in intermediate water depths (100 metres to 1000 metres) or shallow water (less than 100 metres) (Figure 11). Approximately the same number of visual observation hours were accumulated at intermediate (161 hours and 07 minutes) and shallow (168 hours and 33 minutes) water depths.

A larger percentage was visual effort was undertaken while the acoustic source was silent in intermediate water depths (44%) than in deep water (33%) or shallow water (36%) (Figure 12).

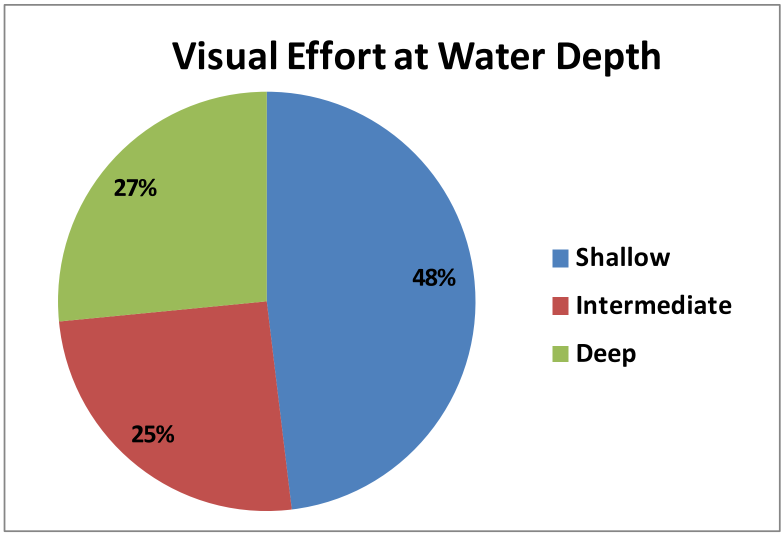


**Figure 11: Percentage of visual observation effort undertaken in shallow, intermediate and deep water during the survey**

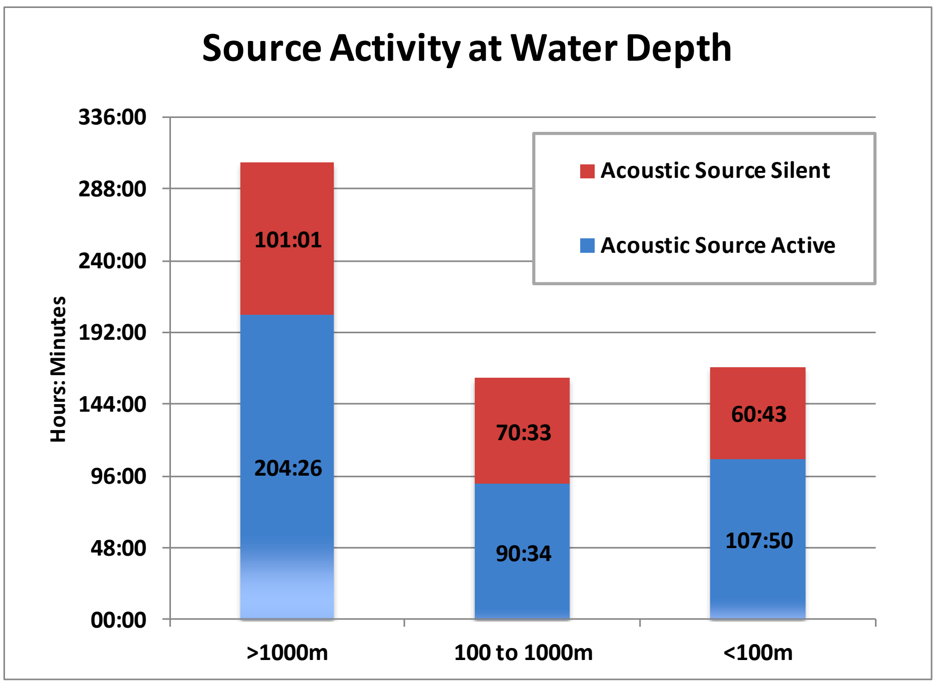


**Figure 12: Visual observation effort undertaken in deep, intermediate, and shallow water while the acoustic source was active and silent**

Visual observations were primarily conducted from the PSO tower. The tower provided PSOs with a 360-degree view around the vessel and the acoustic source and has an observation height of approximately 20 meters above the water surface. Observations could also be conducted from the stern, bridge, and catwalk in front of the bridge. PSOs were able to move to these locations when the conditions were deemed unsafe for monitoring from the tower (when wind speed increased above 30 knots or swells and sea state increased such that the vessel was rolling and pitching in a manner that made accessing the tower unsafe) or when the exhaust from the vessel engine stacks was blowing into the tower. Over 84% of the overall visual monitoring effort (533 hours and 19 minutes) was completed from the tower location during the Shillington Aleutian survey (Figure 13). Observations were occasionally conducted from two locations (one hour and 58 minutes), one PSO stationed outside on the catwalk, in radio contact with the other PSO stationed on the bridge in a position to collect data during detection events and mitigation actions.

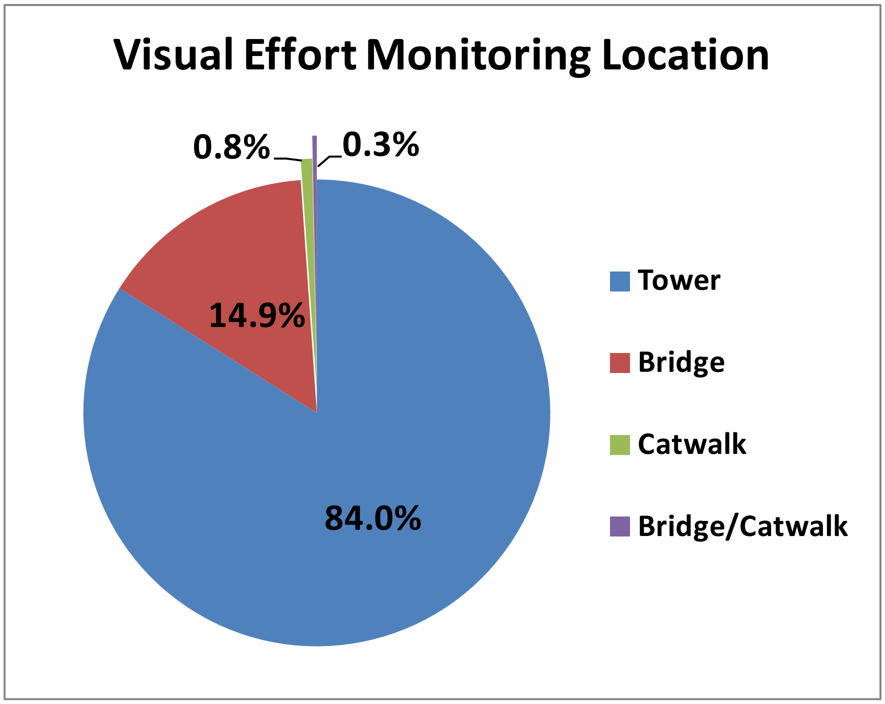


**Figure 13: Visual monitoring effort performed from PSO visual observation locations on board *Langseth* during the Shillington survey**

### 4.3.2. Acoustic Monitoring Survey Summary

The hydrophone cable was deployed for the first time on 3 July 2011 after the vessel had completed deployment of the seismic equipment. Acoustic monitoring began immediately at 09:20 UTC and continued throughout the project with PSOs monitoring the hydrophones aurally and visually monitoring the PAMGuard detection software both day and night. Acoustic monitoring for the project ended at 22:45 UTC on 03 August 2011 when acquisition of the final survey lines was completed and the hydrophone cable was retrieved in preparation for the retrieval of the seismic equipment.

Over the course of the project, PSOs conducted 417 hours and 40 minutes of acoustic monitoring, the majority, 99% (415 hours and 51 minutes), of which occurred while the acoustic source was active (Figure 12, Table 5). A larger percentage of acoustic monitoring occurred while the source was active (99% of total acoustic monitoring effort) than visual monitoring while the source was active (64%) for operational reasons: the hydrophone cable had to be retrieved and remain on board anytime all the port side gun arrays (the side from which the hydrophone cable was deployed) or the entire source were retrieved. A significant amount of visual monitoring during source silence occurred while the vessel was in transit at vessel speeds too great to allow the hydrophone cable to remain deployed, and during deployment and retrieval of the OBSs, when both gun arrays and the hydrophone cable had to remain on board to allow the vessel maximum manoeuvrability.

**Table 5: Acoustic monitoring effort during the Shillington Aleutian seismic survey**

| Acoustic Monitoring | Duration (hh:mm) |
|---|---|
| Total Night time monitoring | 96:59 |
| Total Day time monitoring | 320:41 |
| Total monitoring while airguns active | 415:51 |
| Total monitoring during airgun silence | 01:49 |
| Total acoustic monitoring | 417:40 |

On several occasions during the acquisition of the Shillington Aleutian survey acoustic monitoring had to be suspended resulting in the accumulation of 331 hours and 21 minutes of acoustic monitoring downtime. Acoustic monitoring was most often suspended because the hydrophone cable could not remain deployed; however, there were brief occurrences where monitoring was suspended while the cable remained in the water.

Acoustic monitoring was suspended and the hydrophone cable retrieved during the deployment and retrieval of OBSs during the first phase of the survey project. The hydrophone cable was also retrieved to avoid potential entanglement if seismic equipment on the port side of the vessel had to be retrieved. The cable was also secured on board during periods of bad weather where large swells increased the risk of entanglement. There were two times when the cable had become entangled with the port side source array umbilical during normal operations and the cable had to be untangled before it was retrieved. Entanglement did not occur again after more weight was added to the cable to deepen and stabilize the towing depth. Entanglements were also prevented due to increased vigilance by the PAM operators and crew. There were also a few instances where the vessel was surveying in water depths that were shallower than the towing depth of the hydrophone array and the cable was retrieved to prevent impact with the ocean floor.

Acoustic monitoring downtime was attributed to seismic operations when it related to OBS deployment and retrieval and repairs, maintenance or malfunctioning of streamers, airguns or compressors. Seismic operations accounted for the largest percentage (71%, 236 hours and 33 minutes) of the total acoustic monitoring downtime during the project (Table 6, Figure 14). Weather and PAM hydrophone entanglement with other vessel gear accounted for approximately the same amount of downtown, 12% and 11% of total acoustic monitoring downtime respectively. During high Beaufort sea state conditions, large swells, or when swells were hitting the stern at angle when the risk of entanglement of the PAM cable with vessel equipment increased, the PAM cable was brought on board. A detailed account of each instance where acoustic monitoring was suspended can be found in Appendix G.

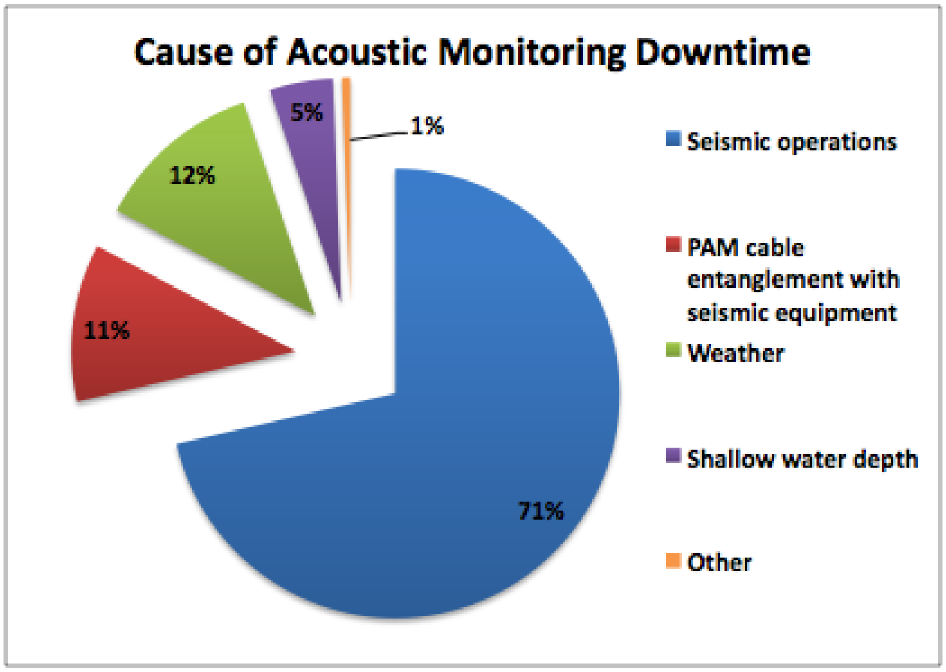


**Figure 14: Causes of acoustic monitoring downtime during the Shillington Aleutian survey**

**Table 6: Cause of acoustic monitoring downtime accumulated during the Shillington Aleutian seismic survey**

| Acoustic Monitoring Downtime | Duration (hh:mm) |
|---|---|
| Seismic Operations | 236:33 |
| PAM Hydrophone Cable Entanglement | 37:38 |
| Weather | 40:05 |
| Shallow Water Depth | 15:09 |
| Other | 1:56 |
| Total Acoustic Monitoring Downtime | 331:21 |

### 4.3.3. Simultaneous Visual and Acoustic Monitoring Summary

As acoustic monitoring continued day and night whenever the hydrophone cable could remain deployed, numerous hours of acoustic observations were conducted overlapping with visual observations, a total of 272 hours and 04 minutes over the course of the survey. Simultaneous acoustic and visual monitoring accounted for 77% of the acoustic monitoring conducted this survey as the hours of daylight which allowed for visual observations were generally 17 to 19 hours.

# 5. DETECTION RESULTS

PSO monitoring effort undertaken during the Shillington Aleutian marine seismic survey resulted in the collection of 201 records of detection for protected species (a complete list of detection events can be found in Appendix H). Eleven species of marine mammals, seven cetaceans, three pinnipeds and one fissiped were identified (Table 7) in addition to several detections of unidentified cetaceans, baleen whales and five pinnipeds that were not identified to species level. There were no detections of marine turtles made during the survey project. All detections of marine mammals were made visually. No detections were made acoustically through monitoring of the PAM system.

**Table 7: Number of detection records collected and number of animals counted for each marine mammal species observed during the survey**

| | Number of Detections | Number of Animals Observed |
|---|---|---|
| **Cetaceans** | **184** | **655** |
| Common minke whale | 01 | 01 |
| Fin whale | 28 | 79 |
| Humpback whale | 92 | 288 |
| North Pacific right whale | 01 | 01 |
| Sei whale | 01 | 02 |
| Unidentified mysticete sp | 29 | 47 |
| Killer whale | 01 | 01 |
| Dall's porpoise | 26 | 227 |
| Unidentified small odontocete | 01 | 02 |
| Unidentified cetacean | 04 | 07 |
| **Pinnipeds** | **14** | **39** |
| Harbour seal | 01 | 09 |
| Northern fur seal | 07 | 07 |
| Stellar sea lion | 01 | 18 |
| Unidentified pinniped sp | 05 | 05 |
| **Fissipeds** | **03** | **39** |
| Sea otter | 03 | 39 |

Some species groups were observed more frequently than others. Mysticetes were detected more often than odontocetes, pinnipeds or fissipeds. Only 17 detection records of the 201 records collected throughout the survey were for pinniped (14 records) or fissiped (three records) species. Of the remaining 184 detection events consisting of cetaceans, only 28 records were collected for odontocetes.

Detections were not distributed evenly over each day. Several days during which continuous visual observations were undertaken produced no detections (9, 18, 24 and 25 July 2011). More than 20 protected species detection records were accumulated on two separate observation days: 30 June (22 records) and 14 July (23 records). On 30 June 2011, the greatest number of different species and the only fissipeds observed during the survey occurred while the vessel was transiting from the port of Kodiak (Figure 15). Observation days when the largest numbers of detections were made corresponded to days where the greatest species diversity was also recorded (i.e the greatest number of different marine mammal species were observed (Figure 16).

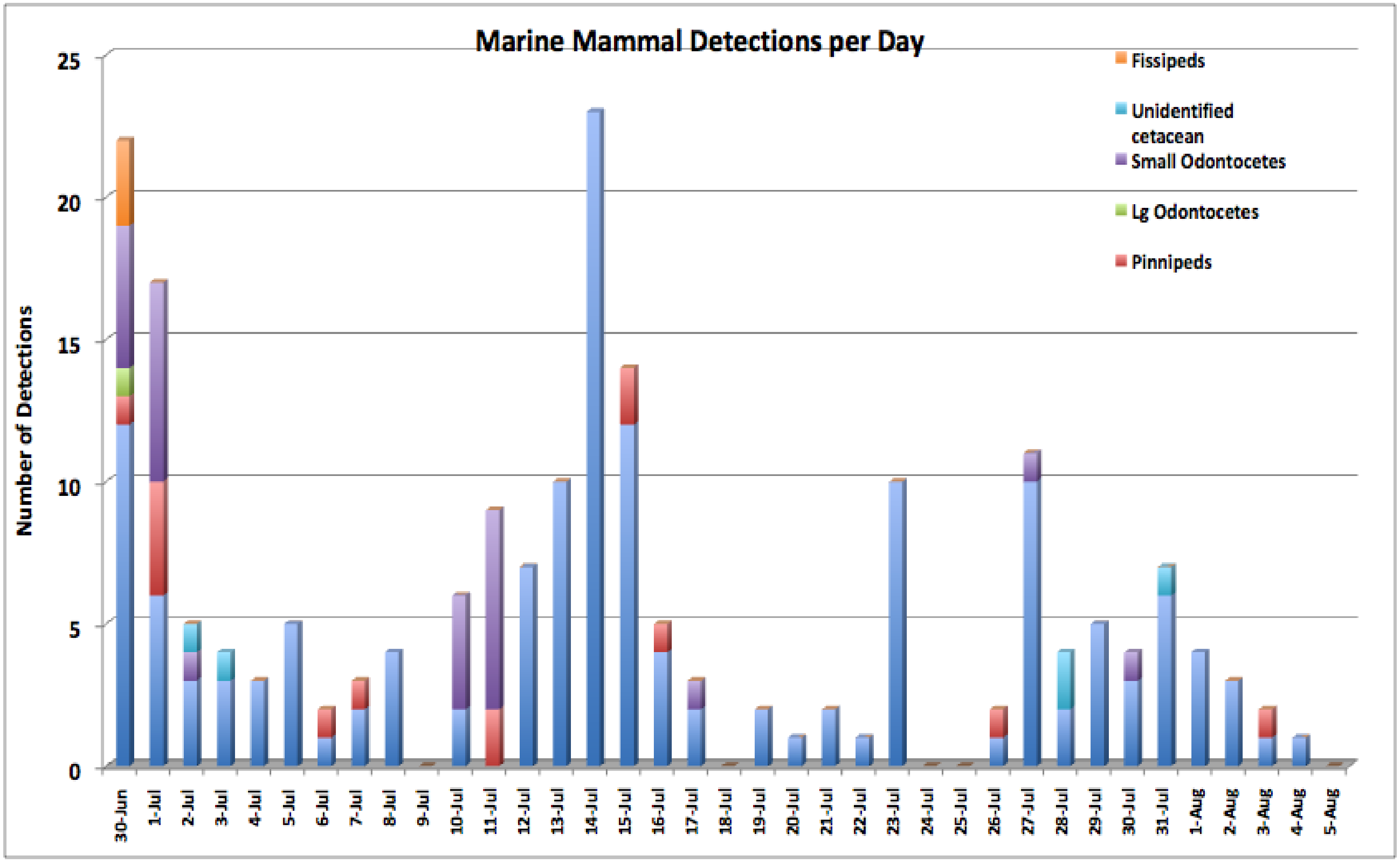


**Figure 15: Detection records collected each day of visual observations during the Shillington Aleutian survey**

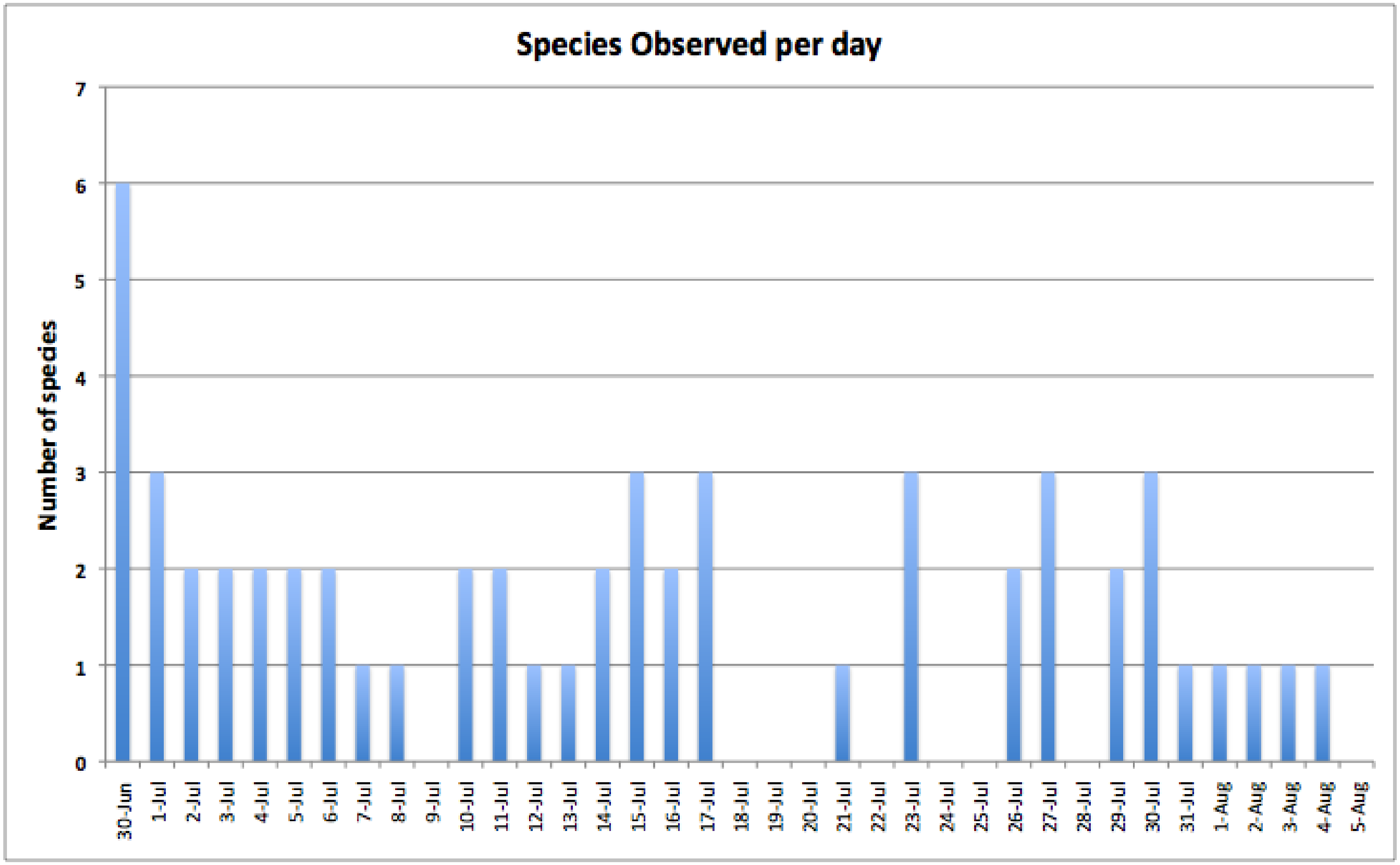


**Figure 16: Number of marine mammal species identified on each day of the Shillington Aleutian survey**

Species diversity varied with water depth with the greatest number of marine mammal species recorded in intermediate water depths (100 metres to 1000 metres). The 9 species were observed in intermediate water depths, 5 species in deep water (>1000m), and 4 species in shallow water (<100m) (Figure 17).

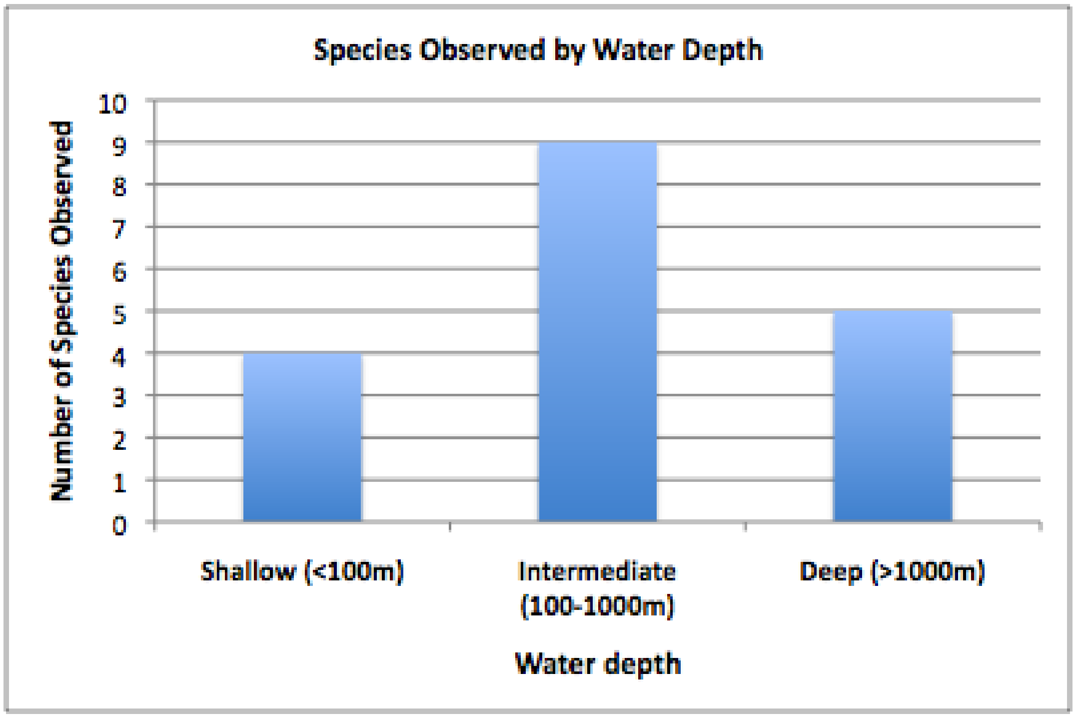


**Figure 17: Number of marine mammal species observed in deep, intermediate and shallow water**

The total number of marine mammal detection records collected per hour of visual monitoring also varied with water depth, with more records collected in intermediate water depths than in either deep or shallow water. While shallow water depths yielded slightly fewer detection records per visual monitoring effort, deep water yielded a significantly lower number of records: 0.447 records per hour of effort at intermediate, 0.3398 records per hour of effort in shallow water but only 0.203 records per effort in deep water (Table 8, Figure 18).

Mysticetes were one exception to this trend of higher detection rates of in intermediate water depths. Mysticetes highest detection rates was recorded in shallow water (0.380 mysticete detections per hour of observation in shallow water compared to 0.298 records per visual effort in intermediate and 0.131 records per visual effort in deep water respectively).

All other species groups examined (large and small odontocetes, unidentified cetaceans, pinnipeds, and fissipeds) were encountered at higher detection rates in intermediate water depths.

**Table 8: Number of detections, hours of visual monitoring and detections per hour of visual monitoring in shallow, intermediate and deep water during the Shillington Aleutian survey**

| Species Group | Shallow water (<100 m) | | | Intermediate water (100 to 1000m) | | | Deep water (<1000m) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Number of Detections | Visual Effort (hrs) | Detections per Hour Effort | Number of Detections | Visual Effort (hrs) | Detections per Hour Effort | Number of Detections | Visual Effort (hrs) | Detections per Hour Effort |
| Mysticetes | 64 | 168.55 | 0.37971 | 48 | 161.12 | 0.2979 | 40 | 305.45 | 0.1310 |
| Large odontocetes | 0 | 168.55 | 0.0000 | 1 | 161.12 | 0.0062 | 0 | 305.45 | 0.0000 |
| Small odontocetes | 0 | 168.55 | 0.0000 | 10 | 161.12 | 0.0620 | 17 | 305.45 | 0.0557 |
| Unidentified cetaceans | 1 | 168.55 | 0.0119 | 8 | 161.12 | 0.1241 | 5 | 305.45 | 0.0000 |
| Pinnipeds | 2 | 168.55 | 0.0059 | 2 | 161.12 | 0.4965 | 0 | 305.45 | 0.0164 |
| Fissipeds | 0 | 168.55 | 0.0000 | 3 | 161.12 | 0.0186 | 0 | 305.45 | 0.0000 |
| **Total** | 67 | 168.55 | 0.3975 | 72 | 161.12 | 0.4469 | 62 | 305.45 | 0.2030 |

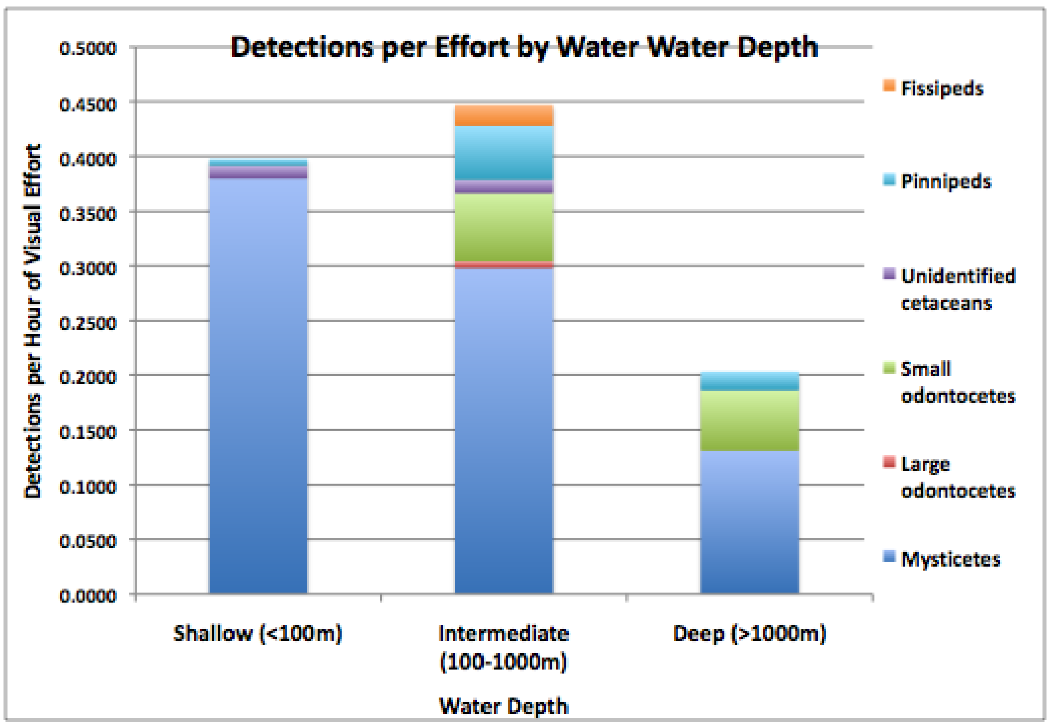


**Figure 18: Number of detection records collected per hour of visual monitoring effort in shallow, intermediate and deep water**

The closest approach to the source and the source volume at the time of the closest approach was recorded during every detection event of the Shillington Aleutian survey. For most species groups, too few detection events had taken place at each level of source operations for the average closest approach to the source to be compared to source operations. For example, only one large odontocete, a pod of killer whale, were observed throughout the entire survey project. Moreover, there were 14 detections of pinnipeds, only one occurred during full volume source operations, mitigation gun operation and ramp-up while the remaining 11 detections occurred while the source was not firing. Mysticete detections, however, occurred in relatively large numbers at all source output levels except ramp-up and the average closest approach of groups of mysticetes to the full volume source was 2463 meters compared to only 1579 meters when the source was not firing (Table 9, Figure 19).

**Table 9: The closest approach to source of marine mammal groups detected at varying acoustic source operation levels**

| Type of Detection | Full Volume | | Mitigation Gun (40 in$^3$) | | Ramp-up | | Not Firing | |
|---|---|---|---|---|---|---|---|---|
| | Number of Detections | Ave Closest Approach to Source (m) | Number of Detections | Ave Closest Approach to Source (m) | Number of Detections | Ave Closest Approach to Source (m) | Number of Detections | Ave Closest Approach to Source (m) |
| Mysticetes | 49 | 2463 | 21 | 848 | 1 | 890 | 81 | 1579 |
| Large Odontocete | 0 | N/A | 0 | N/A | 0 | N/A | 1 | 1500 |
| Small odontocete | 2 | 225 | 1 | 300 | 0 | N/A | 24 | 558 |
| Unidentified cetaceans | 4 | 5338 | 0 | N/A | 0 | N/A | 0 | N/A |
| Pinnipeds | 1 | 223 | 1 | 100 | 1 | 2000 | 11 | 233 |
| Fissipeds | 0 | N/A | 0 | N/A | 0 | N/A | 3 | 443 |

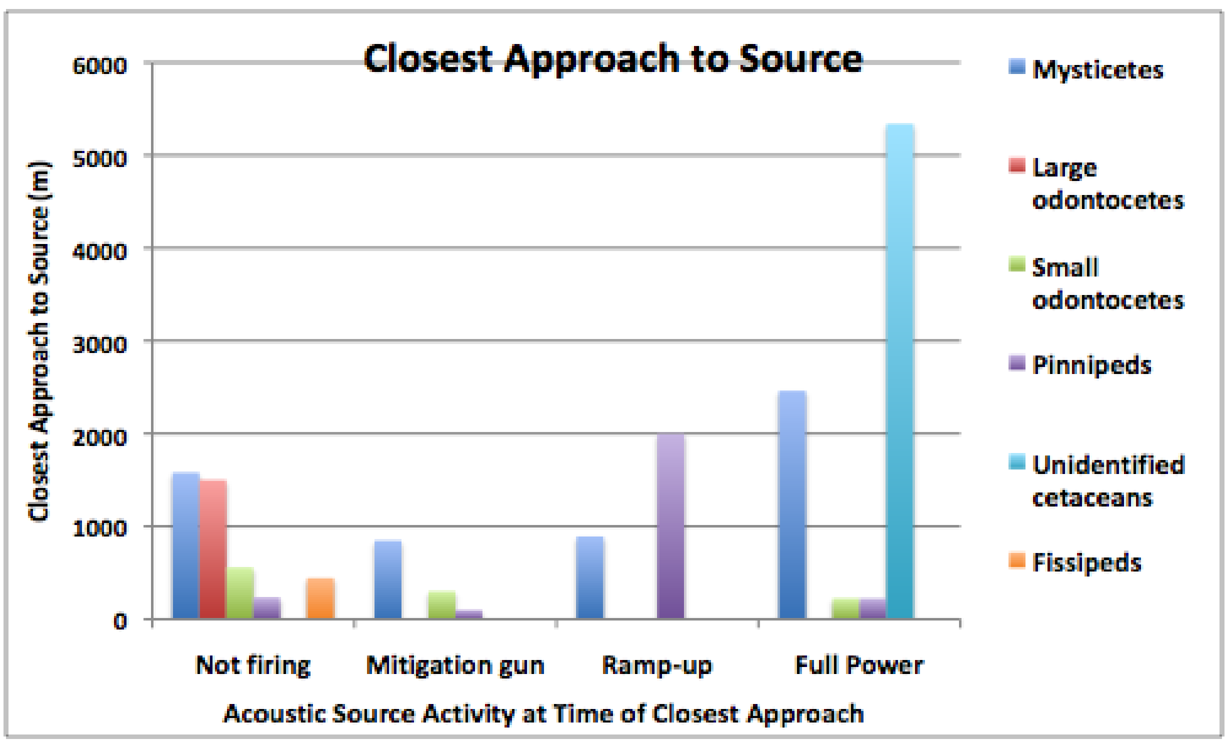


**Figure 19: Closest approach of marine mammals to the acoustic source at source operation level during the Shillington survey**

### 5.1. CETACEAN SIGHTINGS

Seven species, both mysticetes and odontocetes, were identified during the 184 detection events collected for cetaceans during the survey. Odontocetes were observed more infrequently and in smaller numbers than mysticetes, accounting for only 28 of the detection events and 230 of the more than 650 cetaceans observed during the survey. The distribution of cetacean detections can be seen in Figure 20.

Mysticetes accounted for 83% (152 records) of all cetacean detection records collected during the survey project. Humpback whale detections made up 50% of all cetacean detections of the survey while five species or unidentified species categories were observed infrequently enough to each account for only 0.5% of the survey's total number of cetacean detections (Figure 21).

PSOs made a best estimate of the minimum number of animals present during each detection event. The number of detection events for cetacean species as a percentage of the total number of cetacean detections during the survey was usually proportionate to the number of animals of that species observed as a percentage of the total number of cetaceans observed throughout the survey. For example, humpback whales were the largest percentage of cetacean detection events as well as the greatest percentage of individual cetaceans observed. Dall's porpoise were an exception to this trend, making up only 14.1% of all cetacean detection events during the survey, but accounting for 34.6% of all individual cetaceans observed due to their social tendency to form large pods (Figure 22).

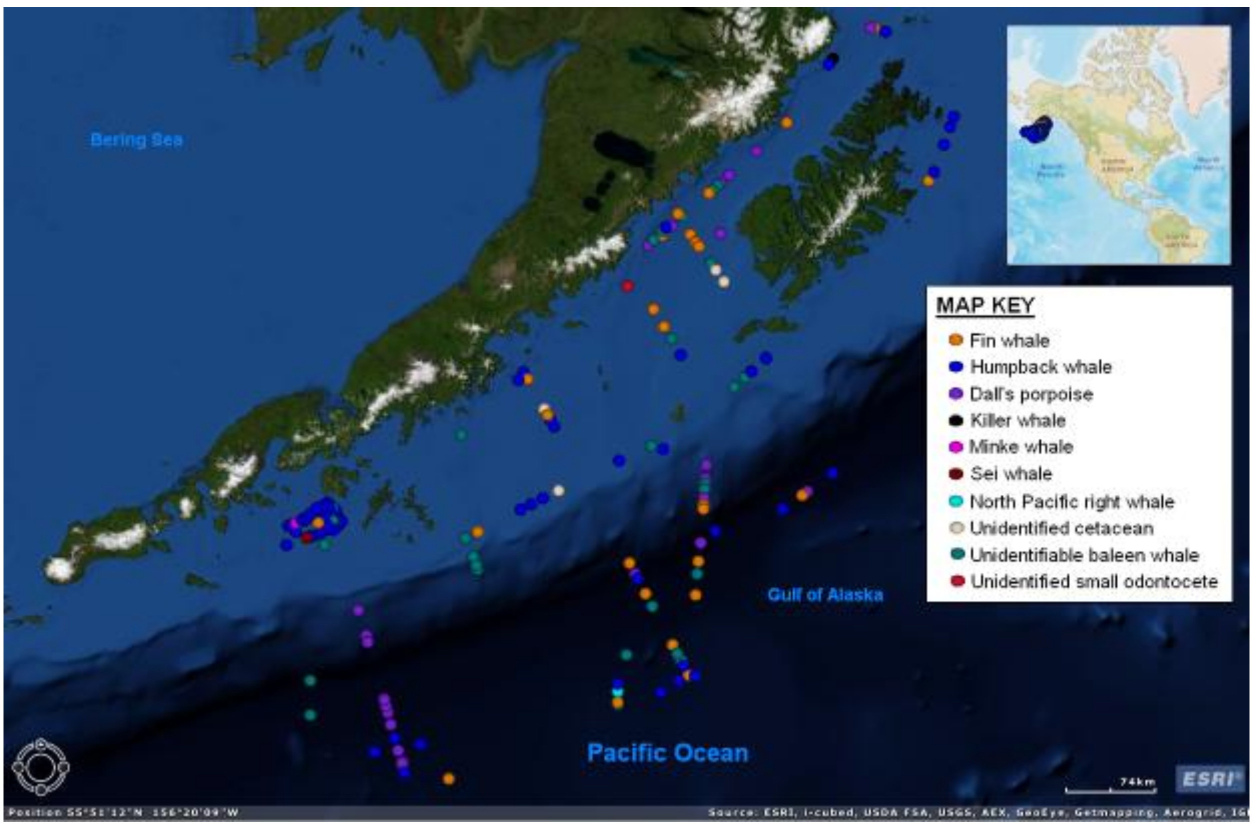


**Figure 20: Cetacean spatial distribution of detections during the Shillington survey**

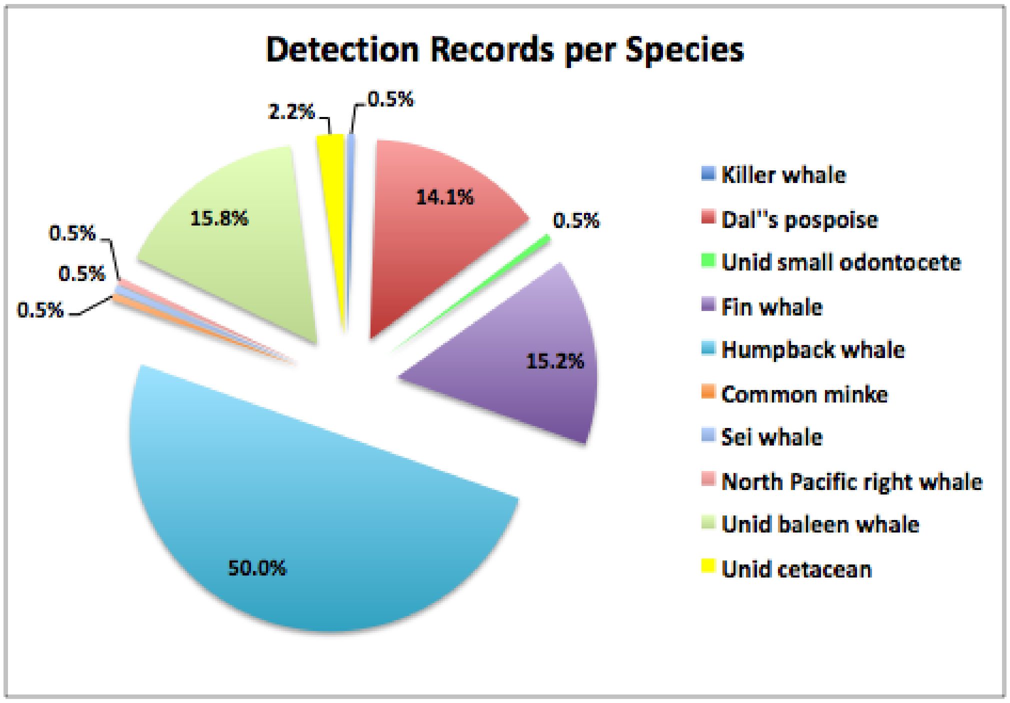


**Figure 21: Percentage of detection records collected for each cetacean species observed during the survey**

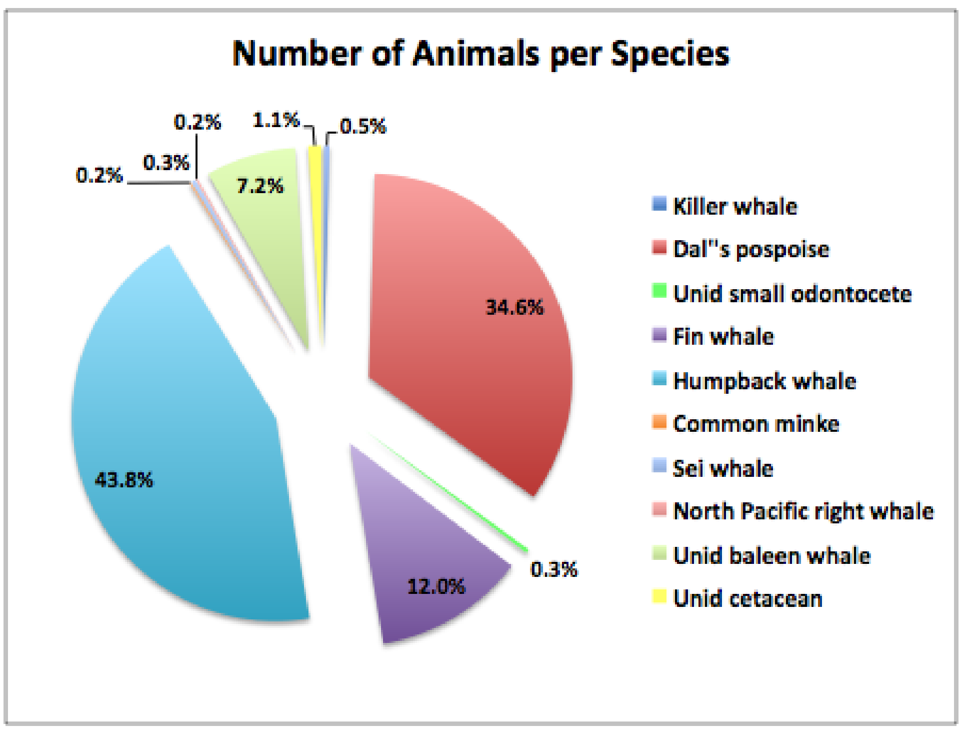


**Figure 22: Percentage of the total number of animals of each cetacean species observed during the survey**

The number of animals present in each pod observed during a detection event varied with species. The average pod size of fin whale and humpback whale detection events was small, three whales, while Dall's porpoise pods averaged ten animals (Table 10). Single humpback whales and fin whales were observed frequently whereas only one Dall's porpoise detection event consisted of a single animal. Dall's porpoise were most often observed in pods of between five and ten individuals. Humpback whales were most often seen alone or in small pods of between two to four animals. Small pods of fin whales were also common, but fin whales were more likely to be seen in pods containing between five and ten whales (Figure 23). All other cetacean species were seen in too few detection events to analyze pod size.

**Table 10: Pod sizes of Dall's porpoise, fin whales and humpback whales observed during the survey**

| Species | Number of Detections | Average Pod Size | Largest Pod Observed | Smallest pod observed |
|---|---|---|---|---|
| Dall's porpoise | 26 | 9 | 35 | 1 |
| Fin whale | 28 | 3 | 10 | 1 |
| Humpback whale | 92 | 3 | 37 | 1 |

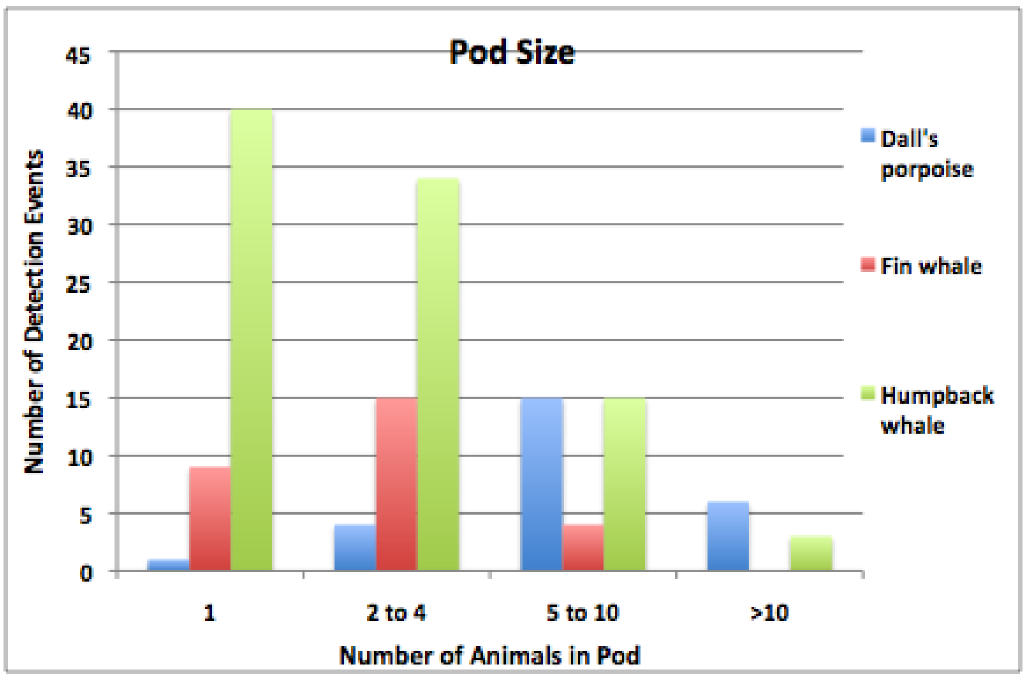


**Figure 23: Pod sizes of Dall's porpoise, fin whales and humpback whales observed during the survey**

As previously noted, both the frequency of detection events and species diversity varied with water depth, with a higher detection rate and greater species diversity observed in intermediate water depths (Figures 19 and 20). Mysticetes were the exception to the trend towards increased detection rates in intermediate water depths, with more mysticetes observed in shallow water. This deviation from the trend can be attributed to humpback whale detections, which outnumbered all other species detections (92 detection events of the 201 detections of the project) and which occurred at the highest rate in shallow water (0.3382 detections per hour of effort as compared to 0.1179 and 0.0534 detections per hour of effort in intermediate and deep water respectively). Fin whales, observed more infrequently than humpback whales, with only 28 detection events were encountered at a higher frequency in intermediate water depths. Dall's porpoise were encountered at almost equal detection rates in intermediate and deep water (Figure 24).

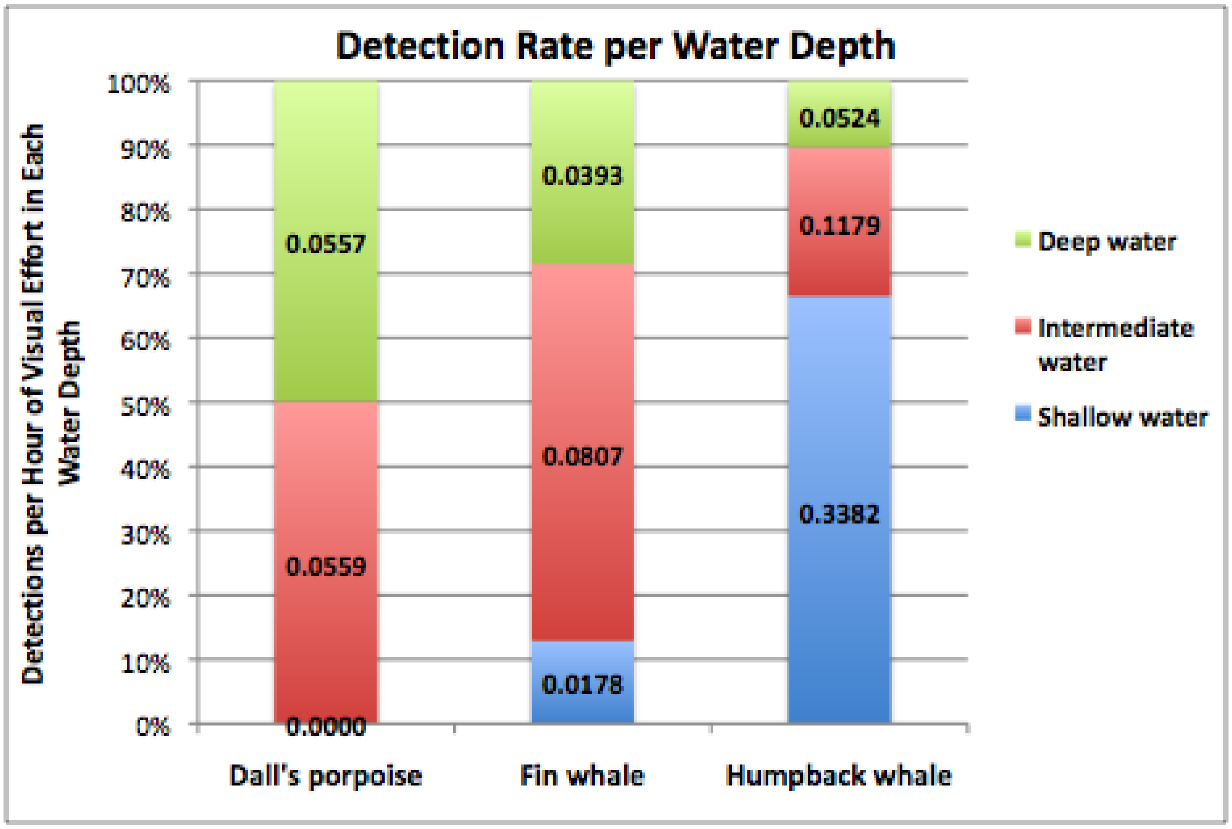


**Figure 24: Detection rate for Dall's porpoise, fin whales and humpback whales in shallow, intermediate and deep water**

The initial direction of travel relative to the vessel and all behavior observed throughout the sighting were recorded during every cetacean detection. Dall's porpoise showed very little variation in behavior, with all pods save one porpoising and/or fast traveling, creating the characteristic rooster tail splashes. Three pods briefly bow-rode after approaching the vessel but only one pod were only observed swimming normally and slower speeds (Figure 25).

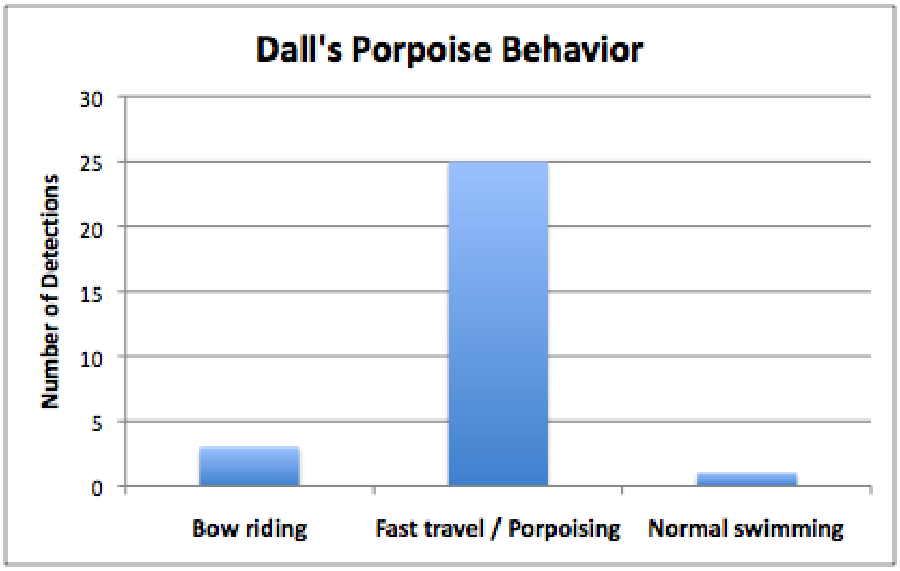

**Figure 25: Behaviors exhibited by Dall's porpoise pods detected during the survey**

Only two pods were detected while the acoustic source was active, one pod initially observed moving toward the vessel while direction of travel could not be determined for the other pod. Pods detected while the source was not firing were most frequently observed traveling parallel in the opposite direction to the vessel or toward the vessel (Figure 26).

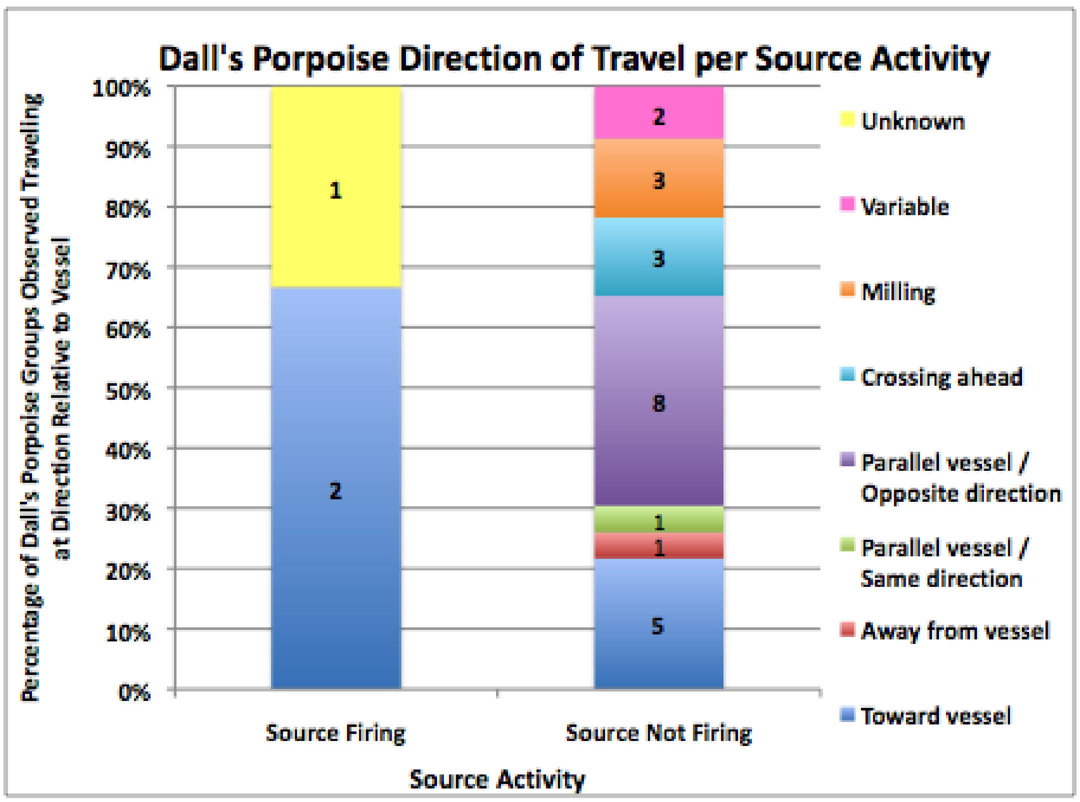

**Figure 26: Initial direction of travel relative to the vessel of Dall's porpoise detected while the acoustic source was firing and not firing**

Fin whales were also observed consistently exhibiting similar behaviors in most detection events. During every detection, the whales were observed blowing and in all detections except one the whales were observed to be swimming at a normal pace and diving. One detection event (Detection #155, 23 July) consisted of animals observed to be traveling fast. Feeding behavior was also observed on one occasion (Figure 27).

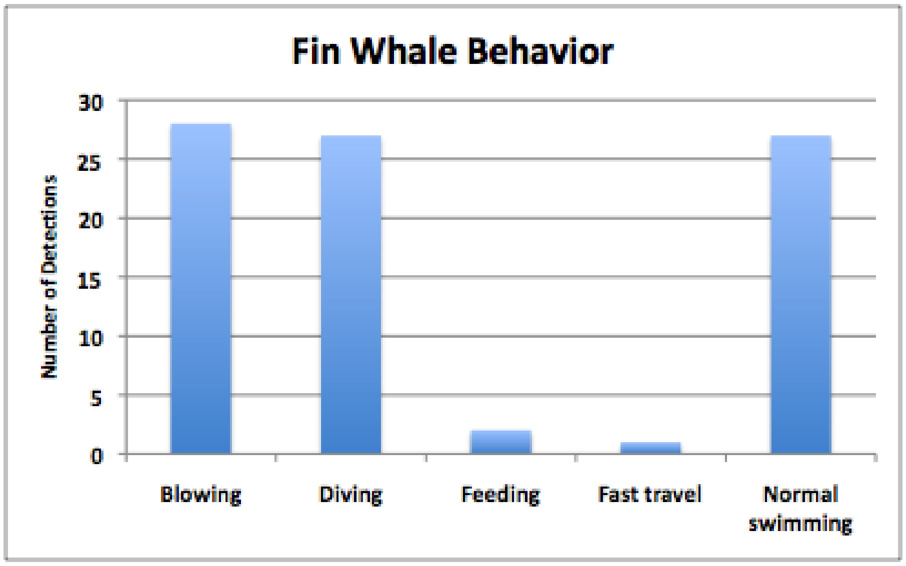


**Figure 27: Behaviors exhibited by fin whales detected during the survey**

Fin whales were most often observed to initially be traveling parallel to the vessel and in the opposite direction, regardless of source activity. While a slightly higher percentage of detections while the source was firing consisted of fin whales moving away from the vessel than those detections occurring while the source was not firing (2% as compared to 1%), no whales were observed moving toward the vessel while the source was not firing and two of 18 fin whale detections made while the source was firing consisted of whales traveling toward the vessel (Figure 28).

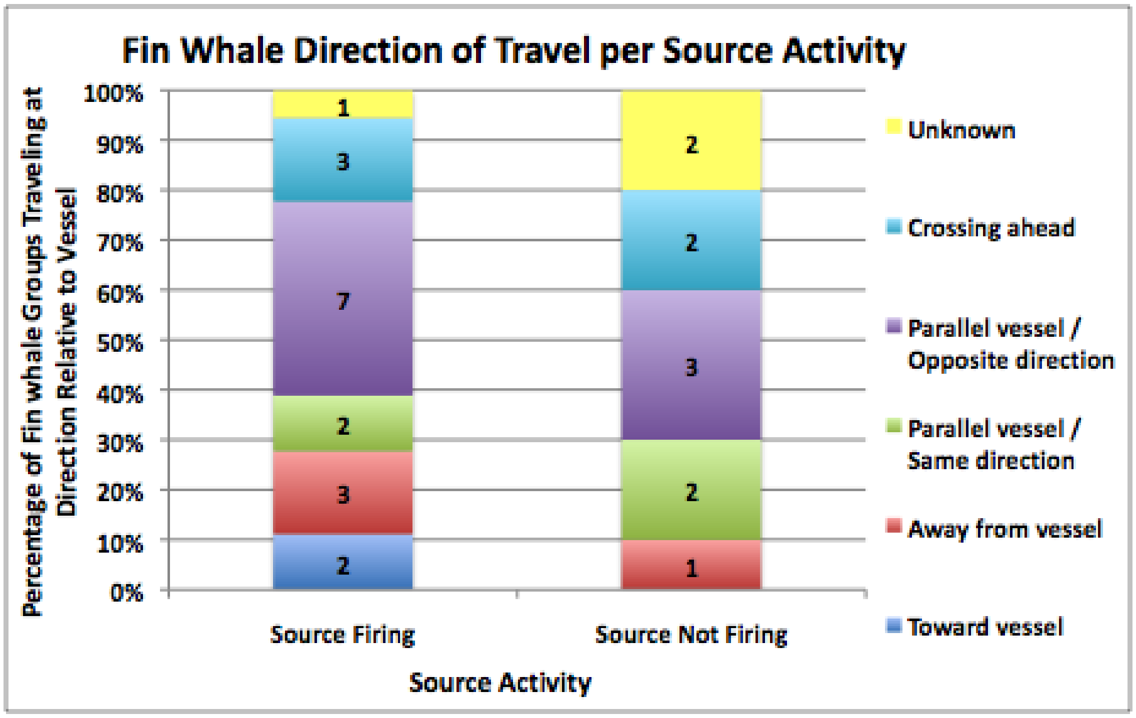


**Figure 28: Initial direction of travel relative to the vessel of fin whales detected while the acoustic source was firing and not firing**

Humpback whales showed the most diverse behaviors, with blowing and fluking (diving with flukes visible) the most commonly observed behaviors. Surface-active behaviors including breaching, tail slapping, pectoral fin slapping and displaying, lobtailing and spy-hopping, were also frequently observed (during 25 detection events). Feeding and mating behavior were also each observed (Figure 29).

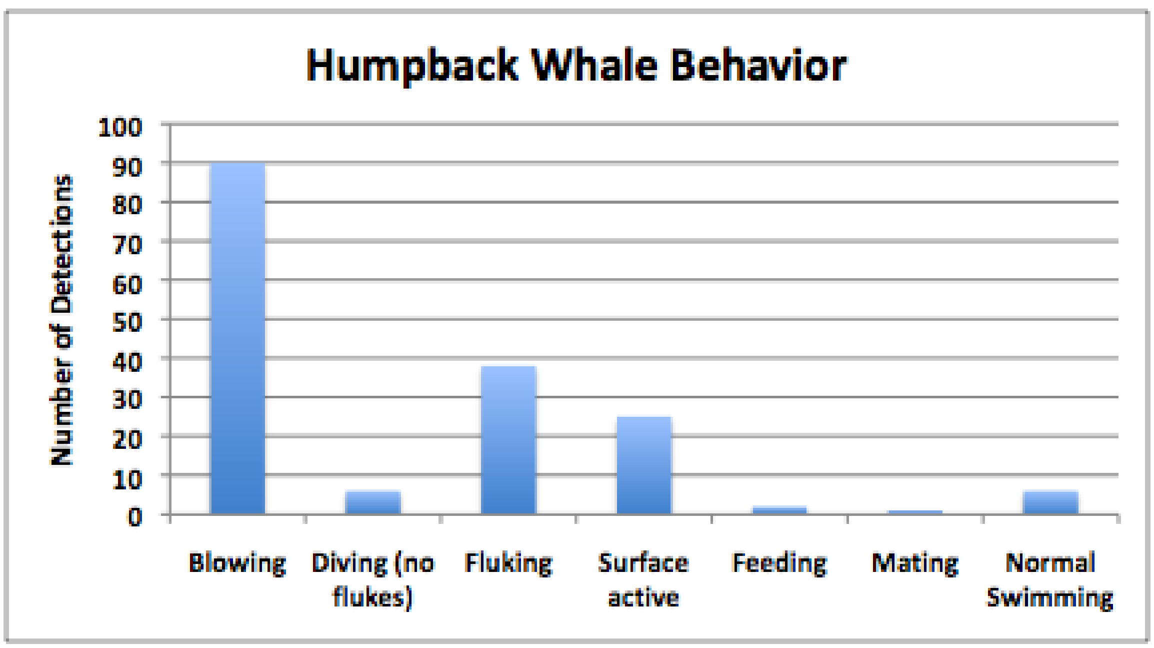


**Figure 29: Behavior exhibited by humpback whales detected during the survey**

Humpback whales were also most often observed initially traveling parallel and in the opposite direction to the vessel, regardless of source activity, although while the source was not firing this was the predominant direction of travel observed (41% of detection events). While the source was active, humpback whales were equally likely to be observed crossing ahead of the vessel as traveling parallel to it but in the opposite direction. There was very little difference in the percentage of humpback whales observed traveling toward the vessel while the source was firing (3%) and not firing (7%) or traveling away from the vessel while the source was firing (16%) and not firing (13%), but the trend favored a direction of travel that avoided the acoustic source (Figure 30).

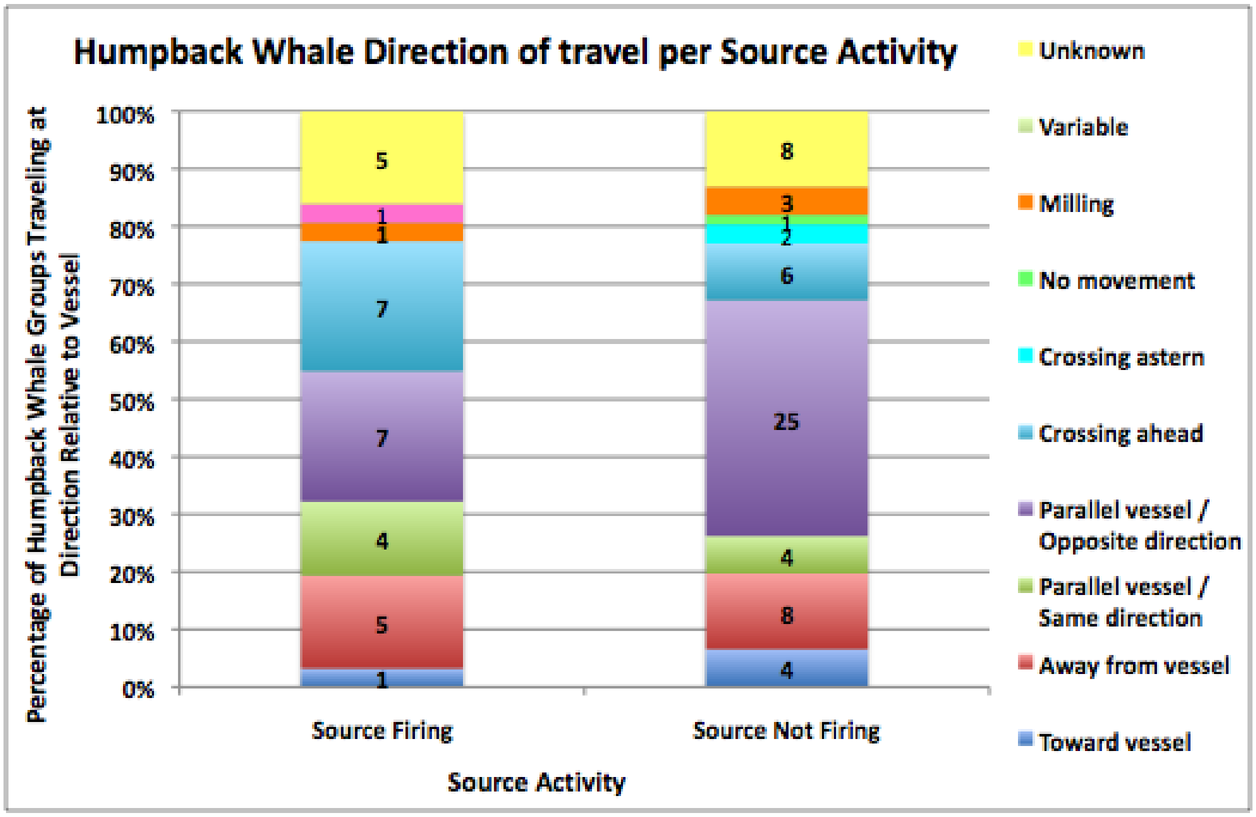


**Figure 30: Initial direction of travel relative to the vessel of humpback whales detected while the acoustic source was firing and not firing**

## 5.2. PINNIPED SIGHTINGS

Pinnipeds were observed during 14 detection events over the course of the Shillington survey project. While three different pinniped species were identified, Stellar sea lions and harbor seals were observed one time each. The detection event where each of the Stellar sea lions and harbor seals were identified consisted of several animals observed on the rocks in a haul-out. The harbor seal, a common coastal seal species in the Gulf of Alaska, were observed in Kodiak harbor as the vessel departed the port in transit to the survey site on the first day of the survey (Detection #4, 30 June). Harbor seals were not detected again during the survey project. Stellar sea lion were observed as the vessel completed a survey line and conducted a line change close to the Shumagin islands. All detections of harbor seals and stellar sea lions were on rocks of haul-out sites where the animals were not indirect contact with the water and therefore not directly exposed to airgun pulses. The distribution of pinniped detections can be seen in Figure 31.

Northern fur seal were positively identified seven times, each sighting event consisting of a single seal observed alongside the vessel while it was offshore on the survey site. Unidentified solitary pinnipeds were also observed on five occasions offshore during the survey. As some species-specific characteristics could not be observed during these sighting events, the pinnipeds were classified as unidentified.

Of the 12 detection events of solitary pinnipeds observed offshore and in the water, only two occurred while the acoustic source was active (both times firing on full volume). One of the pinnipeds sighted during acquisition was observed stationary in a patch of kelp of the surface while the other was initially sighted swimming parallel to the vessel and in the opposite direction. Of the ten pinnipeds detected while the source was not firing, the most frequently observed initial direction of travel was towards the vessel, observed during five of the ten detections events (Figure 32).


**Figure 31: Pinniped spatial distribution of detections during the Shillington survey**

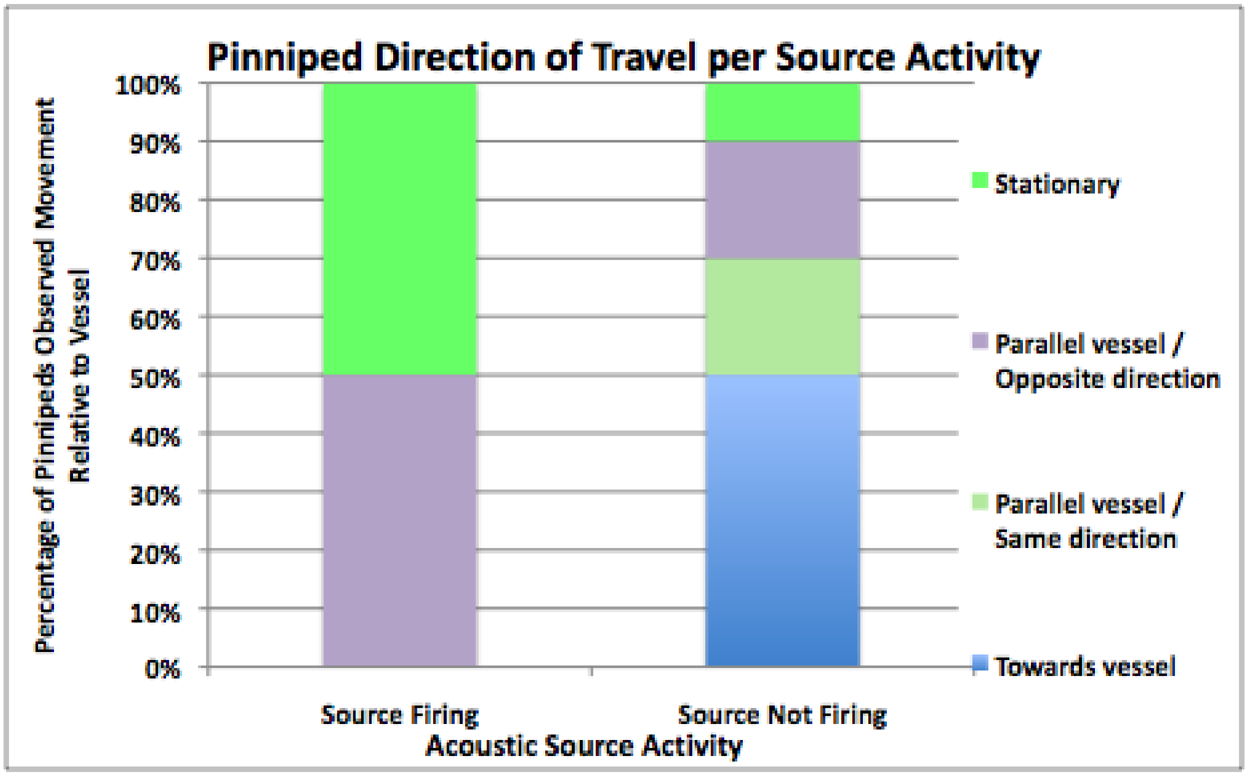


**Figure 32: Initial direction of travel in relation to vessel of pinnipeds observed while the acoustic source was firing and silent during the survey**

## 5.3. ACOUSTIC DETECTIONS

All of the detections of marine mammals during the Aleutian Island Megathrust survey were made through visual observations by the PSOs during dedicated watches. No detections were made through acoustic monitoring of the PAM system during the Shillington survey project. Several factors (masking, vocalization characteristics, species, etc.) may have contributed to the lack of acoustic detections.

## 6. MITIGATION ACTION SUMMARY

There were 50 mitigation actions implemented during 44 detection events over the course of the Shillington seismic survey, the complete list of which can be found in Table 10 on the following page. Power-downs were implemented more frequently than any other mitigation procedure, 39 times as compared to only four shut-down procedures and seven delayed ramp-ups executed throughout the survey program (Table 11). While every mitigation action implemented was accounted for individually, occasionally multiple mitigation actions were carried out over the course of one detection event, such as a power-down procedure followed by a shut-down procedure. Four detection events during the Shillington survey (Detections #64, 138, 156 and 196) resulted in the implementation of multiple mitigation actions.

**Table 11: Number and duration of mitigation actions implemented during the Shillington Aleutian marine seismic survey**

| Mitigation Action | Cetaceans | | Pinnipeds | | Total | |
|---|---|---|---|---|---|---|
| | Number | Duration | Number | Duration | Number | Duration |
| Delayed ramp-up | 07 | 07:00 | 00 | 00:00 | 07 | 07:00 |
| Power-down | 37 | 31:24 | 02 | 01:05 | 39 | 32:29 |
| Shut-down | 04 | 01:07 | 00 | 00:00 | 04 | 01:07 |
| Total | 48 | 39:31 | 02 | 01:05 | 50 | 40:36 |

In addition to being the most frequently performed mitigation action, power-downs also accounted for the largest percentage of mitigation downtime (80% of the 40 hours and 36 minutes) with cetacean power-downs making up most of that time (Figure 33).

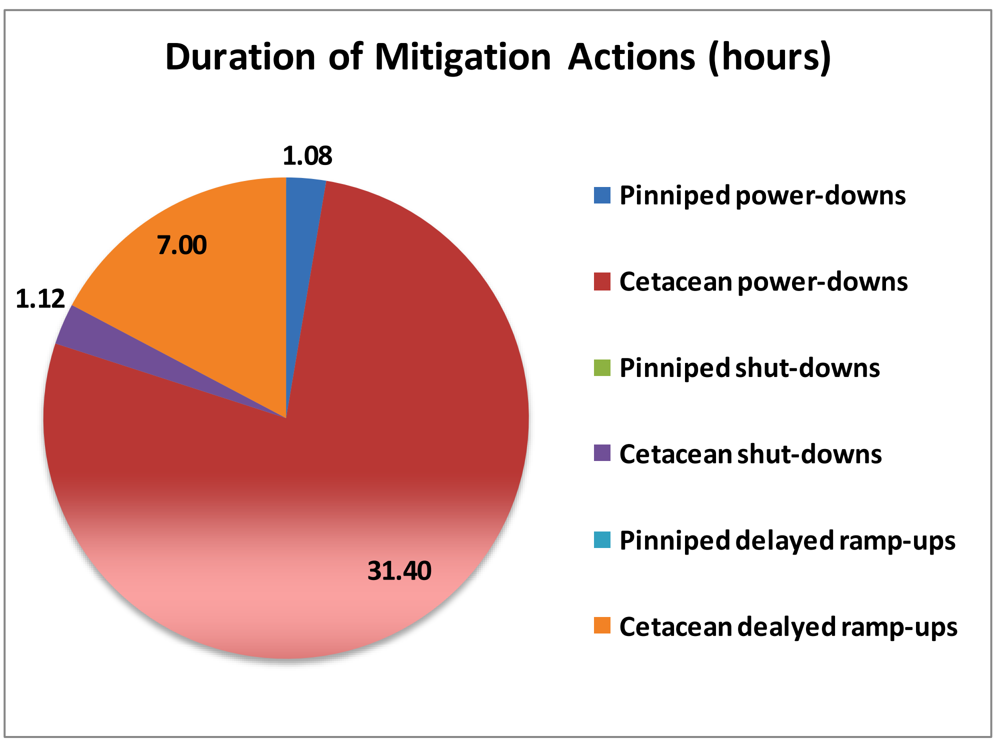


**Figure 33: Total duration of each type of mitigation action implemented for pinnipeds and cetaceans during the survey project**

Of the 40 hours and 36 minutes of mitigation down-time accumulated during the project, 12 hours and 4 minutes consisted of ramping up of the acoustic source to resume operations following the implementation of a mitigation action(s). Only seven sets of mitigation actions (including multiple mitigation actions carried out during a single detection event or back-to back mitigation actions carried out for multiple detection events) implemented during the survey project did not require a ramp-up to resume source operations. All other series of mitigation actions exceeded eight minutes in duration requiring a full ramp-up of the acoustic source be conducted to resume acquisition.

**Table 12: Summary of all mitigation actions initiated during the Shillington Aleutian seismic survey**

| Date | Det. Number | Species or common name | Group Size | Source Activity (initial detection) | Closest Approach to Firing Source / Power Level | Mitigation Action | Time Initiated | Time Completed | Duration | Ramp-up Required to resume? | Duration | Total Duration of Mitigation Event |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3-Jul | 47 | Fin whale | 3 | Full power | 845 Full power | Power-down | 15:14 | 16:06 | 0:52 | Y | 0:31 | 1:23 |
| 4-Jul | 51 | Humpback whale | 1 | Full power | 951 Full power | Power-down | 23:57 | 0:06 | 0:09 | N | N/A | 0:17 |
| | | | | | | | 0:09 | 0:17 | 0:08 | N | N/A | |
| 8-Jul | 64 | Humpback whale | 9 | Not firing | 220 40 cu in | Delayed ramp-up | 19:16 | 19:26 | 0:10 | N/A | N/A | 0:58 |
| | | | | | | Shut-down | 19:26 | 19:30 | 0:04 | N/A | N/A | |
| | | | | | | Delayed ramp-up | 19:30 | 20:14 | 0:44 | N/A | N/A | |
| 8-Jul | 65 | Humpback whale | 1 | Full power | 500 Full power | Power-down | 22:13 | 22:47 | 0:34 | Y | 0:27 | 1:01 |
| 15-Jul | 127 | Humpback whale | 1 | Not firing | N/A | Delayed ramp-up | 14:14 | 14:23 | 0:09 | N | N/A | 0:09 |
| 15-Jul | 128 | Humpback whale | 2 | Full power | 1535 Full power | Power-down | 16:58 | 17:05 | 0:07 | N | N/A | 0:07 |
| 15-Jul | 129 | Northern fur seal | 1 | Full power | 223 Full power | Power-down | 19:26 | 19:42 | 0:16 | Y | 0:11 | 0:27 |
| 15-Jul | 130 | Humpback whale | 3 | Ramp-up | 1289 40 cu in | Power-down | 19:53 | 20:29 | 0:36 | Y | 0:21 | 0:57 |
| 15-Jul | 132 | Humpback whale | 3 | Full power | 1932 Full power | Power-down | 22:45 | 22:52 | 0:07 | N | N/A | 0:07 |
| 15-Jul | 133 | Humpback whale | 1 | Full power | 1932 Full power | Power-down | 23:18 | 23:23 | 0:05 | N | N/A | 0:05 |

| Date | Det. Number | Common name | Group Size | Source Activity (Initial detection) | Closest Approach to Firing Source / Power Level | Mitigation Action | Time Initiated | Time Completed | Duration | Ramp-up Required to resume? | Duration | Total Duration of Mitigation Event |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15-Jul | 134 | Humpback whale | 4 | Full power | 500 40 cu in | Power-down | 23:48 | 0:24 | 0:36 | Y | 0:28 | 1:04 |
| 16-Jul | 135 | Humpback whale | 5 | Ramp-up | 890 Ramp-up | Power-down | 0:52 | 1:25 | 0:33 | Y | 0:03 | 0:36 |
| 16-Jul | 136 | Humpback whale | 3 | Ramp-up | 400 40 cu in | Power-down | 1:28 | 2:02 | 0:34 | Y | 0:31 | 1:05 |
| 16-Jul | 138 | Humpback whale | 11 | Full power | 250 40 cu in | Power-down | 3:06 | 3:23 | 0:17 | N | N/A | 2:50 |
| | | | | | | Shut-down | 3:23 | 3:36 | 0:13 | N | N/A | |
| | | | | | | Power-down | 3:36 | 4:57 | 1:21 | Y | 0:09 | |
| | | | | | | Power-down | 5:06 | 5:36 | 0:30 | Y | 0:20 | |
| 17-Jul | 140 | Dall's porpoise | 7 | Full power | 300 40 cu in | Power-down | 1:06 | 1:26 | 0:20 | Y | 0:20 | 0:40 |
| 17-Jul | 141 | Humpback whale | 1 | Full power | 800 Full power | Power-down | 18:10 | 18:43 | 0:33 | Y | 0:20 | 0:53 |
| 18-Jul | 142 | Fin whale | 1 | Full power | 600 40 cu in | Power-down | 1:52 | 2:31 | 0:39 | Y | 0:19 | 0:58 |
| 23-Jul | 151 | Unidentifie d baleen whale | 1 | Half power 3300 cu inch | 677 40 cu in | Power-down | 3:05 | 3:40 | 0:35 | Y | 0:19 | 0:54 |
| 23-Jul | 152 | Humpback whale | 7 | Full power | 800 Full power | Power-down | 5:34 | 6:05 | 0:31 | Y | 0:21 | 0:52 |
| 23-Jul | 155 | Fin whale | 2 | Full power | 180 40 cu in | Power-down | 15:48 | 17:24 | 1:36 | N/A | N/A | 1:36 |

| Date | Det. Number | Common name | Group Size | Source Activity (Initial detection) | Closest Approach to Firing Source / Power Level | Mitigation Action | Time Initiated | Time Completed | Duration | Ramp-up Required to resume? | Duration | Total Duration of Mitigation Event |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 23-Jul | 156 | North Pacific right whale | 1 | 40 cu inch | 400<br>40 cu in | Delayed ramp-up | 17:24 | 18:06 | 0:42 | N/A | N/A | 1:20 |
| | | | | | | Shut-down | 18:06 | 18:44 | 0:38 | N/A | N/A | |
| 23-Jul | 157 | Humpback whale | 1 | Not firing | 200<br>Not firing | Delayed ramp-up | 18:44 | 19:12 | 0:28 | Y | 0:30 | 1:56 |
| 26-Jul | 159 | Northern fur seal | 1 | Full power | 100<br>40 cu in | Power-down | 5:00 | 5:16 | 0:16 | Y | 0:22 | 0:38 |
| 26-Jul | 160 | Humpback whale | 1 | Full power | 845<br>40 cu in | Power-down | 17:23 | 18:48 | 1:25 | Y | 0:31 | 1:56 |
| 27-Jul | 162 | Fin whale | 10 | Full power | 1089<br>40 cu in | Power-down | 3:12 | 3:57 | 0:45 | Y | 0:21 | 1:06 |
| 27-Jul | 163 | Fin whale | 6 | Full power | 300<br>Full power | Power-down | 6:13 | 6:22 | 0:09 | N | N/A | 0:09 |
| 27-Jul | 164 | Dall's porpoise | 4 | Full power | 150<br>Full power | Power-down | 14:20 | 14:43 | 0:23 | Y | 0:18 | 0:41 |
| 27-Jul | 165 | Unidentified mysticete | 6 | Full power | 1755<br>Full power | Power-down | 15:50 | 16:02 | 0:12 | Y | 0:20 | 0:32 |
| 27-Jul | 171 | Fin whale | 4 | Full power | 1765<br>Full power | Power-down | 23:31 | 23:50 | 0:19 | Y | 0:23 | 0:42 |
| 28-Jul | 172 | Unidentified mysticete | 1 | Full power | 690 / Full power | Power-down | 1:24 | 1:31 | 0:07 | N | N/A | 0:07 |
| 28-Jul | 175 | Unidentified mysticete | 1 | Full power | 1400 / 40 cu in | Power-down | 23:43 | 0:15 | 0:33 | Y | 0:23 | 0:56 |
| 29-Jul | 176 | Unidentified mysticete | 4 | Full power | 1755 / Full power | Power-down | 1:44 | 2:43 | 0:59 | N | N/A | 0:59 |

| Date | Det. Number | Common name | Group Size | Source Activity (Initial detection) | Closest Approach to Firing Source / Power Level | Mitigation Action | Time Initiated | Time Completed | Duration | Ramp-up Required to resume? | Duration | Total Duration of Mitigation Event |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 29-Jul | 177 | Fin whale | 2 | 40 cu inch | 1089 / 40 cu in | Delayed ramp-up | 2:43 | 3:17 | 0:34 | N/A | N/A | 0:34 |
| 29-Jul | 178 | Humpback whale | 2 | 40 cu inch | 1274 / 40 cu in | Delayed ramp-up | 3:17 | 4:15 | 0:58 | N/A | 0:09 | 1:07 |
| 29-Jul | 179 | Humpback whale | 4 | Full power | 1085 / Full power | Power-down | 5:06 | 5:36 | 0:30 | Y | 0:26 | 0:56 |
| 30-Jul | 181 | Dall's porpoise | 4 | Full power | 300 / Full power | Power-down | 1:50 | 2:06 | 0:16 | Y | 0:15 | 0:31 |
| 30-Jul | 183 | Humpback whale | 3 | Full power | 400 / 40 cu in | Power-down | 5:48 | 6:06 | 0:18 | Y | 0:17 | 0:35 |
| 30-Jul | 184 | Humpback whale | 1 | Full power | 690 / 40 cu in | Power-down | 15:29 | 16:06 | 0:37 | Y | 0:15 | 0:52 |
| 31-Jul | 185 | Humpback whale | 1 | Full power | 220 / 40 cu in | Power-down | 2:49 | 3:15 | 0:26 | Y | 0:21 | 0:47 |
| 31-Jul | 187 | Humpback whale | 2 | Full power | 583 / 40 cu in | Power-down | 7:14 | 7:53 | 0:39 | Y | 0:31 | 1:10 |
| 31-Jul | 190 | Humpback whale | 6 | Full power | 1758 / 40 cu in | Power-down | 18:35 | 18:53 | 0:18 | Y | 0:41 | 0:59 |
| 31-Jul | 191 | Humpback whale | 1 | Full power | 1289 / Full power | Power-down | 19:49 | 20:38 | 0:49 | Y | 0:32 | 1:21 |
| 2-Aug | 196 | Humpback whale | 20 | Full power | 160 / Not Firing | Power-down | 1:13 | 2:00 | 0:47 | N | N/A | 2:37 |
| | | | | | | Shut-down | 2:00 | 2:12 | 0:12 | N | N/A | |
| | | | | | | Delayed ramp-up | 2:12 | 3:32 | 1:20 | Y | 0:18 | |
| 2-Aug | 197 | Humpback whale | 4 | Ramp-up | 951 / 40 cu in | Power-down | 3:55 | 4:30 | 0:35 | Y | 0:31 | 1:06 |

# 7. MARINE MAMMALS EXPOSED AND POTENTIALLY AFFECTED

Any marine mammal that was exposed to airgun pulses with received sound levels higher than 160dB was assumed to have been "taken" by harassment as authorized in the IHA and potentially disturbed.

## 7.1. ESTIMATES FROM DIRECT OBSERVATIONS

The number of marine mammals observed close to the *Langseth* and the acoustic source during seismic operations provides a minimum estimate of the animals actually exposed to 160dB received sound, the level at which harassment taking occurs as defined by the IHA. This number is likely an underestimate of the number of animals actually present and potentially affected for several reasons:

1) Visual observations can only be undertaken during daylight hours while seismic operations were conducted continually throughout the night. Passive acoustic monitoring can be conducted during night operations but has many limitations to detecting marine mammals.

2) The 160dB range calculated for *Langseth*'s source varied between 4,400 meters in deep water (greater than 1,000 meters) to 23-470 meters in water depths less than 100 meters. Visual range extends only to 10 kilometres under ideal visual observations conditions, leaving more than half of the disturbance radius in shallow water and nearly one third in intermediate water depths out of visual observation range under the best of circumstances. Observation effort was often hampered by environmental conditions such as fog, rain and increased Beaufort sea state that reduced visual range significantly (see section 4.2)

3) Marine mammals may leave the area before they are observed and counted by PSOs undertaking visual observations

4) Obtrusive species or animals below the surface that are not vocalising will be missed. Beaked whales are difficult to detect and three species are known to inhabit the Gulf of Alaska. Sperm whales can perform dives that exceed an hour in duration.

### 7.1.1. Cetaceans Potentially Exposed to Sounds >180dB and Pinnipeds Exposed to >190dB

During the Shillington Aleutian survey four species of cetaceans in 35 groups (detection events) totaling 97 animals were observed within the mitigation safety radius around the acoustic source while it was active (Table 13). An additional six detection events affecting at least 12 unidentified cetaceans, mostly large unidentified baleen whales were also documented inside the mitigation safety radius for the acoustic source.

These animals were all assumed to have been exposed to ≥180 dB received sound based on their horizontal distance at the surface of the water to the centre of the source. The sound levels received by these cetacean groups were likely ≥180 dB re 1 µParms for some of the airgun shots prior to the implementation of the power down or shut-down (especially during acquisition of the MCS portion of the survey where the shot interval was 50 meters equating to approximately 30 seconds) as it took time for PSOs on watch to notify the science lab that a mitigation action was required and for that mitigation action to be implemented. The assumption was made that the animal(s) was below the water surface when one or more of the airgun pulses were received while the animal was inside the safety radius.

The estimated 180dB and 190dB radii are the *maximum* distances from the airgun array where sound levels were expected to be greater than 180 and 190 dB re 1 µParms. These distances apply at the water depth and in the direction from the source where the maximum received level occurs. As these factors vary in each sighting event, it is impossible to calculate the maximum sound level to which any specific animal was exposed. Received sound levels at the water surface are considerably lower so animals that remained logging on the surface, were bow-riding, or porpoising for the duration of their presence inside the safety radius would likely not have been exposed to the maximum received sound levels.

Airgun operations continued at night as well as during daytime, but PSOs were not able to conduct visual observations during hours of darkness. During the Shillington Aleutian survey, 30% of the airgun operations occurred at night when no visual observations were being undertaken. If marine mammals were encountered at similar rates during night time operations as they were during the day, then the total number of animals exposed to 180 or 190 dB sound levels were presumably 30% higher than the numbers available from direct visual observations. In the absence of these visual observations to implement mitigation actions such as power-downs and shut-downs it can be concluded that those animals exposed at night would have been exposed for longer periods of time to these higher sound levels and potentially more animals would have been exposed in the absence of the implementation of mitigation measures.

### 7.1.2. Marine Mammals Exposed to Sounds >160dB

A total of 50 detection events for four marine mammal species including a minimum of 174 animals were observed within the 160dB safety radius for the acoustic source (Table 11). An additional 22 detection events involving 37 unidentified cetaceans were also exposed to 160dB sound from the acoustic source, most of which were identified as large baleen whales.

These numbers provide the minimum estimate of marine mammals exposed to 160dB received sound levels from the acoustic source. The same factors apply to estimating additional exposure at the 160dB level as did at the 180dB and 190dB levels. With 30% (145 hours and 04 minutes) of the airgun operations occurring at night when no visual observations were being undertaken, if marine mammals were encountered at similar rates during night time operations as they were during the day, then the total number of animals exposed to 160dB sound levels were presumably 30% higher than the numbers available from direct visual observations. Using this adjustment factor for detections missed at night during the 30% of operations undertaken without accompanying visual monitoring, an additional 14 fin whales, 32 humpback whales, five Dall's porpoise and one northern fur seal were exposed to 160dB received sound level from the source (Table 15).

**Table 13: Cetaceans exposed to >180dB sound levels and pinnipeds exposed to >190dB sound levels during Shillington Aleutian survey in shallow, intermediate and deep water**

| Species | Number of Groups and Animals Exposed to 180dB (Cetaceans) / 190dB (Pinnipeds) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Total | | Shallow | | Intermediate | | Deep | |
| **Mysticetes** | **Detections** | **Animals** | **Detections** | **Animals** | **Detections** | **Animals** | **Detections** | **Animals** |
| North Pacific right whale | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Gray whale | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Humpback whale | 24 | 65 | 16 | 35 | 3 | 17 | 5 | 13 |
| Minke whale | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sei whale | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Fin whale | 6 | 14 | 1 | 1 | 3 | 10 | 2 | 3 |
| Blue whale | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Odontocetes** | | | | | | | | |
| Sperm whale | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cuvier's beaked whale | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Baird's beaked whale | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Stejneger's beaked whale | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Beluga whale | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Pacific white-sided dolphins | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Risso's dolphins | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Killer whale | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Short-finned pilot whale | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Harbor porpoise | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Dall's porpoise | 3 | 16 | 0 | 0 | 1 | 4 | 2 | 12 |
| **Pinnipeds** | | | | | | | | |
| N. fur seal | 2 | 2 | 1 | 1 | 1 | 1 | 0 | 0 |
| N. elephant seal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Harbor seal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| California sea lion | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Stellar sea lion | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **All species** | **35** | **97** | **18** | **36** | **8** | **32** | **9** | **28** |

**Table 14: Level B Harassment Takes authorized by the NMFS IHA for the Shillington Aleutian survey and number of animal groups and individual animals observed inside the 160dB safety radii**

| Species | IHA Authorized Takes | Number of Groups Observed Inside Radii | Number of Animals Observed Inside Radii |
|---|---|---|---|
| **Mysticetes** | | | |
| North Pacific right whale | 1 | 0 | 0 |
| Gray whale | 6 | 0 | 0 |
| Humpback whale | 1824 | 30 | 108 |
| Minke whale | 60 | 0 | 0 |
| Sei whale | 1 | 0 | 0 |
| Fin whale | 598 | 15 | 48 |
| Blue whale | 1 | 0 | 0 |
| **Odontocetes** | | | |
| Sperm whale | 5 | 0 | 0 |
| Cuvier's beaked whale | 12 | 0 | 0 |
| Baird's beaked whale | 4 | 0 | 0 |
| Stejneger's beaked whale | 15 | 0 | 0 |
| Beluga whale | 0 | 0 | 0 |
| Pacific white-sided dolphins | 127 | 0 | 0 |
| Risso's dolphins | 33 | 0 | 0 |
| Killer whale | 415 | 0 | 0 |
| Short-finned pilot whale | 50 | 0 | 0 |
| Harbor porpoise | 180 | 0 | 0 |
| Dall's porpoise | 1167 | 3 | 16 |
| **Pinnipeds** | | | |
| Northern fur seal | 54[1] | 2 | 2 |
| Northern elephant seal | 0 | 0 | 0 |
| Harbour seal | 218 | 0 | 0 |
| California sea lion | 0 | 0 | 0 |
| Stellar sea lion | 270 | 0 | 0 |
| **All species** | **N/A** | **50** | **174** |

*In the initial IHA approved by NMFS on 24 July granted no takes for northern fur seals. An amended IHA (amended on 28 July 2011) was received and 54 northern fur seal takes were granted.

Additional factors also apply to detecting protected species within the 160dB radius that were not applicable to the smaller mitigation radii of 180dB and 190dB received sound levels. Under the best observation conditions visibility extended to eight to ten kilometres. The 160dB safety radius extended to 13,395 kilometers in intermediate water depths and to 23,470 kilometers in shallow water such that even under ideal visual monitoring conditions, the entire level B harassment radius around the acoustic source was not visible. The deep water radius extended to 4,400 kilometers and was visible for the majority of monitoring effort undertaken.

Assuming that visibility extended to eight kilometres, in shallow water only 34% of the 160dB radius was visible while in intermediate 60% of the radius was visible. If marine mammals were distributed at similar densities to those detected by PSOs, then detection rates in shallow water could be assumed to be 66% higher than actually recorded while detection rates in intermediate water would be 40% higher. Using these estimated correction factors (66% more detections in shallow water and 40% more detection in intermediate water of each species detected in those water depths) for animals outside the range of visibility but inside the shallow water and intermediate water 160dB safety radii, an additional 24 fin whale, 143 humpback whales, 44 Dall's porpoise and two northern fur seal were potentially exposed to level B harassment from the acoustic source (Table 15).

Even accounting for animals not detected at night or outside the range of visibility but inside the safety radius, the Shillington survey exposed a relatively low number of take-authorized species to 160dB sound from the source. None of the take limits for level B harassment were exceeded for any species either in observed numbers of exposed animals or in estimated number of exposed animals (Table 15).

**Table 15: Estimated 160dB harassment takes adjusted for animals not visible during night time operations and in shallow and intermediate water depths where the radius extends beyond visibility**

| Species | Known 160dB exposures | Additional estimated takes adjusted for night time exposure | Additional estimated takes adjusted for parts of source radius not visible | Total potential exposed animals | % Estimated Takes relative to IHA authorized takes |
|---|---|---|---|---|---|
| Fin whale | 48 | 14 | 24 | 86 | 14% |
| Humpback whale | 108 | 32 | 143 | 283 | 16% |
| Dall's porpoise | 16 | 5 | 44 | 65 | 6% |
| Northern fur seal | 2 | 1 | 2 | 5 | 9% |

## 7.2. BEHAVIOUR EXHIBITED BY ANIMALS EXPOSED OR POTENTIALLY EXPOSED

It is difficult to analyze the behavioural effects, if any, exhibited by marine mammals exposed to an estimated sound level at which harassment is expected to potentially occur. First, as received sound levels are variable and dependant on many factors, it is impossible to determine, in a survey environment, which animals were exposed and for how long in any given detection event. Then, with animals exposed, a determination must be made as to which behaviors are being exhibited as a result of exposure to received sound level and then which of those behaviors could be considered an adverse reaction. Due to the large safety radii for 160dB sound level in intermediate and shallow water, all behavior exhibited by any of the marine mammals initially detected while the acoustic source was active was behavior exhibited by an animal already exposed to level B harassment and there is no baseline behavior available for those animals with which to compare.

### 7.2.1. Fin whales

Of the 15 detection events of fin whale pods observed within the 160dB safety radius of the acoustic source while it was active, none were observed to change their initial behavior throughout the duration of the sighting event in a manner that suggested avoidance of the source. In each detection event, the whales were initially observed blowing at the surface and this behavior continued throughout the detection, with no perceptible change in the pattern of the frequency or number of blows expelled by the animals.

During on detection event (Detection #155, 23 July), a pair of fin whales that were initially observed blowing also began to lunge feed in the vicinity of the vessel after a mitigation power-down of the acoustic source had been initiated. This detection event took place in deep water where the 160dB safety radius extended 4400 kilometres from the centre of the source but at the time of the detection visibility was impeded by fog such that it is possible that the pair of whales were engaged in feeding behavior prior to exposure to the source but were not visible to PSOs at that range. If the feeding behavior was interrupted by acoustic exposure then the interruption was brief as the whales were observed to continue feeding after the power-down was initiated. It is also possible that the change in behavior observed had no bearing on the presence of the vessel or the acoustic source.

Six of the 15 pods of fin whales potentially exposed to 160dB received sound were not observed to change their direction of travel relative to the vessel over the course of the detection event. Two pods were observed to travel away from the vessel although only one pod was observed to change direction to move away (Detection #142, 18 July), the other pod having been initially observed travelling on a course away from the vessel. One pod changed course to approach the vessel (Detection 162, 27 July) while several other pods exhibited movement difficult to interpret: changing direction temporarily before resuming their original heading or changing their direction of travel but not onto a heading that would take them directly away from the vessel. These movement changes could be related to the vessel or the acoustic source activity or could be entirely unrelated movements involving feeding or social or migratory behavior (Figure 34).

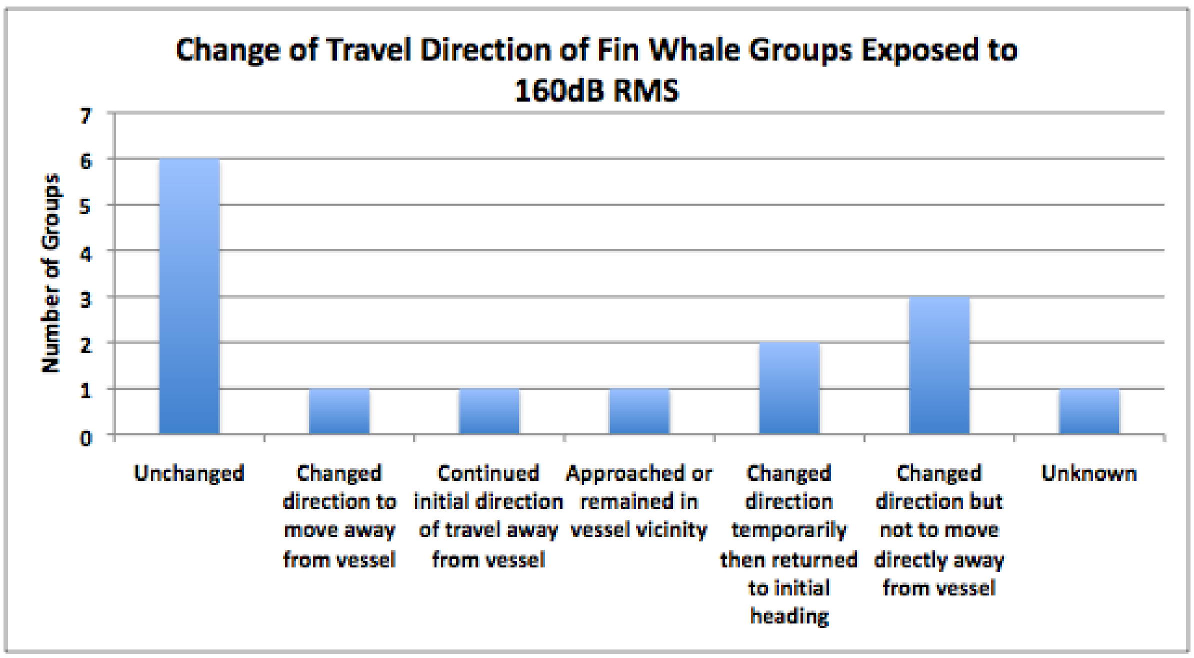


**Figure 34: Change in direction of travel relative to vessel from initial heading of fin whale pods potentially exposed to 160dB sound from the acoustic source**

### 7.2.2. Humpback whales

Humpback whales exhibited the greatest range of behaviors during detection events throughout the Shillington survey regardless of source activity and exposure to 160dB sound level. The most common behavioural change noted throughout detection events where whales were exposed to 160dB received sound was the initiation of diving cycles with or without fluking where initially only blowing or occasionally surface-active behaviors had been recorded (Figure 35). This behavior change is not necessarily a reaction to the vessel but more likely a continuation of natural diving behavior that was only detected by PSOs after the initial blows were sighted, being more visible from a distance. Many pods were not observed to undergo any changes in behavior throughout the entire detection event (eight pods of the 30 pods exposed). Other animals were observed either to initiate surface-active behavior like breaching or tail slapping or to cease those behaviors which they were initially sighted performing however because there is little understanding as to why these behaviors are performed, it is impossible to determine whether these changes are indicative of a reaction to the vessel's presence or the activity of the acoustic source.

The direction of travel relative to the vessel of pods of humpbacks exposed to 160dB did not appear to change in a manner suggesting avoidance behavior. Most frequently pods were not observed to change their direction of travel at all (11 of the 30 pods exposed). Only one pod was observed to change direction from the initial heading to move away from the vessel and this change in direction of travel did not occur until the whale had dropped astern of the vessel after the vessel overtook it, first travelling parallel in the same direction and coming alongside and past the animal. Had the animal been exhibiting an overt avoidance behavior related to the vessel or source activity, it is likely that the change in direction of travel would have occurred before the animal had already been overtaken (Figure 36).

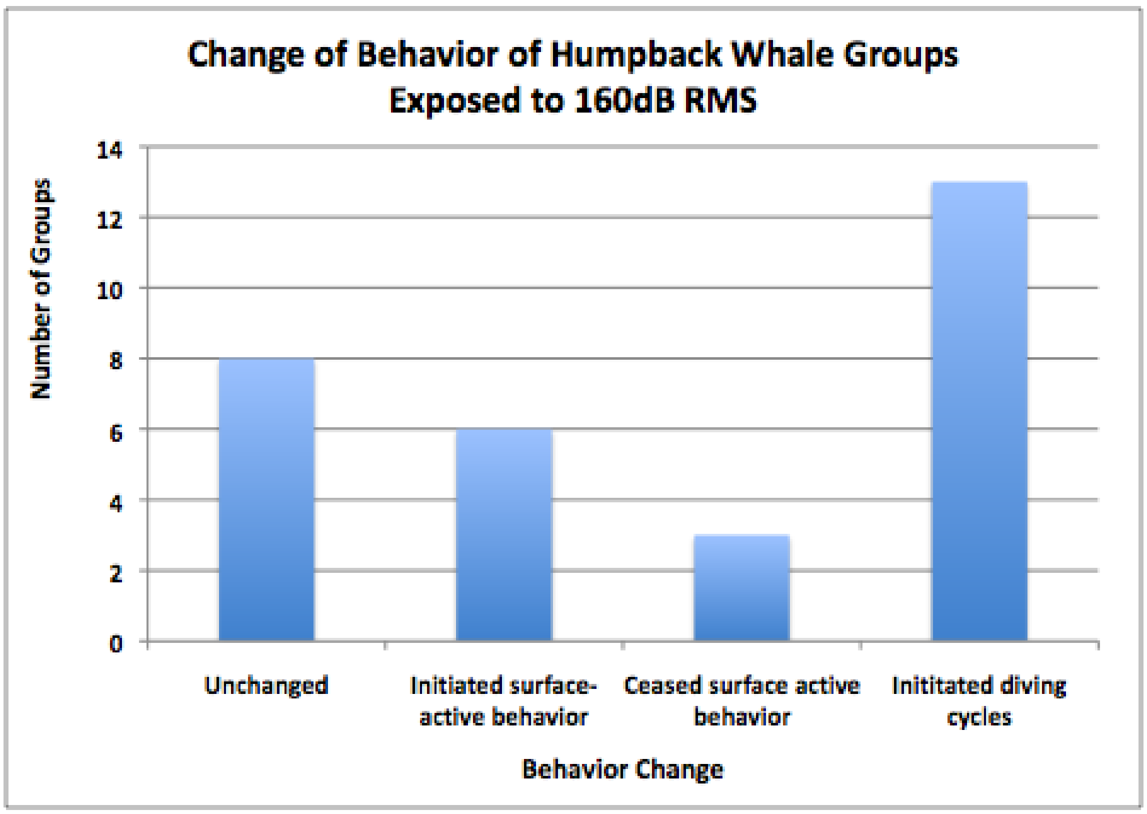


**Figure 35: Change in behavior of humpback whale pods potentially exposed to 160dB sound from the acoustic source**

Many humpback whale pods also exhibited movement difficult to interpret: changing direction temporarily before resuming their original heading or changing their direction of travel but not onto a heading that would take them directly away from the vessel. As previously stated, these movement changes could be related to the vessel or the acoustic source activity or could be entirely unrelated movements involving feeding or social or migratory behavior.

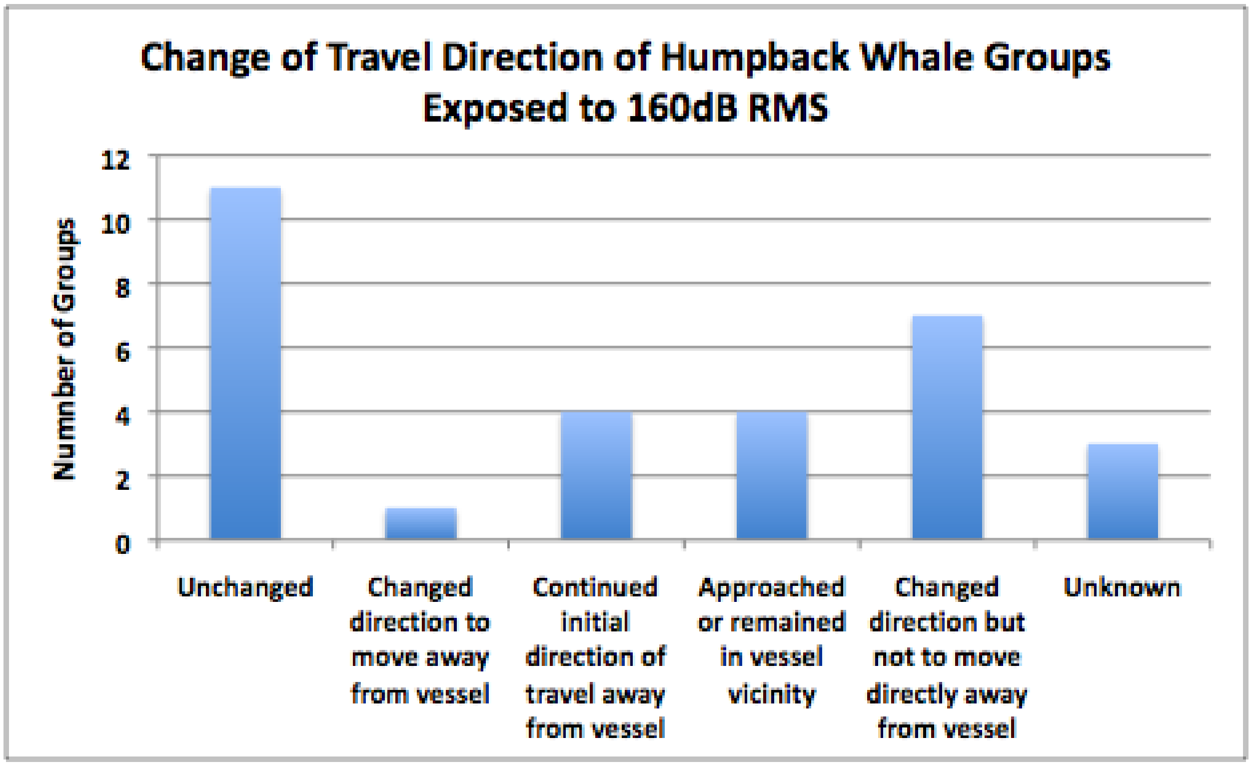


**Figure 36: Change in direction of travel relative to vessel from initial heading of humpback whale pods potentially exposed to 160dB sound from the acoustic source**

#### 7.2.3. Dall's porpoise

Three detection events involving Dall's porpoise exposed to 160dB from the acoustic source took place during the survey. None of these detection events differed from the 23 detections taking place while the acoustic source was silent in that no differences in behavior, direction of travel or duration of the detection event were observed. In each of the three detection events where exposure to 160dB sound occurred, the animals were observed porpoising or fast swimming, the same behavior noted in all but one detection event (Figure 27). In each of the three detection events the pod approached the vessel, which suggests that the acoustic source activity was not inducing avoidance behavior. While the pods all departed within a few minutes, porpoise detections were typically very short, regardless of the source activity. Dall's porpoise are frequently documented as curious animals that will approach vessels but depart again if the vessel speed is not sufficient to create a large bow wave for bow-riding (Shirihai et al, 2006).

#### 7.2.4. Northern fur seal

Only two solitary northern fur seal were observed within the 160dB range for the acoustic source while it was active. In each detection event the animal was well within the safety radii at the point of initial detection so it is impossible to determine whether the animal's behavior changed upon exposure to an estimated 160dB received sound. However, when the behavior of the two seal assumed exposed is compared to behavior observed during the ten detection events of pinnipeds observed while the source was silent, no differences are apparent.

One of the two seals (Detection #129, 16 July) exposed to 160dB was initially observed porpoising alongside the vessel, travelling parallel and in the opposite direction, moving astern and toward the acoustic source while it was still firing, and at which point the mitigation power-down was implemented. This direction of travel was frequently observed (in seven out of ten detections) during pinniped sightings occurring while the source was silent (toward the vessel, or alongside, parallel in the opposite direction after having approached the vessel) (Figure 32) and as the behavior was also exhibited by the seal detected while the source was active, the acoustic source did not appear to induce any avoidance behavior.

The second detection event (Detection #159, 26 July) where a northern fur seal was exposed to 160dB involved an animal initially observed drifting in surface algae as the vessel approached then diving as it came alongside the active acoustic source. While this behavior could be interpreted as avoidance behavior, it is impossible to determine whether the avoidance was of the vessel itself or the acoustic source or a combination of the two. Only one other detection event (Detection 3200, 5 Aug) of a northern fur seal involved an animal initially detected resting and on this occasion the animal also eventually dove as the vessel approached alongside it although in this case the acoustic source was not firing.

# 8. CONCLUSIONS AND RECOMMENDATIONS

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

In order to minimize the incidental 'taking' of marine mammals by harassment, L-DEO implemented the mitigation measures outlined in Section 6.0 of this report for marine mammals and sea turtles sighted near or within the safety radius. Ramp-ups were performed as described in the IHA prior to all seismic operations. Delays to ramp-up, power-downs and shut-downs were implemented as described each time a marine mammal was detected within the applicable safety radius and operations were resumed in the manner specified by the IHA. There were no instances during the acquisition of the Shillington Aleutian program that necessary mitigation measures were not applied or not applied as dictated by the IHA.

In addition to the monitoring and typical mitigation measures such as ramp ups, power downs, and shut downs, the IHA also specified some survey specific mitigation measures:

1) The vessel was to avoid, if possible, concentrations of humpback whales, fin whales and killer whales, if possible, and the array powered down if necessary. A concentration was defined as more than three animals that did not appear to be traveling (e.g feeding or socializing)
2) The source was to be shut down of in the event that a North Pacific right whale, sei whale, blue whale or beluga whale was sighted at any distance from the acoustic source and seismic operations were not to resume until 30 minutes following the last sighting of the animal
3) Operations in Chignik Bay were to be conducted from nearshore to offshore
4) Subsistence fishing activities were to be avoided.

No blue whales or beluga whales were observed during the survey. Two sei whales were observed on 15 July while the vessel was deploying the recording streamers and prior to deployment of the gun strings so that the entire sighting event occurred during a period of non-seismic activity. On 23 July a single North Pacific right whale was observed while the vessel was undertaking acquisition of a survey line but the source was in a state of mitigation power-down with only the single 40 cubic inch airgun operating due to the presence of a pair of fin whales inside the safety radius for the full array at the time of the initial sighting of the right whale. The animal was initially sighted at 17:23 UTC but was not positively identified as a North Pacific right whale until 18:06 UTC at which time the source was shut completely off. The final sighting of the right whale occurred at 18:10 UTC and the source remained off for more than 30 minutes, as required by the IHA, with the single mitigation gun enabled at 18:44 UTC.

Langseth entered Chignik Bay on two occasions during acquisition of the Shillington survey. During the OBS phase of the survey, the vessel positioned OBSs along the seafloor then transited into the Bay as close to shore as the vessel was to approach and began a turn to come around to head offshore online, beginning a ramp-up of the acoustic source at the height of the turn. Acquisition online occurred from nearshore to offshore. During the MCS portion of the survey the vessel approached Chignik Bay online but aborted and began a turn prior to entry into the bay.

No subsistence fishing activities were encountered during the survey program.

# 9. ACKNOWLEDGEMENTS

The RPS Energy Protected Species Observer team on board *Langseth* during the Shillington Aleutian two-dimensional marine seismic program would like to thank the National Science Foundation and Lamont-Doherty Earth Observatory for the opportunity to provide protected species mitigation and monitoring services for this survey project. It was a pleasure to work with Donna Shillington, Chief Scientist, in addition to the rest of her science team. We would especially like to thank Olivia Lee, National Science Foundation, and Meagan Cummings, Marine Environmental Safety Coordinator for L-DEO for their work as Protected Species Observers during the survey. We would also like to thank the marine crew and science technical staff on board the *Marcus Langseth* for their assistance and hospitality.

# 10. LITERATURE CITED

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## **APPENDIX A:** Incidental Harassment Authorization for USGS GOA ECS Marine Seismic Survey

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## <u>APPENDIX B:</u> Basic Summary Data Form

| | | |
|---|---|---|
| **L-DEO Project Number** | | MGL1110 |
| **Seismic Contractor** | | Lamont-Doherty Earth Observatory of Columbia University |
| **Vessel Owner** | | National Science Foundation |
| **Client** | | Donna Shillington |
| **Area Surveyed During Reporting Period** | | Aleutian Islands, Gulf of Alaska |
| **Survey Type** | | 2D marine surface seismic and ocean bottom seismometer |
| **Vessel Name** | | R/V *Marcus G. Langseth* |
| **Permit Number** | | IHA granted by NMFS on 24 June 2011 (Appendix A) |
| **Location / Distance of Acoustic Source Deployment** | | 232.1m from the Navigational Reference Point |
| **Water Depth** | **Min** | 25 meters |
| | **Max** | 6000 meters |
| **Dates of project** | | 27 June 2011 through 05 August 2011 |
| **Total duration of source operations:** | | 521:09 |
| **Duration of full power source operations in acquisition:** | | 436:47 |
| **Duration of full/partial source operations on line change:** | | 24:29 |
| **Duration of mitigation gun operations (1 gun 40cu$^3$):** | | 38:05 |
| **Duration of gun testing:** | | 8:05 |
| **Duration of source ramp-up operations:** | | 13:43 |
| **Total number of ramp-ups (day and night):** | | 39 |
| **Number daytime ramp-ups from silence:** | | 2 |
| **Number daytime ramp-ups from mitigation source:** | | 35 |
| **Number of nighttime ramp-ups (from mitigation source):** | | 2 |
| **Duration of visual observations:** | | 635:07 |
| **Duration of visual observations with source active:** | | 402:50 |
| **Duration of visual observations with source silent:** | | 232;17 |
| **Duration of acoustic monitoring:** | | 417:40 |
| **Duration of acoustic monitoring with source active:** | | 415:51 |
| **Duration of acoustic monitoring with source silent:** | | 01:49 |
| **Lead Protected Species Observer:** | | Stephanie Milne |
| **Additional PSOs:** | | Meagan Cummings (L-DEO representative) |
| | | Kendra Davis |
| | | Christine Voigtlander |
| | | Olivia Lee (National Science Foundation representative, on board until 12 July) |
| **Passive Acoustic Monitoring Operator:** | | Meghan Wood |
| **Number of marine mammals visually detected:** | | 201 |
| **Number of marine mammals acoustically detected:** | | 00 |
| **Number of acoustic detections correlated with visual sighting:** | | 00 |
| **Number of sea turtles detected:** | | 00 |
| **Number of mitigation actions undertaken:** | | 50 |
| **Duration of mitigation actions:** | | 40:36 |

# APPENDIX C: Passive Acoustic Monitoring System Specifications

Main cable and spare cable:

**Mechanical Information**
Length 250m
Diameter 14mm over cable 32mm over mouldings 64mm over connectors
Weight 60kg
Connector CEEP 39 pin

**Hydrophone elements**

| | | | |
|---|---|---|---|
| Hydrophone 1 | Sphere 1 Broad band | 2 kHz to 200kHz | (3dB points) |
| Hydrophone 2 | Sphere 2 Broad band | 2 kHz to 200 kHz | (3dB points) |
| Hydrophone 3 | Sphere 3 Broad band | 2 kHz to 200 kHz | (3dB points) |
| Hydrophone 4 | Sphere 4 Low frequency | 75Hz to 30 kHz | (3dB points) |

**Depth Capability** 100m

| | | |
|---|---|---|
| Spacing between elements 1 & 2 (for HF detection) | 0.25m | 0.16mSecs |
| Spacing between elements 2 & 3 (for HF detection) | 1.2m | 0.8mSecs |
| Spacing between elements 3 & 4 (for LF detection) | 1.2m | 0.8mSecs |

#### 10.1.1.1. Interface unit Array 1 outputs

Broad band channel sensitivity -166dB re 1V/uPa
Low frequency channel sensitivity -157dB re 1V/uPa

**Deck cable specification**
Length 100m
Diameter 14mm
Connectors 39 pin ITT female
Flying lead for onboard connection
Connector Diameter 64mm

**Inboard Deck Cable**
**Deck cable specification**
Length 1m
Diameter 14mm
Connectors 39 pin ITT male
Flying lead for onboard connection
Connector Diameter 64mm

## APPENDIX D: Typical Pamguard Screenshots

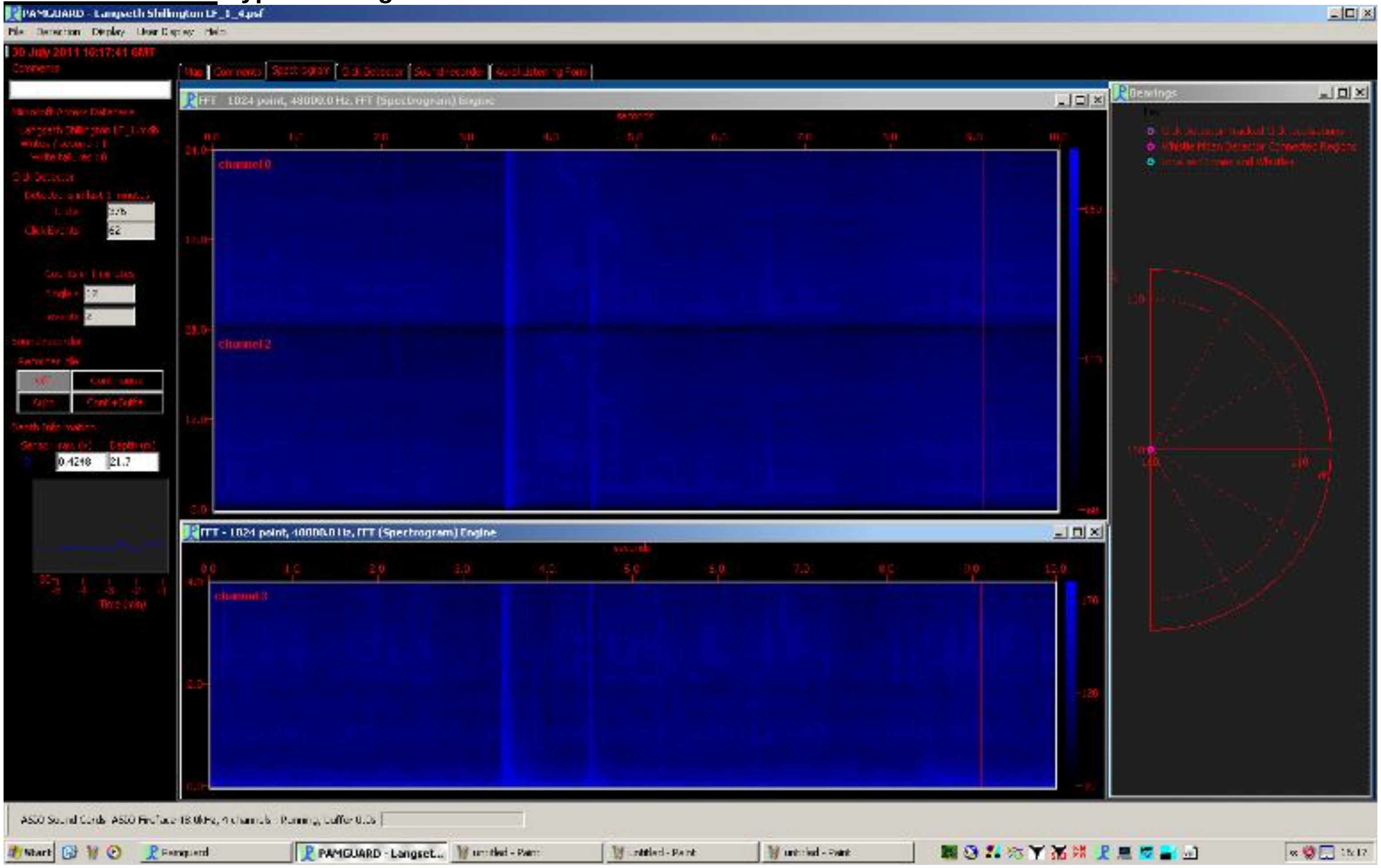


Figure 37 Main Pamguard low frequency operation screen displaying scrolling Spectrograms from three hydrophone channels and the Whistle and Moan Bearing Radar which plots the bearing of detected whistles and moans in relation to the hydrophones

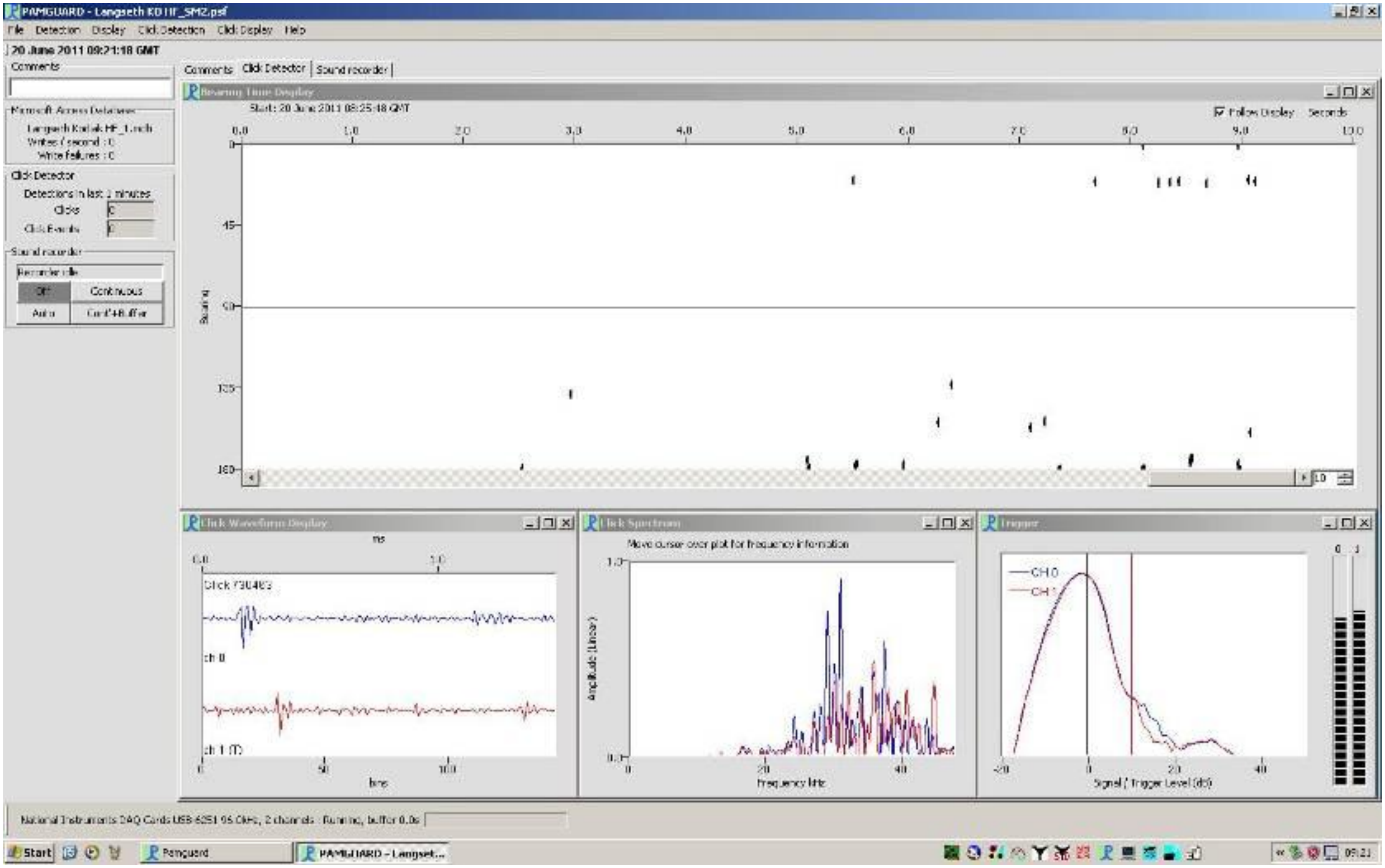


**Figure 38 Click Detector module used on both high frequency and low frequency Pamguard laptops to track echolocation clicks**

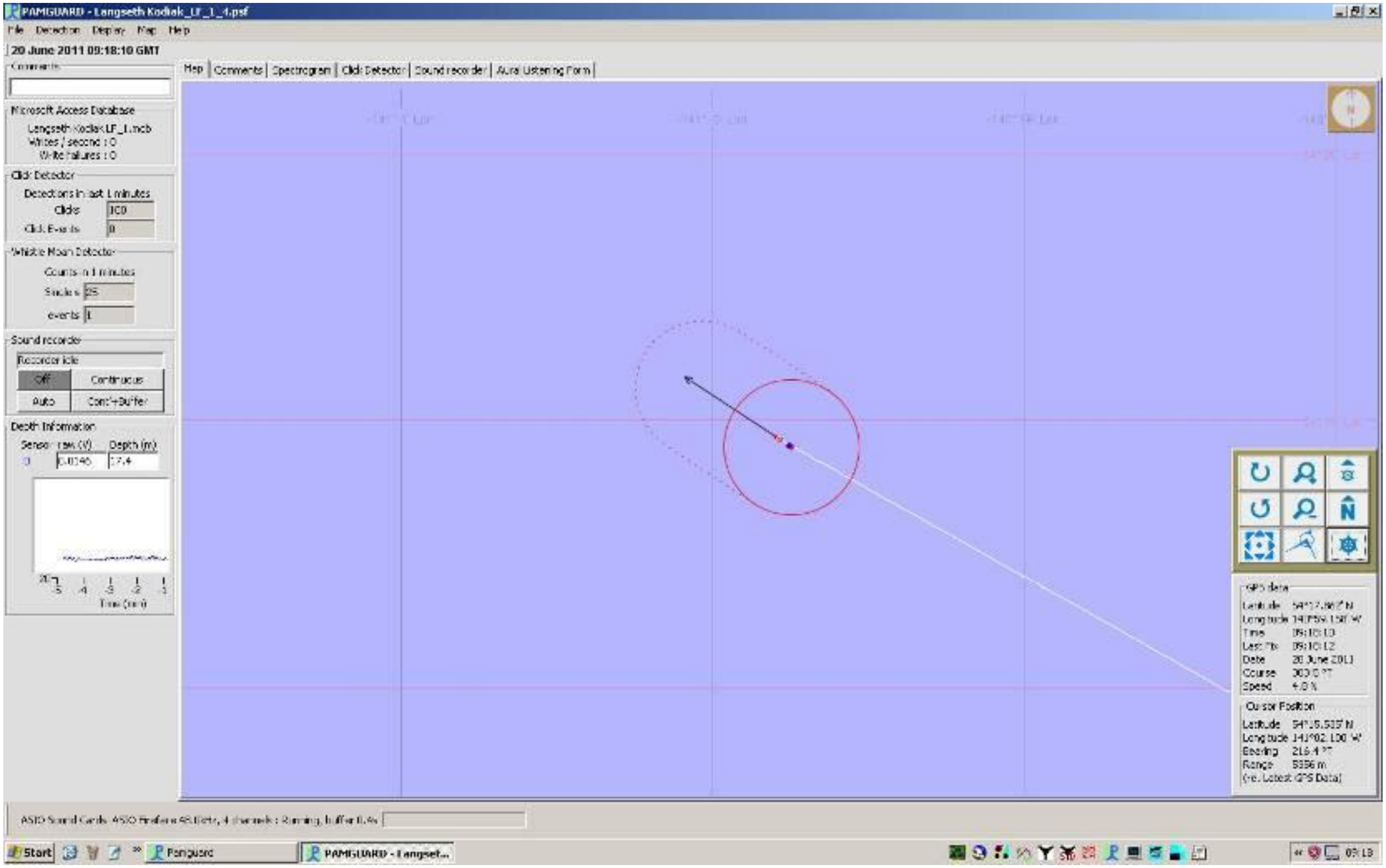


**Figure 39 Map module on the low frequency Pamguard laptop where tracked marine mammal vocalisations can be plotted and range can be calculated**

# **APPENDIX E:** PAM Hydrophone Deployment on *R/V Marcus Langseth*

## Overview

The research vessel *Langseth* is equipped with a towed PAM array system comprised of a low frequency laptop, a high frequency laptop, a data processing unit, a 100m deck cable, and a 250m linear hydrophone cable with 4 hydrophones and a depth gauge at the last 5m of the cable (Figure 6). The system is capable of detected a broad range of marine mammal vocalizations due to three of the hydrophone elements having a broadband frequency range of 2 to 200kHz while the fourth hydrophone has a shorter frequency range of 75 to 30kHz for lower frequency detections and all four hydrophones having preamplifiers.

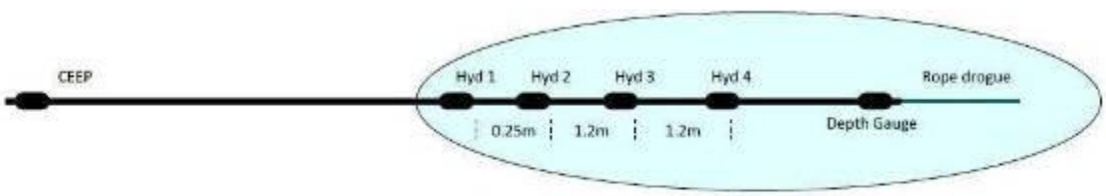


**Figure 42 Diagram of Linear Hydrophone Array**

The two laptops and data processing unit are set up in the main lab with a GPS cable feed (INGGA string) directly from the ship's navigation system to the low frequency laptop (Figure 7). The data processing unit connects to the 250m hydrophone cable through a 100m deck cable that is run from the main lab out to the gun deck. The 250m hydrophone cable is wound on a section of a deckhead winch on the port side of the gun deck (Figure 8). From the winch the hydrophone cable is fed astern and pulled further port by a line secured by a yale grip to the port sponson. (Figure 9). An 8m rope drogue was secured to the end of the hydrophone cable with zip ties with a 1kg shackle secured to the end of the rope drogue with a knot and tape (Figure 10). Second three lengths of chain weighing approximately 2.5kg in each were secured on the cable with tape, 3m, 45m, and 96m up from the depth gauge (Figure 11). The hydrophone is deployed approximately 150m from the stern and 50m before the center of string (Figure 12). Being that the hydrophone cable is free and independent of the guns the cable is always retrieved before port gun strings are moved.

**Figure 43 PAM Laptops and data processing unit setup**

**Figure 44 Hydrophone cable on winch**

**Figure 45 Hydrophone cable secured by a yale grip to the port sponson**

**Figure 46 Rope drogue and first chain weight secured near hyrdophone elements.**

**Figure 47 One of the three lengths of chain used to weigh down the cable.**

# APPENDIX F: Environmental Conditions

**Table 16: Beaufort sea scale**

| *Beaufort* Number | Wind Speed (knots) | Wind Description | Specification for Use |
|---|---|---|---|
| 0 | Less than 1 | Calm | Sea like a mirror |
| 1 | 1 to 3 | Light air | Ripple with the appearance of scales are formed, but without foam crests. |
| 2 | 4 to 6 | Light breeze | Small wavelets, still short, but more pronounced. Crests have a glassy appearance and do not break. |
| 3 | 7 to 10 | Gentle breeze | Large wavelets. Crests begin to break. Foam of glassy appearance. Perhaps scattered white horses. |
| 4 | 11 to 16 | Moderate breeze | Small waves, becoming larger; fairly frequent white horses. |
| 5 | 17 to 21 | Fresh breeze | Moderate waves, taking a more pronounced long form; many white horses are formed. Chance of some spray. |
| 6 | 22 to 27 | Strong breeze | Large waves begin to form; the white foam crests are more extensive everywhere. Probably some spray. |
| 7 | 28 to 33 | Near gale | Sea heaps up and white foam from breaking waves begins to be blown in streaks along the direction of the wind. |
| 8 | 34 to 40 | Gale | Moderately high waves of greater length; edges of crests begin to break into spindrift. The foam is blown in well-marked streaks along the direction of the wind. |
| 9 | 41 to 47 | Strong gale | High waves. Dense streaks of foam along the direction of the wind. Crests of waves begin to topple, tumble and roll over. Spray may affect visibility. |
| 10 | 48 to 55 | Storm | Very high waves with long overhanging crests. The resulting foam, in great patches, is blown in dense white streaks along the direction of the wind. On the whole the surface of the sea takes on a white appearance. The 'tumbling' of the sea becomes heavy and shock-like. Visibility affected. |
| 11 | 56 to 63 | Violent storm | Exceptionally high waves (small and medium-size ships might be for a time lost to view behind the waves). The sea is completely covered with long white patches of foam lying along the direction of the wind. Everywhere the edges of the wave crests are blown into froth. Visibility affected. |
| 12 | More than 64 | Hurricane | The air is filled with foam and spray. Sea completely white with driving spray; visibility very seriously affected. |

## APPENDIX G:

**Table 17: Acoustic monitoring down-time events during the USGS GOA ECS survey**

| Date | Time Watch Suspended | Date | Time Watch Resumed | Duration acoustic monitoring suspended | Comments |
|---|---|---|---|---|---|
| 2011-06-09 | 17:15 | 2011-06-09 | 18:00 | 00:45 | PAM Operator/Lead PSO needed in tower for mitigation situation with potential zero take species |
| 2011-06-10 | 8:37 | 2011-06-10 | 9:42 | 1:05 | PAM shut down to deploy the hydrophone cable further astern to reduce ship noise interference. |
| 2011-06-10 | 19:00 | 2011-06-11 | 0:11 | 5:11 | Hydrophone cable retrieved to allow for port side gun strings to be brought on board without fear of entanglement. |
| 2011-06-14 | 16:13 | 2011-06-14 | 18:40 | 2:27 | Hydrophone cable retrieved to allow for port side gun strings to be brought on board without fear of entanglement. |
| 2011-06-16 | 15:03 | 2011-06-17 | 6:30 | 15:27 | Vessel retrieving PAM cable and magnometer d/t increased sea state of B6, seas 4m. |

## APPENDIX H: Protected Species Detections During USGS GOA ECS survey

| Detection Number | Date | Species | Number of Animals | Source Activity at First Sighting | Closest Approach to Firing Source (m) | Power Level | Closest Approach to source | Airgun activity at Closest detection | Water Depth | Mitigation Action? | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 30-Jun | Sea otter | 1 | Not Firing | N/A | N/A | 300 | Not Firing | 110 | None | |
| 2 | 30-Jun | Sea otter | 5 | Not Firing | N/A | N/A | 700 | Not Firing | 110 | None | |
| 3 | 30-Jun | Sea otter | 33 | Not Firing | N/A | N/A | 329 | Not Firing | 110 | None | |
| 4 | 30-Jun | Harbour seal | 9 | Not Firing | N/A | N/A | 421 | Not Firing | 110 | None | |
| 5 | 30-Jun | Fin whale | 2 | Not Firing | N/A | N/A | 2614 | Not Firing | 49 | None | |
| 6 | 30-Jun | Humpback whale | 5 | Not Firing | N/A | N/A | 845 | Not Firing | 59 | None | |
| 7 | 30-Jun | Humpback whale | 5 | Not Firing | N/A | N/A | 5664 | Not Firing | 122 | None | |
| 8 | 30-Jun | Humpback whale | 1 | Not Firing | N/A | N/A | 845 | Not Firing | 126 | None | |
| 9 | 30-Jun | Humpback whale | 10 | Not Firing | N/A | N/A | 360 | Not Firing | 67 | None | |
| 10 | 30-Jun | Humpback whale | 37 | Not Firing | N/A | N/A | 50 | Not Firing | 308 | None | |
| 11 | 30-Jun | Fin whale | 8 | Not Firing | N/A | N/A | 600 | Not Firing | 275 | None | |
| 12 | 30-Jun | Dall's porpoise | 1 | Not Firing | N/A | N/A | 50 | Not Firing | 275 | None | |
| 13 | 30-Jun | Killer Whale | 3 | Not Firing | N/A | N/A | 1500 | Not Firing | 216 | None | |
| 14 | 30-Jun | Humpback whale | 1 | Not Firing | N/A | N/A | 950 | Not Firing | 216 | None | |
| 15 | 30-Jun | Dall's porpoise | 20 | Not Firing | N/A | N/A | 150 | Not Firing | 239 | None | |
| 16 | 30-Jun | Fin whale | 1 | Not Firing | N/A | N/A | 1535 | Not Firing | 239 | None | |
| 17 | 30-Jun | Dall's porpoise | 35 | Not Firing | N/A | N/A | 845 | Not Firing | 252 | None | |
| 18 | 30-Jun | Dall's porpoise | 10 | Not Firing | N/A | N/A | 3417 | Not Firing | 236 | None | |
| 19 | 30-Jun | Dall's porpoise | 16 | Not Firing | N/A | N/A | 20 | Not Firing | 230 | None | |
| 20 | 30-Jun | Unidentifiable baleen whale | 1 | Not Firing | N/A | N/A | 500 | Not Firing | 230 | None | |
| 21 | 30-Jun | Unidentifiable baleen whale | 1 | Not Firing | N/A | N/A | 5664 | Not Firing | 230 | None | |
| 22 | 30-Jun | Fin whale | 5 | Not Firing | N/A | N/A | 200 | Not Firing | 230 | None | |
| 23 | 1-Jul | Unidentifiable baleen whale | 1 | Not Firing | N/A | N/A | 1535 | Not Firing | 228 | None | |
| 24 | 1-Jul | Dall's porpoise | 15 | Not Firing | N/A | N/A | 1000 | Not Firing | 286 | None | |
| 25 | 1-Jul | Dall's porpoise | 3 | Not Firing | N/A | N/A | 1089 | Not Firing | 250 | None | |
| 26 | 1-Jul | Fin whale | 3 | Not Firing | N/A | N/A | 4096 | Not Firing | 205 | None | |

| Detection Number | Date | Species | Number of Animals | Source Activity at First Sighting | Closest Approach to Firing Source (m) | Power Level | Closest Approach to source | Airgun activity at Closest detection | Water Depth | Mitigation Action? | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 27 | 1-Jul | Unidentifiable small odontocete | 2 | Not Firing | N/A | N/A | 360 | Not Firing | 184 | None | |
| 28 | 1-Jul | Unidentified pinniped | 1 | Not Firing | N/A | N/A | 838 | Not Firing | 184 | None | |
| 29 | 1-Jul | Dall's porpoise | 6 | Not Firing | N/A | N/A | 2614 | Not Firing | 623 | None | |
| 30 | 1-Jul | Dall's porpoise | 20 | Not Firing | N/A | N/A | 505 | Not Firing | 1585 | None | |
| 31 | 1-Jul | Unidentifiable baleen whale | 1 | Not Firing | N/A | N/A | 1535 | Not Firing | 1926 | None | |
| 32 | 1-Jul | Unidentifiable baleen whale | 1 | Not Firing | N/A | N/A | 1535 | Not Firing | 1926 | None | |
| 33 | 1-Jul | Dall's porpoise | 2 | Not Firing | N/A | N/A | 1089 | Not Firing | 2118 | None | |
| 34 | 1-Jul | Fin whale | 2 | Not Firing | N/A | N/A | 2479 | Not Firing | 2877 | None | |
| 35 | 1-Jul | Fin whale | 1 | Not Firing | N/A | N/A | 951 | Not Firing | 2877 | None | |
| 36 | 1-Jul | Unidentified pinniped | 1 | Not Firing | N/A | N/A | 50 | Not Firing | 4798 | None | |
| 37 | 1-Jul | Unidentified pinniped | 1 | Not Firing | N/A | N/A | 25 | Not Firing | >5000 | None | |
| 38 | 1-Jul | Dall's porpoise | 5 | Not Firing | N/A | N/A | 50 | Not Firing | >5000 | None | |
| 39 | 1-Jul | Northern fur seal | 1 | Not Firing | N/A | N/A | 300 | Not Firing | >5000 | None | |
| 40 | 2-Jul | Fin whale | 1 | Not Firing | N/A | N/A | 1535 | Not Firing | 5649 | None | |
| 41 | 2-Jul | Unidentifiable baleen whale | 4 | Not Firing | N/A | N/A | 1274 | Not Firing | 5544 | None | |
| 42 | 2-Jul | Fin whale | 3 | Not Firing | N/A | N/A | 1535 | Not Firing | 5143 | None | |
| 43 | 2-Jul | Dall's porpoise | 3 | Not Firing | N/A | N/A | 550 | Not Firing | 4999 | None | |
| 44 | 3-Jul | Humpback whale | 1 | Not Firing | N/A | N/A | 3031 | Not Firing | 93 | None | |
| 45 | 3-Jul | Humpback whale | 2 | Not Firing | N/A | N/A | 2614 | Not Firing | 99 | None | |
| 46 | 3-Jul | Humpback whale | 5 | Not Firing | N/A | N/A | 2614 | Not Firing | 98 | None | |
| 47 | 3-Jul | Fin whale | 3 | Full power | 845 | Full power | 845 | Full power | 130 | Power-Down | Only one whale exposed to 180dB resulting in power-down. Other 2 whales exposed to 160dB only |
| 48 | 3-Jul | Unidentified cetacean | 1 | Full power | 2754 | Full power | 2754 | Full power | 101 | None | |
| 49 | 4-Jul | Fin whale | 1 | Full power | 1715 | Full power | 1715 | Full power | 5632 | None | |
| 50 | 4-Jul | Fin whale | 1 | Full power | 4296 | Full power | 4296 | Full power | 4652 | None | |
| 51 | 4-Jul | Humpback whale | 1 | Full power | 951 | Full power | 951 | Full power | 4560 | Power-down | |
| 52 | 5-Jul | Humpback whale | 5 | Full power | 1535 | Full power | 1535 | Full power | 4537 | None | 3 whales with 160dB zone, other 2 outside |
| 53 | 5-Jul | Fin whale | 1 | Full power | 5664 | Full power | 5664 | Full power | 4537 | None | |

| Detection Number | Date | Species | Number of Animals | Source Activity at First Sighting | Closest Approach to Firing Source (m) | Power Level | Closest Approach to source | Airgun activity at Closest detection | Water Depth | Mitigation Action? | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 54 | 5-Jul | Fin whale | 4 | Full power | 1932 | Full power | 690 | Full power | 4491 | None | Online at initial detection. EOL mid sighting, source turned off. Animals approached to CPA while source off |
| 55 | 5-Jul | Humpback whale | 2 | Full power | 5859 | Full power | 1932 | Full power | 4431 | None | Online at initial detection. EOL mid sighting, source turned off. Animals approached to CPA while source off |
| 56 | 5-Jul | Humpback whale | 1 | Not firing | N/A | N/A | 398 | Not firing | 5000 | None | |
| 57 | 6-Jul | Fin whale | 1 | Not firing | N/A | N/A | 583 | Not firing | 4500 | None | |
| 58 | 6-Jul | Northern fur seal | 1 | Not firing | N/A | N/A | 500 | Not firing | 475 | None | |
| 59 | 7-Jul | Unidentified pinniped | 1 | Not firing | N/A | N/A | 30 | Not firing | 145 | None | |
| 60 | 7-Jul | Humpback whale | 1 | Not firing | N/A | N/A | 400 | Not firing | 147 | None | |
| 61 | 7-Jul | Humpback whale | 1 | Not firing | N/A | N/A | 500 | Not Firing | 4726 | None | |
| 62 | 8-Jul | Humpback whale | 1 | Not firing | N/A | N/A | 505 | Not Firing | 95 | None | |
| 63 | 8-Jul | Humpback whale | 2 | Not firing | N/A | N/A | 3031 | Not Firing | 94 | None | |
| 64 | 8-Jul | Humpback whale | 9 | Not firing | 220 | 40 cu in | 220 | 40 cu in | 63 | Delayed ramp-up / Shut-down | Airguns being deployed during initial detection, delaying ramp-up. Mitigation gun enabled then shut-down as animal sighted inside smaller radius |
| 65 | 8-Jul | Humpback whale | 1 | Full power | 500 | Full power | 500 | Full power | 70 | Power-Down | |
| 66 | 10-Jul | Dall's porpoise | 6 | Not firing | N/A | N/A | 250 | Not Firing | | None | |
| 67 | 10-Jul | Humpback whale | 1 | Not firing | N/A | N/A | 50 | Not Firing | 5130 | None | |
| 68 | 10-Jul | Dall's porpoise | 8 | Not firing | N/A | N/A | 250 | Not Firing | 5130 | None | |
| 69 | 10-Jul | Dall's porpoise | 15 | Not firing | N/A | N/A | 250 | Not Firing | 5130 | None | |
| 70 | 10-Jul | Dall's porpoise | 6 | Not firing | N/A | N/A | 100 | Not Firing | 5000 | None | |
| 71 | 10-Jul | Humpback whale | 2 | Not firing | N/A | N/A | 1525 | Not Firing | 4700 | None | |
| 72 | 11-Jul | Dall's porpoise | 6 | Not firing | N/A | N/A | 600 | Not Firing | 4974 | None | |
| 73 | 11-Jul | Dall's porpoise | 6 | Not firing | N/A | N/A | 50 | Not Firing | 5000 | None | |
| 74 | 11-Jul | Dall's porpoise | 5 | Not firing | N/A | N/A | 10 | Not Firing | 5000 | None | |
| 75 | 11-Jul | Dall's porpoise | 5 | Not firing | N/A | N/A | 10 | Not Firing | 5613 | None | |
| 76 | 11-Jul | Northern fur seal | 1 | Not firing | N/A | N/A | 5 | Not Firing | 5613 | None | |
| 77 | 11-Jul | Dall's porpoise | 5 | Not firing | N/A | N/A | 100 | Not Firing | 5545 | None | |
| 78 | 11-Jul | Dall's porpoise | 8 | Not firing | N/A | N/A | 20 | Not Firing | 3041 | None | |

| Detection Number | Date | Species | Number of Animals | Source Activity at First Sighting | Closest Approach to Firing Source (m) | Power Level | Closest Approach to source | Airgun activity at Closest detection | Water Depth | Mitigation Action? | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 79 | 11-Jul | Dall's porpoise | 5 | Not firing | N/A | N/A | 10 | Not Firing | 1136 | None | |
| 80 | 11-Jul | Northern fur seal | 1 | Not firing | N/A | N/A | 200 | Not Firing | 140 | None | |
| 81 | 12-Jul | Humpback whale | 3 | Not firing | N/A | N/A | 200 | Not Firing | 81 | None | |
| 82 | 12-Jul | Humpback whale | 1 | Not firing | N/A | N/A | 800 | Not Firing | 90 | None | |
| 83 | 12-Jul | Humpback whale | 4 | Not firing | N/A | N/A | 150 | Not Firing | 106 | None | |
| 84 | 12-Jul | Humpback whale | 2 | Not firing | N/A | N/A | 583 | Not Firing | 103 | None | |
| 85 | 12-Jul | Humpback whale | 2 | Not firing | N/A | N/A | 2614 | Not Firing | 113 | None | |
| 86 | 12-Jul | Humpback whale | 4 | Not firing | N/A | N/A | 2614 | Not Firing | 70 | None | |
| 87 | 12-Jul | Humpback whale | 1 | Not firing | N/A | N/A | 2614 | Not Firing | 154 | None | |
| 88 | 13-Jul | Humpback whale | 1 | Not firing | N/A | N/A | 1535 | Not Firing | 68 | None | |
| 89 | 13-Jul | Humpback whale | 2 | Not firing | N/A | N/A | 1000 | Not Firing | 83 | None | |
| 90 | 13-Jul | Humpback whale | 3 | Not firing | N/A | N/A | 300 | Not Firing | 91 | None | |
| 91 | 13-Jul | Humpback whale | 1 | Not firing | N/A | N/A | 1000 | Not Firing | 103 | None | |
| 92 | 13-Jul | Humpback whale | 2 | Not firing | N/A | N/A | 600 | Not Firing | 77 | None | |
| 93 | 13-Jul | Humpback whale | 1 | Not firing | N/A | N/A | 600 | Not Firing | 76 | None | |
| 94 | 13-Jul | Humpback whale | 1 | Not firing | N/A | N/A | 200 | Not Firing | 77 | None | |
| 95 | 13-Jul | Unidentifiable baleen whale | 1 | Not firing | N/A | N/A | 4096 | Not Firing | 118 | None | |
| 96 | 13-Jul | Humpback whale | 1 | Not firing | N/A | N/A | 1535 | Not Firing | 118 | None | |
| 97 | 13-Jul | Humpback whale | 1 | Not firing | N/A | N/A | 1535 | Not Firing | 79 | None | |
| 98 | 14-Jul | Humpback whale | 1 | Not firing | N/A | N/A | 1535 | Not Firing | 75 | None | |
| 99 | 14-Jul | Humpback whale | 5 | Not firing | N/A | N/A | 2614 | Not Firing | 115 | None | |
| 100 | 14-Jul | Humpback whale | 2 | Not firing | N/A | N/A | 2614 | Not Firing | 84 | None | |
| 101 | 14-Jul | Humpback whale | 4 | Not firing | N/A | N/A | 1000 | Not Firing | 76 | None | |
| 102 | 14-Jul | Humpback whale | 3 | Not firing | N/A | N/A | 2000 | Not Firing | 92 | None | |
| 103 | 14-Jul | Humpback whale | 1 | Not firing | N/A | N/A | 3000 | Not Firing | 89 | None | |
| 104 | 14-Jul | Humpback whale | 1 | Not firing | N/A | N/A | 4096 | Not Firing | 90 | None | |
| 105 | 14-Jul | Humpback whale | 1 | Not firing | N/A | N/A | 1535 | Not Firing | 92 | None | |
| 106 | 14-Jul | Humpback whale | 1 | Not firing | N/A | N/A | 1535 | Not Firing | 75 | None | |
| 107 | 14-Jul | Humpback whale | 1 | Not firing | N/A | N/A | 1932 | Not Firing | 80 | None | |
| 108 | 14-Jul | Humpback whale | 1 | Not firing | N/A | N/A | 2614 | Not Firing | 93 | None | |

| Detection Number | Date | Species | Number of Animals | Source Activity at First Sighting | Closest Approach to Firing Source (m) | Power Level | Closest Approach to source | Airgun activity at Closest detection | Water Depth | Mitigation Action? | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 109 | 14-Jul | Humpback whale | 1 | Not firing | N/A | N/A | 3000 | Not Firing | 89 | None | |
| 110 | 14-Jul | Humpback whale | 1 | Not firing | N/A | N/A | 4096 | Not Firing | 128 | None | |
| 111 | 14-Jul | Humpback whale | 1 | Not firing | N/A | N/A | 4000 | Not Firing | 98 | None | |
| 112 | 14-Jul | Common minke whale | 1 | Not firing | N/A | N/A | 800 | Not Firing | 113 | None | |
| 113 | 14-Jul | Humpback whale | 1 | Not firing | N/A | N/A | 845 | Not Firing | 116 | None | |
| 114 | 14-Jul | Humpback whale | 2 | Not firing | N/A | N/A | 1500 | Not Firing | 97 | None | |
| 115 | 14-Jul | Humpback whale | 5 | Not firing | N/A | N/A | 750 | Not Firing | 102 | None | |
| 116 | 14-Jul | Humpback whale | 5 | Not firing | N/A | N/A | 1535 | Not Firing | 67 | None | |
| 117 | 14-Jul | Unidentifiable baleen whale | 1 | Not firing | N/A | N/A | 2614 | Not Firing | 84 | None | |
| 118 | 14-Jul | Humpback whale | 3 | Not firing | N/A | N/A | 1535 | Not Firing | 79 | None | |
| 119 | 14-Jul | Humpback whale | 3 | Not firing | N/A | N/A | 1535 | Not Firing | 73 | None | |
| 120 | 14-Jul | Humpback whale | 3 | Not firing | N/A | N/A | 690 | Not Firing | 75 | None | |
| 121 | 15-Jul | Humpback whale | 3 | Not firing | N/A | N/A | 690 | Not Firing | 82 | None | |
| 122 | 15-Jul | Humpback whale | 3 | Not firing | N/A | N/A | 845 | Not Firing | 85 | None | |
| 123 | 15-Jul | Humpback whale | 6 | Not firing | N/A | N/A | 50 | Not Firing | 90 | None | |
| 124 | 15-Jul | Humpback whale | 5 | Not firing | N/A | N/A | 1932 | Not Firing | 89 | None | |
| 125 | 15-Jul | Sei whale | 2 | Not firing | N/A | N/A | 1535 | Not Firing | 92 | None | |
| 126 | 15-Jul | Unidentified Pinniped | 1 | Not firing | N/A | N/A | 10 | Not Firing | 129 | None | |
| 127 | 15-Jul | Humpback whale | 1 | Not Firing | N/A | N/A | 480 | Not Firing | 89 | Delayed ramp-up | |
| 128 | 15-Jul | Humpback whale | 2 | Full power | 1535 | Full power | 1535 | Full power | 85 | Power-Down | |
| 129 | 15-Jul | Northern fur seal | 1 | Full power | 223 | Full power | 223 | Full power | 91 | Power-Down | |
| 130 | 15-Jul | Humpback whale | 3 | Soft start | 1735 | Ramp-up | 1289 | 40 cu in | 80 | Power-Down | |
| 131 | 15-Jul | Unidentifiable baleen whale | 1 | Full power | 4096 | Full power | 4096 | Full power | 79 | None | |
| 132 | 15-Jul | Humpback whale | 3 | Full power | 1932 | Full power | 1932 | Full power | 84 | Power-Down | |
| 133 | 15-Jul | Humpback whale | 1 | Full power | 1932 | Full power | 1932 | Full power | 82 | Power-Down | |
| 134 | 15-Jul | Humpback whale | 4 | Full power | 500 | 40 cu in | 500 | 40 cu in | 78 | Power-Down | |
| 135 | 16-Jul | Humpback whale | 5 | Soft start | 890 | Ramp-up | 890 | Ramp-up | 84 | Power-Down | |
| 136 | 16-Jul | Humpback whale | 3 | Soft start | 400 | 40 cu in | 400 | 40 cu in | 59 | Power-Down | |

| Detection Number | Date | Species | Number of Animals | Source Activity at First Sighting | Closest Approach to Firing Source (m) | Power Level | Closest Approach to source | Airgun activity at Closest detection | Water Depth | Mitigation Action? | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 137 | 16-Jul | Stellar sea lion | 18 | Soft start | 2000 | Ramp-up | 2000 | Ramp-up | 100 | None | On the rocks as vessel approached. No animals observed entering water |
| 138 | 16-Jul | Humpback whale | 11 | Full power | 250 | 40 cu in | 250 | 40 cu in | 99 | Power-Down / Shut-down / Power-down / Power-down | |
| 139 | 16-Jul | Humpback whale | 1 | Full power | 4100 | Full power | 4100 | Full power | 79 | None | |
| 140 | 17-Jul | Dall's porpoise | 7 | Full power | 300 | 40 cu in | 300 | 40 cu in | 3521 | Power-Down | |
| 141 | 17-Jul | Humpback whale | 1 | Full power | 800 | Full power | 800 | Full power | 4683 | Power-Down | |
| 142 | 17-Jul | Fin whale | 1 | Full power | 600 | 40 cu in | 600 | 40 cu in | 4711 | Power-Down | |
| 143 | 19-Jul | Unidentifiable baleen whale | 2 | Full power | 2000 | Full power | 2000 | Full power | 1037 | None | |
| 144 | 19-Jul | Unidentifiable baleen whale | 2 | Full power | 2614 | Full power | 2614 | Full power | 571 | None | |
| 145 | 20-Jul | Unidentifiable baleen whale | 1 | Full power | 2998 | Full power | 2998 | Full power | 108 | None | |
| 146 | 21-Jul | Unidentifiable baleen whale | 1 | 40 cu in | 3000 | 40 cu in | 3000 | 40 cu in | 101 | None | |
| 147 | 21-Jul | Fin whale | 2 | Full power | 4096 | Full power | 4096 | Full power | 100 | None | |
| 148 | 22-Jul | Unidentifiable baleen whale | 1 | Full power | 2000 | Full power | 2000 | Full power | 5301 | None | |
| 149 | 23-Jul | Unidentifiable baleen whale | 1 | Full power | 1420 | Full power | 1420 | Full power | 4547 | None | |
| 150 | 23-Jul | Humpback whale | 5 | Full power | 1803 | Full power | 1803 | Full power | 4516 | None | |
| 151 | 23-Jul | Unidentifiable baleen whale | 1 | 3300 | 677 | 40 cu in | 677 | 40 cu in | 4603 | Power-Down | Firing stbd side strings only, 18 guns, while port side strings coming in for repair |
| 152 | 23-Jul | Humpback whale | 7 | Full power | 800 | Full power | 800 | Full power | 4532 | Power-Down | |
| 153 | 23-Jul | Humpback whale | 2 | Full power | 1362 | Full power | 1362 | Full power | 4574 | None | |
| 154 | 23-Jul | Unidentifiable baleen whale | 3 | Full power | 5026 | Full power | 5026 | Full power | 4572 | None | |
| 155 | 23-Jul | Fin whale | 2 | Full power | 180 | 40 cu in | 180 | 40 cu in | 4582 | Power-Down | |
| 156 | 23-Jul | North Pacific right whale | 1 | 40 cu in | 400 | 40 cu in | 400 | 40 cu in | 4611 | Delayed ramp-up / Shut-down | Source was firing on mitigation for duration of entire sighting until positive ID was made when source was shut off. CPA to sourcew as 400m, greater than 160dB safety radius for one gun |

| Detection Number | Date | Species | Number of Animals | Source Activity at First Sighting | Closest Approach to Firing Source (m) | Power Level | Closest Approach to source | Airgun activity at Closest detection | Water Depth | Mitigation Action? | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 157 | 23-Jul | Humpback whale | 1 | Not firing | N/A | N/A | 200 | Not firing | 4644 | Delayed ramp-up | |
| 158 | 23-Jul | Unidentifiable baleen whale | 1 | Full power | 1866 | Full power | 1866 | Full power | 4792 | None | |
| 159 | 26-Jul | Northern fur seal | 1 | Full power | 100 | 40 cu in | 100 | 40 cu in | 956 | Power-Down | |
| 160 | 26-Jul | Humpback whale | 1 | Full power | 845 | 40 cu in | 845 | 40 cu in | 59 | Power-Down | |
| 161 | 27-Jul | Unidentifiable baleen whale | 1 | Full power | 6000 | Full power | 6000 | Full power | 101 | None | |
| 162 | 27-Jul | Fin whale | 10 | Full power | 1089 | 40 cu in | 1089 | 40 cu in | 227 | Power-Down | |
| 163 | 27-Jul | Fin whale | 6 | Full power | 300 | Full power | 300 | Full power | 296 | Power-Down | |
| 164 | 27-Jul | Dall's porpoise | 4 | Full power | 150 | Full power | 150 | Full power | 109 | Power-Down | |
| 165 | 27-Jul | Unidentifiable baleen whale | 6 | Full power | 1755 | Full power | 1755 | Full power | 202 | Power-Down | |
| 166 | 27-Jul | Unidentifiable baleen whale | 2 | Full power | 2000 | Full power | 2000 | Full power | 198 | None | |
| 167 | 27-Jul | Humpback whale | 2 | Full power | 4096 | Full power | 4096 | Full power | 243 | None | |
| 168 | 27-Jul | Fin whale | 1 | Full power | 4096 | Full power | 4096 | Full power | 282 | None | |
| 169 | 27-Jul | Fin whale | 2 | Full power | 1932 | Full power | 1932 | Full power | 236 | None | |
| 170 | 27-Jul | Fin whale | 4 | Full power | 2162 | Full power | 2162 | Full power | 256 | None | |
| 171 | 27-Jul | Fin whale | 4 | Full power | 1765 | Full power | 1765 | Full power | 247 | Power-Down | |
| 172 | 28-Jul | Unidentifiable baleen whale | 1 | Full power | 690 | Full power | 690 | Full power | 217 | Power-Down | |
| 173 | 28-Jul | Unidentified cetacean | 1 | Full power | 7500 | Full power | 7500 | Full power | 176 | None | |
| 174 | 28-Jul | Unidentified cetacean | 4 | Full power | 7000 | Full power | 7000 | Full power | 65 | None | |
| 175 | 28-Jul | Unidentifiable baleen whale | 1 | Full power | 1400 | 40 cu in | 1400 | 40 cu in | 142 | Power-Down | |
| 176 | 29-Jul | Unidentifiable baleen whale | 4 | Full power | 1755 | Full power | 1755 | Full power | 103 | Power-Down | |
| 177 | 29-Jul | Fin whale | 2 | 40 cu in | 1089 | 40 cu in | 1089 | 40 cu in | 93 | Delayed ramp-up | |
| 178 | 29-Jul | Humpback whale | 2 | 40 cu in | 1274 | 40 cu in | 1274 | 40 cu in | 93 | Delayed ramp-up | |
| 179 | 29-Jul | Humpback whale | 4 | Full power | 1065 | Full power | 1065 | Full power | 90 | Power-Down | |
| 180 | 29-Jul | Humpback whale | 1 | Full power | 2614 | Full power | 2614 | Full power | 5398 | None | |
| 181 | 30-Jul | Dall's porpoise | 5 | Full power | 300 | Full power | 300 | Full power | 5421 | Power-Down | |
| 182 | 30-Jul | Fin whale | 4 | Full power | 4096 | Full power | 4096 | Full power | 5419 | None | |
| 183 | 30-Jul | Humpback whale | 3 | Full power | 400 | 40 cu in | 400 | 40 cu in | 5119 | Power-Down | |

| Detection Number | Date | Species | Number of Animals | Source Activity at First Sighting | Closest Approach to Firing Source (m) | Power Level | Closest Approach to source | Airgun activity at Closest detection | Water Depth | Mitigation Action? | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 184 | 30-Jul | Humpback whale | 1 | Full power | 690 | 40 cu in | 690 | 40 cu in | 5288 | Power-Down | |
| 185 | 31-Jul | Humpback whale | 1 | Full power | 220 | 40 cu in | 220 | 40 cu in | 220 | Power-Down | |
| 186 | 31-Jul | Unidentifiable baleen whale | 1 | Full power | 4096 | Full power | 4096 | Full power | 189 | None | |
| 187 | 31-Jul | Humpback whale | 2 | Full power | 583 | 40 cu in | 583 | 40 cu in | 183 | Power-Down | |
| 188 | 31-Jul | Unidentified cetacean | 1 | Full power | 4096 | Full power | 4096 | Full power | 91 | None | |
| 189 | 31-Jul | Humpback whale | 3 | Full power | 5664 | Full power | 5664 | Full power | 74 | None | |
| 190 | 31-Jul | Humpback whale | 6 | Full power | 1758 | 40 cu in | 1758 | 40 cu in | 68 | Power-Down | |
| 191 | 31-Jul | Humpback whale | 1 | Full power | 1289 | Full power | 1289 | Full power | 73 | Power-Down | |
| 192 | 1-Aug | Fin whale | 2 | Full power | 2800 | Full power | 2800 | Full power | 155 | None | |
| 193 | 1-Aug | Unidentifiable baleen whale | 2 | Full power | 2700 | Full power | 2700 | Full power | 91 | None | |
| 194 | 1-Aug | Unidentifiable baleen whale | 1 | Full power | 2614 | Full power | 2614 | Full power | 109 | None | |
| 195 | 1-Aug | Fin whale | 2 | Full power | 3922 | Full power | 3922 | Full power | 91 | None | |
| 196 | 2-Aug | Humpback whale | 20 | Full power | 220 | 40 cu in | 160 | Not Firing | 104 | Power-Down / Shut-down / Delayed ramp-up | |
| 197 | 2-Aug | Humpback whale | 4 | Ramp-up | 951 | 40 cu in | 951 | 40 cu in | 90 | Power-Down | |
| 198 | 2-Aug | Unidentifiable baleen whale | 1 | Full power | 1932 | Full power | 1932 | Full power | 5366 | None | |
| 199 | 3-Aug | Unidentifiable baleen whale | 1 | Full power | 2835 | Full power | 2835 | Full power | 6074 | None | |
| 200 | 3-Aug | Northern fur seal | 1 | Not firing | N/A | N/A | 180 | Not firing | 4918 | None | |
| 201 | 4-Aug | Humpback whale | 1 | Not firing | N/A | N/A | 1089 | Not firing | 4742 | None | |

## APPENDIX I: Bird Species Observed During USGS GOA ECS Seismic Survey

| Common Name | Family | Genus | Species | Approximate Number of Individuals Observed | Approximate Number of Days Species Was Observed |
|---|---|---|---|---|---|
| Laysan albatross | Diomedeidae | *Diomedea* | *immutuabilis* | 22 | 10 |
| Black-footed albatross | Diomedeidae | *Phoebastra* | *nigripes* | 45 | 9 |
| Northern fulmar | Procellariidae | *Fulmarus* | *glacialis* | 290 | 17 |
| Tufted puffin | Alcidae | *Fratercula* | *cirrhata* | 136 | 17 |
| Horned puffin | Alcidae | *Fratercula* | *corniculata* | 9 | 2 |
| Sooty shearwater | Procellariidae | *Puffinus* | *griseus* | 13 | 5 |
| Crested auklet | Alcidae | *Aethia* | *cristatella* | 7 | 1 |
| Parakeet auklet | Alcidae | *Aethia* | *psittacula* | 1 | 1 |
| Black-legged kittiwake | Laridae | *Larus* | *tridactyla* | 38 | 5 |
| Leach's storm petrel | Hydrobatidae | *Oceanodroma* | *leucorhoa* | 189 | 11 |
| Mottled petrel | Procellariidae | *Pterodroma* | *inexpectata* | 4 | 3 |
| Fork-tailed storm petrel | Hydrobatidae | *Oceanodroma* | *furcata* | 3 | 1 |
| Arctic tern | Laridae | *Sterna* | *paradisaea* | 2 | 1 |
| Aleutian tern | Laridae | *Onychoprion* | *aleuticus* | 2 | 2 |