Draft Protected Species Mitigation and Monitoring Report

Juan de Fuca Plate Evolution and Hydration in the Northeast Pacific Ocean

14 June 2012 - 8 July 2012

R/V Marcus G. Langseth

Prepared for

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1. EXECUTIVE SUMMARY

The National Science Foundation (NSF) owned research vessel (R/V), *Marcus G. Langseth*, operated by Lamont-Doherty Earth Observatory (L-DEO), a part of Columbia University, conducted a seismic survey of the Juan de Fuca plate at the Cascadia subduction zone in the Northeast Pacific Ocean. The purpose of the survey was to characterize the evolution and state of hydration of the Juan de Fuca plate crust and shallow mantle, from formation at the mid-ocean Juan de Fuca ridge, through alteration and hydration within the plate interior, to subduction at the Cascadia trench. The *Langseth* left Astoria, Oregon on 14 June 2012 and began the survey on the same day. The survey was completed on 7 July 2012 and the *Langseth* arrived back in Astoria on 8 July 2012.

L-DEO submitted applications to the National Marine Fisheries Service (NMFS) and the Fisheries and Aquaculture Branch of Fisheries and Oceans Canada (DFO) for permits to harass marine mammals, incidental to the marine geophysical survey. The mission was scheduled to leave port on 11 June 2012, however NMFS was unable to coordinate the additional monitoring and mitigation plans with the regional office over concerns raised over the endangered population of the Southern Resident killer whales. An Incidental Harassment Authorization (IHA) was eventually granted on 13 June 2012 from NMFS and a Letter of Advice (LOA) was granted 22 May 2012 from DFO (Appendix A), with several mitigation measures that stipulated harassment to marine mammals. Mitigation measures were implemented to minimize potential impacts to marine mammals throughout the duration of the survey. Mitigation measures included, but were not limited to, the use of NMFS and DFO approved 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 and DFO in the IHA and LOA. 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, conducting a total of 371 hours 02 minutes of visual observations and 420 hours 08 minutes of acoustic monitoring over the course of the survey.

This visual monitoring effort produced a project total of 121 protected species detection records; 76 for cetaceans and 45 for pinnipeds. Of the 76 cetacean records collected, 21 records were collected for mysticetes, 41 records of odontocetes, nine records of unidentified large cetaceans, and five records of unidentified small cetaceans. Of the 45 pinniped records, 33 were collected for otariids while the remaining 12 were of unidentified pinnipeds. There were no detections of sea turtles during the survey. There were 14 acoustic detections using the passive acoustic monitoring (PAM) system, five of these detections correlating with visual detection.

Detections of protected species resulted in 72 mitigation actions being implemented; 45 power-downs, 20 shut-downs of the acoustic source, and seven delayed soft-starts. This amounted to a total of 57 hours 20 minutes of mitigation downtime. There was an additional 1 hour 32 minutes of downtime due to fog delaying the soft-start of the acoustic source. A known 470 cetaceans and 48 pinnipeds were exposed to received sound pressure levels equal to or greater than 160 dB, constituting a level B harassment take as defined by NMFS. Cetacean level B harassment 'takes' included one sei whale, eight humpback whales, 19 fin whales, 87

Dall's porpoises, 151 Pacific white-sided dolphins, 173 Northern right whale dolphins, six unidentified baleen whales, six unidentified whales, 13 unidentified dolphins, and six unidentified small cetaceans. Pinniped level B harassment 'takes' included one Steller's sea lion, 35 Northern fur seals, and 12 unidentified pinnipeds.

A project summary sheet of observation, detection, and operational totals can be found in Appendix B.

2. INTRODUCTION

The following report details protected species monitoring and mitigation as well as seismic survey operations undertaken as part of the Juan de Fuca Plate (Carbotte) marine geophysical survey on board the *R/V Langseth* from 14 June to 8 July 2012 in the Northeast Pacific Ocean.

This document serves to meet the reporting requirements dictated in the IHA issued to L-DEO by NMFS on 13 June 2012 and the LOA issued by DFO on 22 May 2012. The IHA authorized non-lethal takes of 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 160 dB could potentially disturb marine mammals, temporarily disrupting behavior, such that they could be considered as "takes" of these exposed animals. Potential consequences of Level B harassment taking could include effects such as temporary or permanent 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 adverse effects.

The LOA issued by DFO authorized the exposure of marine mammals to received sound pressure levels less than 160 dB re 1 µPa (rms). The DFO required that safety radii, power-downs, and shut-downs be implemented to mitigate potential adverse effects.

2.1. PROJECT OVERVIEW AND LOCATION

The survey was conducted in the north eastern Pacific Ocean, off the coasts of Washington and Oregon. The survey took place in the approximate area of 43 to 48° North and 124 to 130° West, where water depths ranged from ~50 m to >3000 m (Figure 1). The *Langseth* deployed an array of 36 airguns as an energy source. The receiving system consisted of one eight kilometer hydrophone streamer or ocean bottom seismometers (OBSs). As the airgun array was towed along the survey lines, the hydrophone streamer received the returning acoustic signals and transferred the data to the onboard processing system. The OBSs record the returning acoustic signals internally for later analysis.

A total of approximately 3484 km of transect lines were surveyed. The *Langseth*'s cruising speed was about 10-12 knots during transits and varied between 4 and 5 knots during the seismic survey. Seismic acquisition began on 14 June and continued until 7 July.

The results of this 2-D seismic survey of the Juan de Fuca plate at the Cascadia subduction zone will be used to characterize the evolution and state of hydration of the Juan de Fuca plate crust and shallow mantle, from formation at the mid-ocean Juan de Fuca ridge, through alteration and hydration within the plate interior, to subduction at the Cascadia trench. The survey included two ridge-to-trench transects, the first complete transects ever acquired of an

oceanic plate. It is expected that differences in hydration of the down-going plate from Oregon to Washington may play a significant role in the seismic hazard of the Cascadia subduction zone along this heavily populated Pacific northwest margin.

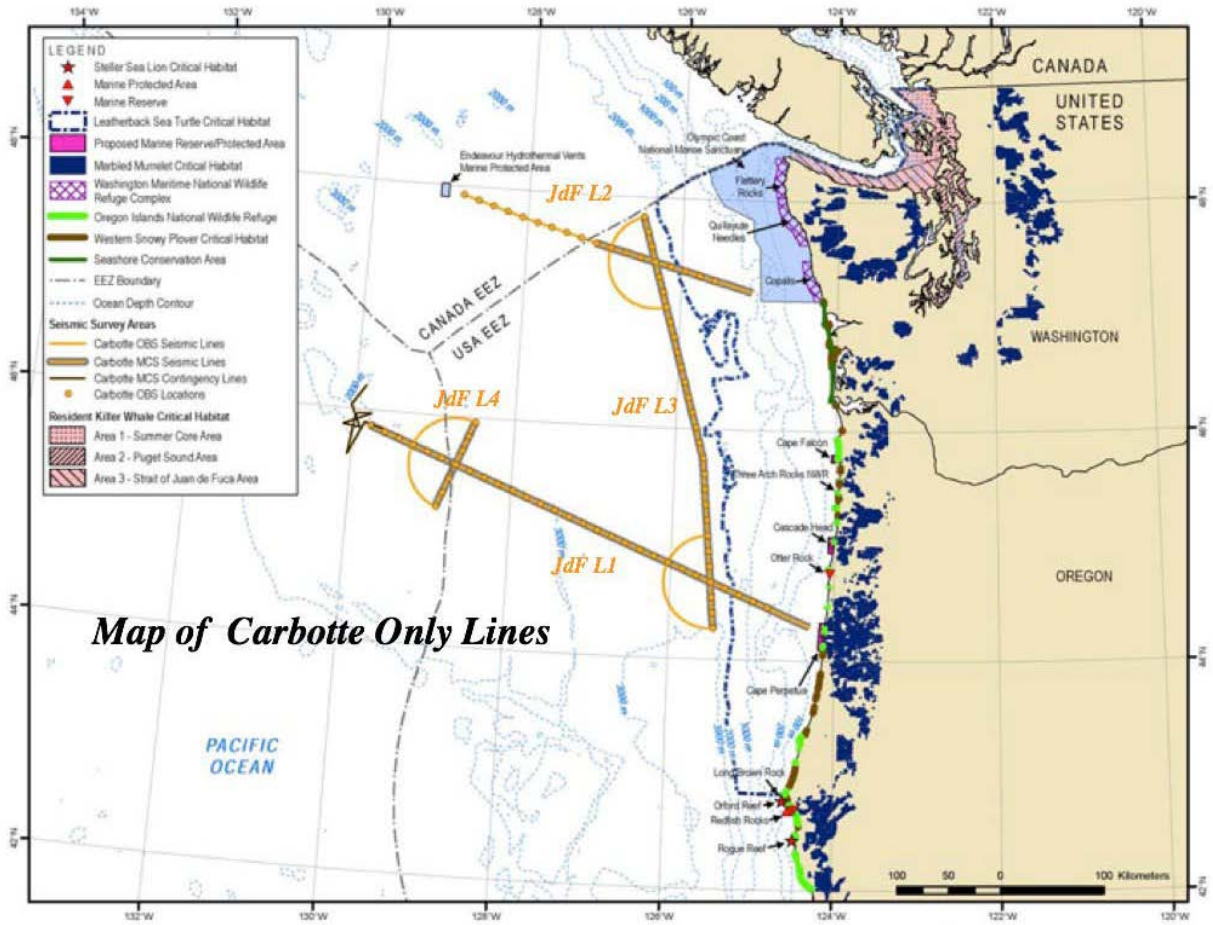

Figure 1. Location of the Juan de Fuca Plate (Carbotte) marine geophysical survey in the Northeast Pacific Ocean.

2.1.1. Energy Source

The acoustic source consisted of four towed airgun sub-arrays and one hydrophone streamer cable. The sub-arrays were deployed centrally astern as a single acoustic source with each array separated by eight meters. The airguns were towed at a depth of nine meters for multi-channel survey lines (MCS) and 12 meters for OBS survey lines, were situated 232 meters from the Navigational Reference Point (NRP), which was located on the PSO observation tower.

Each source array utilized a mixture of Bolt 1500LL and Bolt 1900LLX airguns ranging in volume from the smallest airgun of 40 in^3 to 360 in^3. Each sub-array contained ten airguns, with the first and last spaced 16 meters apart. Only nine airguns on each sub-array were firing during survey acquisition, with the tenth gun utilized as a spare. The total volume of each sub-array was 1,650 in^3. The full power source of four sub-arrays (36 airguns) had a total discharge volume of 6,600 in^3 and a pressure of 1,900 psi. Each discharge of the source consisted of a single brief pulse of sound (duration of approximately 0.1 second) with the greatest energy output occurring in the two to 188 hertz frequency range.

The shot point interval for the MCS survey was 37.5 meters, equating to approximately 16 seconds at typical survey speed, but was lengthened to 500 meters (~200 seconds) during the OBS survey lines. The sound signal receiving system during the acquisition of the MCS transect lines consisted of a single eight kilometer long hydrophone streamer, which received the returning acoustic signals and transferred the data to the processing system located on board the vessel. Due to the length and placement of the cables, the maneuverability of the vessel was limited to turns of five degrees per minute while the gear was being towed.

Forty-six OBSs will be deployed along the northern line and the alongshore line (Figure 1). Once those lines have been shot, the OBSs will be retrieved and 39 of them will be deployed along the southern line then retrieved once the line is shot. Woods Hole Oceanographic Institution (WHOI) "D2" OBSs were used during the cruise. This type of OBS has a height of ~1 m and a maximum diameter of 50 cm. The anchor is made of hot-rolled steel and weighs 23 kg. The anchor dimensions are 2.5×30.5×38.1 cm. Once an OBS is ready to be retrieved, an acoustic release transponder interrogates the instrument at a frequency of 9–11 kHz, and a response is received at a frequency of 9–13 kHz. The burn-wire release assembly is then activated, and the instrument is released from the anchor to float to the surface. OBS deployment and retrieval will be carried out by the R/V *Oceanus*.

In addition to the operations of the airgun array, a Kongsberg EM 122 multibeam echosounder (MBES), a Knudsen Chirp 3260 sub-bottom profiler (SBP), and a hull-mounted acoustic Doppler current profiler (ADCP) was operated from the *Langseth* continuously throughout the cruise. These sound sources are operated from the *Langseth* simultaneous with the airgun array.

3. MITIGATION AND MONITORING METHODS

The PSO monitoring program on the *Langseth* was established to meet the IHA and LOA requirements that were issued to the L-DEO by NMFS and DFO, which included both monitoring and mitigation objectives. The survey mitigation program is designed to minimize potential impacts of the *Langseth*'s seismic program on marine turtles, marine mammals, and other protected species of interest. 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 the mitigation objectives outlined in the IHA and LOA, PSOs collected and analyzed necessary data mandated by the IHA and LOA 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 modeling 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

There were five trained and experienced PSOs on board to conduct the monitoring for marine mammals, record and report on observations, and request mitigation actions in accordance to the IHA and LOA. The PSOs on board were NMFS/DFO approved and held certifications from a recognized Joint Nature Conservation Committee (JNCC) course and/or approved Bureau of Ocean Energy Management (BOEM) course. Visual monitoring was primarily carried out from an observation tower (Figure 2) located 18.9 meters above the water surface which afforded the PSOs a 360 degree viewpoint around the acoustic source.

Figure 2. Protected Species Observer observation tower with mounted big-eye binoculars.

The PSO tower was equipped with Fujinon 7x50 binoculars as well as two mounted 25x150 Big-eye binoculars. Inside the tent located in the middle of the platform was a laptop for data collection as well as a telephone for communication with the PAM station, bridge, or main lab. Also inside the tent was a monitor that displayed current information about the vessel's position, speed, and heading, along with water depth, wind speed and direction, and source activity. Most observations were held from the tower; however, when there was severe weather or poor environmental conditions observations would be performed from the bridge (~12.8m above sea level) or the catwalk (~12.3m above sea level) in front of the bridge. Night Quest NQ2200 Night Vision Devices were also available to conduct night time observations for nighttime ramp-ups of the acoustic source, but were not used during this survey.

Visual monitoring methods were implemented in accordance with the survey requirements outlined in the IHA and LOA. At least one PSO, but most often two PSOs, watched for marine mammals and sea turtles at all times while airguns operated during daylight periods and whenever the vessel was underway when the airguns were not firing.

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 safety radii were visible, and continued past sunset until the safety radii became obscured. Start of observation times ranged from 4:49 to 5:30 local time, while end of observation times ranged from 21:46 to 22:25 local time.

A visual monitoring schedule was established by the PSOs where each person completed visual observations watches which varied in length between two to four hours, two to three times a day, for a total of four to eight hours of visual monitoring per day. This schedule was arranged to ensure that two PSOs were on visual observation duty at all times except during meal times and restroom breaks when PSOs would maintain a solo watch so that the entire team could eat while maintaining both visual and acoustic monitoring. Solo watches lasted less than 45 minutes and occurred each day at meal times. In the event of a sighting event during a single PSO watch a second PSO would be notified and would immediately return to assist observations.

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 blows indicating the presence of a marine mammal, splashes or disturbances to the sea surface, the presence of large flocks of feeding seabirds and other sighting cues indicating the possible presence of a protected species.

Upon the visual detection of a protected species, PSOs would first identify the animals range to the acoustic source while identifying the observed animal (cetacean, pinniped, or sea turtle) to determine which safety radius applied to the animal. The visual PSOs would then notify the PAM operator, who was located in the main science lab, that there was an animal inside or outside of the safety radius. If the animal was observed inside the safety radius and a mitigation action was necessary, the PAM operator would relay the message to the seismic technician who sits nearby. Table 1 describes the various safety radii applied to cetaceans and pinnipeds, as well as what constituted the Level-B harassment zone, while in US waters. Table 2 describes the various safety radii applied to both cetaceans and pinnipeds while in Canadian waters. The PAM operator was also notified of all marine mammal sightings as soon as possible in order to enable recordings to be made for possible analysis later by one of the more experienced acoustic operators to determine whether vocalizations had been detected on the PAM system during the sighting.

Table 1. Safety radii (SR) for triggering mitigation.

Source and Volume	Array Tow Depth (m)	Water Depth (m)	Power/Shut-down SR for Pinnipeds 190 dB (m)	Power/Shut-down SR for Cetaceans 180 dB (m)	Level-B Harassment Zone 160 dB (m)
Single bolt airgun (40 in³)	6 to 15	Shallow (<100)	150	296	1,050
		Intermediate (100-1,000)	18	60	578
		Deep (>1,000)	12	40	385
4 strings 36 airguns (6,600 in³)	9 MCS Survey lines	Shallow (<100)	680	2,140	20,550
		Intermediate (100-1,000)	550	1,540	12,200
		Deep (>1,000)	400	940	3,850
4 strings 36 airguns (6,600 in³)	12 OBS Survey lines	Shallow (<100)	770	2,250	23,470
		Intermediate (100-1,000)	615	1,810	13,935
		Deep (>1,000)	460	1,100	4,400

Table 2. Safety radii for triggering mitigation in Canadian waters.

Source and Volume	Array Tow Depth (m)	Power/Shut-down Safety Radii for Cetaceans and Pinnipeds (m)
Single bolt airgun (40 in^3)	9 to 12	500
4 strings 36 airguns (6,600 in^3)	9 to 12	4,400

When a protected species was observed range estimations were made using reticle binoculars, the naked eye, and by relating the animal to an object at a known distance, such as the acoustic array located 232 meters from the PSO tower. 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 most sightings. Sometimes photographs were not taken due to the brevity of a sighting. The camera used was a Canon EOS 60D with a 300 millimeter telephoto lens. Marine mammal identification manuals were consulted and photos were examined during visual watch breaks to confirm identifications.

During or immediately after each sighting event PSOs 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 determine if the animals had been exposed to 160 dB and/or 180/190 dB of sound from the source during the sighting event. Additionally, 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 environmental conditions, vessel, or seismic activity changed. Each sighting event was linked to an entry on a datasheet such that environmental conditions were available for each sighting event.

3.2. ACOUSTIC MONITORING SURVEY METHODOLOGY

PAM was used to augment visual monitoring efforts, by helping to detect, identify, and locate marine mammals within the area. 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. PAM was not used exclusively to execute any mitigation actions without a concurrent visual sighting of the marine mammal, with the exception of acoustic detections of killer whales (*Orcinus orca*) where the acoustic source was to be shut-down until 30 minutes after the last acoustic detection. No

killer whales were acoustically detected during this survey.

Two PSOs, who were trained and experienced with the use of PAM, were present throughout the cruise. One person was designated as the PAM operator to oversee and conduct the PAM operations. All PSOs completed a PAM training provided by the PAM Operator in the initial days of the hydrophone deployment during which basic PAM system operation was covered. To achieve 24-hours of monitoring, the PSOs and the PAM operator rotated through acoustic monitoring shifts with the PAM operator monitoring many of the night time hours when PSOs were not making visual observations and the PAM was the only system in use for detecting cetaceans. Monitoring shifts lasted one to six hours. During daylight hours, acoustic operators were in communication with visual PSOs in the tower relaying sighting and seismic activity information. The PAM system was located in the main science lab to provide adequate space for the system, allow a quick exchange of communications with the visual PSOs on watch and seismic technicians, and to provide access to the vessel's instrumentation. The vessel's position, water depth, heading and speed, vessel and airgun activity were recorded every hour.

Acoustic monitoring for marine mammals was conducted aurally with *Sennheiser* headphones and visually with *Pamguard Beta 1.10.00*. Delphinid whistles, clicks, and burst pulses as well as sperm whale and baleen whale vocalizations may be viewed on a spectrogram display within *Pamguard*. Sperm whale, beaked whale, *Kogia* species, and delphinid echolocation clicks may be viewed on low and high frequency click detector displays. The Spectrogram's amplitude range and appearance were adjusted as needed to suit the operator's preference to maximize the vocalizations appearance above the pictured background noise.

3.2.1. Passive Acoustic Monitoring Parameters

Acoustic monitoring was carried out using a PAM system developed by Seiche Measurements Limited. PAM system specifications can be found in Appendix C. The PAM system consists of seven main components: a 250m hydrophone tow cable, a 100m deck cable, a data processing unit, two laptops, an acoustic analysis software package, and headphones for aural monitoring.

The hydrophone cable contains four hydrophone elements and a depth gauge molded into a 5m section of the cable. Three of the hydrophone elements are broadband (2 to 200 kHz) and the fourth element is for sampling lower frequencies (75Hz to 30 kHz). Preamplifiers are also embedded into the array cable just ahead of each hydrophone element. The four-element linear hydrophone array permits a large range for sampling marine mammal vocalizations.

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 Beta 1.10.00* 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* can use 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 can display the detected clicks within the HF envelope band pass filter in real time, which would allow 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 can be calculated using a Time-of-Arrival-Distance (TOAD) method (the signal time delay between the arrival of a signal on each hydrophone is compared), and presented on a radar display along with amplitude information for the detected signal as a proxy for range. 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. 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.

3.2.2. 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 science lab.

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 above can be found in Appendix D.

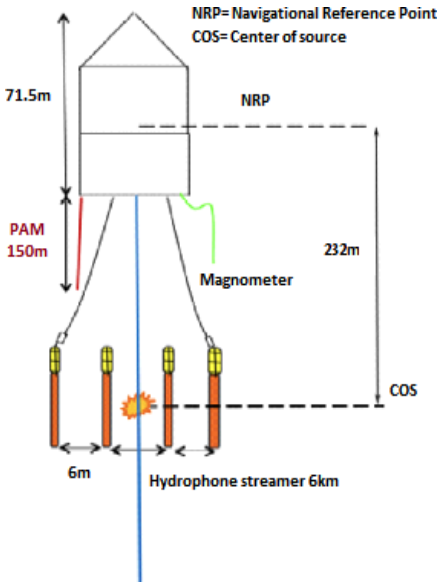

Figure 3. Location of the hydrophone deployment.

4. MONITORING EFFORT SUMMARY

4.1. SURVEY OPERATIONS SUMMARY

The *R/V Langseth* departed Astoria for the seismic survey site at 1:57 UTC on 14 June. The seismic gear was deployed and use of the acoustic source commenced later that day at 15:13 UTC. Acquisition began on the first OBS survey line began at 20:22 UTC on 14 June. Acquisition of a portion of the OBS survey lines was completed at 13:54 on 20 June. At this time the acoustic streamer was deployed and acquisition of MCS lines began. Both OBS and MCS survey lines continued to be acquired until 21:02 UTC on 3 July, when the *Langseth* began acquisition of Trehu survey lines. The *Langseth* returned to Carbotte survey lines at 3:45 UTC on 6 July and completed all survey lines at 8:12 UTC on 7 July when the seismic gear was brought on board and the *Langseth* began transit to Astoria, Oregon arriving at 20:00 UTC on 8 July 2012. Table 3 outlines the dates and times of acquisition for each survey line.

Table 3. Juan de Fuca Plate marine geophysical survey multi-channel seismic and ocean bottom seismometer survey lines acquired.

Survey Line	Date Acquisition Commenced	Time Acquisition Commenced	Date Acquisition Completed	Time Acquisition Completed
MGL1211OBS03 Seq001	14-Jun-2012	20:22	16-Jun-2012	22:13
MGL1211OBSFS01 Seq002	17-Jun-2012	00:44	17-Jun-2012	12:47
MGL1211OBS01A Seq003	17-Jun-2012	22:12	17-Jun-2012	23:35
MGL1211OBST01 Seq004	17-Jun-2012	23:41	18-Jun-2012	09:17
MGL1211OBST02 Seq005	18-Jun-2012	09:34	19-Jun-2012	02:35
MGL1211OBST02A Seq006	19-Jun-2012	14:49	20-Jun-2012	13:54
MGL1211MCS02 Seq007	21-Jun-2012	04:51	21-Jun-2012	10:55
MGL1211MCS02A Seq008	21-Jun-2012	21:45	22-Jun-2012	14:25
MGL1211MCST02 Seq009	22-Jun-2012	17:09	22-Jun-2012	19:00
MGL1211MCST02A Seq010	22-Jun-2012	19:23	22-Jun-2012	20:54
MGL1211MCST03 Seq011	22-Jun-2012	21:09	22-Jun-2012	23:09
MGL1211MCS02B Seq012	22-Jun-2012	23:10	23-Jun-2012	03:38
MGL1211MCS03 Seq013	23-Jun-2012	04:02	23-Jun-2012	05:06
MGL1211OBS03B Seq014	23-Jun-2012	05:27	23-Jun-2012	09:11
MGL1211MCS03A Seq015	23-Jun-2012	09:14	25-Jun-2012	13:13
MGL1211MCST02 Seq016	25-Jun-2012	19:46	26-Jun-2012	00:41
MGL1211MCS01 Seq017	26-Jun-2012	01:29	28-Jun-2012	12:43
MGL1211MCST05 Seq018	28-Jun-2012	12:55	28-Jun-2012	15:47
MGL1211MCSAX1 Seq019	28-Jun-2012	16:43	28-Jun-2012	20:28
MGL1211MCST06 Seq020	28-Jun-2012	21:08	28-Jun-2012	23:45
MGL1211MCSAX2 Seq021	29-Jun-2012	01:04	29-Jun-2012	05:16
MGL1211MCS01A Seq022	29-Jun-2012	08:45	29-Jun-2012	12:00
MGL1211OBS01 Seq023	29-Jun-2012	12:03	29-Jun-2012	17:55
MGL1211OBSSF02A Seq024	29-Jun-2012	18:06	30-Jun-2012	04:04
MGL1211OBS04 Seq025	30-Jun-2012	04:22	30-Jun-2012	15:37
MGL1211OBSFS02B Seq026	30-Jun-2012	15:53	1-Jul-2012	01:14
MGL1211OBS01A Seq027	1-Jul-2012	01:31	1-Jul-2012	13:06
MGL1211OBS01B Seq028	1-Jul-2012	20:26	3-Jul-2012	05:02
MGL1211OBS01C Seq029	3-Jul-2012	08:47	3-Jul-2012	21:02
MGL1211OBST02 Seq039	6-Jul-2012	03:45	6-Jul-2012	16:36
MGL1211OBSFS03 Seq040	6-Jul-2012	16:39	7-Jul-2012	08:12
MGL1211OBS03A Seq041	7-Jul-2012	08:18	7-Jul-2012	19:47

The acoustic source was active throughout the survey, with multiple periods of source silence, for a total of 447 hours 35 minutes of source activity. This includes ramp-up of the airguns, full power and partial power firing both online and during line changes, and operation of a single 40 in^3 mitigation airgun (Figure 4). The mitigation source was to be used during mitigation power-downs initiated for protected species inside the safety radius as well as for mechanical/technical reasons and was active for 22 hours 36 minutes during the survey. Full power source operations, while online, accounted for 86% (384 hours 04 minutes) of airgun activity during the project. Also because the data was still usable while shooting at partial power (volume ranging from 3300 in^3 to 4950 in^3) portions of survey lines were sometimes shot using partial power while maintenance was performed on an array, accounting for 6 hours 17 minutes of array activity. Line changes were all shot at full or partial power, totalling 26 hours 29 minutes of array activity. Additionally, the full volume of the acoustic source (36 airguns firing) ranged from 6140 in^3 to 6600 in^3, caused by various guns of different sizes being changed out on the arrays.

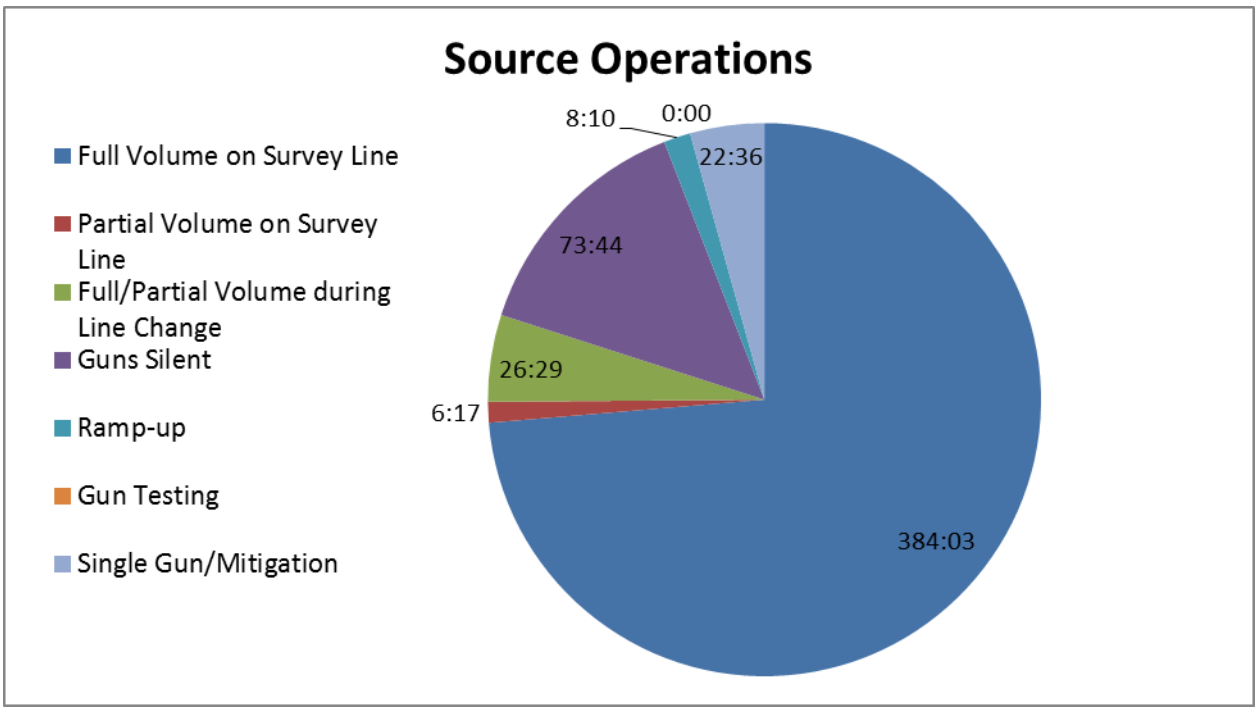

Figure 4. Total acoustic source operations.

The acoustic source was ramped-up 15 times over the course of the survey in order to commence full power survey operations: once to begin production at the beginning of the survey, once to resume operations after deploying the acoustic streamer, and 13 times after mitigation shut-downs that resulted in the acoustic source being off for longer than eight minutes (Table 4). Fourteen of the ramp-ups ranged from 30 to 34 minutes. With one ramp-up lasting 49 minutes because the acoustic arrays were still being deployed during ramp-up. The ramp ups were conducted using the NMFS approved automated gun controller program, DigiShot which adds guns sequentially to achieve full source over the required period of time. Since a doubling of the number of airguns is typically equal to a 6 dB increase in sound level, the array was not ramped up if more than half of the airguns in the array were already firing.

Table 4. Total acoustic source operations during the Juan de Fuca Plate marine geophysical survey.

Acoustic Source Operations	Number	Duration (hh:mm)
Gun Tests		**0:00**
Ramp-up	**15**	**8:10**
Day time ramp-ups from silence	**4**	
Day time ramp-ups from mitigation	**10**	
Night time ramp-ups from mitigation	**1**	
Full power survey acquisition		**384:03**
Partial power survey acquisition		**6:17**
Full/partial power line changes		**26:29**
Single airgun (40 in³)		**22:36**
Total time acoustic source was active		**447:35**

4.2. VISUAL MONITORING SURVEY SUMMARY

The PSOs began visual observations immediately upon departure and while in transit to the survey site. This was done to collect baseline data about protected species abundance in the area. Visual monitoring began at 2:00 UTC on 14 June 2012 and continued until 4:52 UTC on 8 June 2012 the evening before the vessel arrived in Astoria, Oregon at the completion of the survey project. Visual monitoring was over a period of approximately 22 days. Monitoring was conducted by two PSOs each day between just before dawn until just after dusk, when it was too dark for the entire safety radius to be visible, averaging approximately 17 hours of visual observations per day.

The acoustic source was active during the majority of visual monitoring (83%) and the majority of acoustic monitoring (95%), as shown in Figure 5.

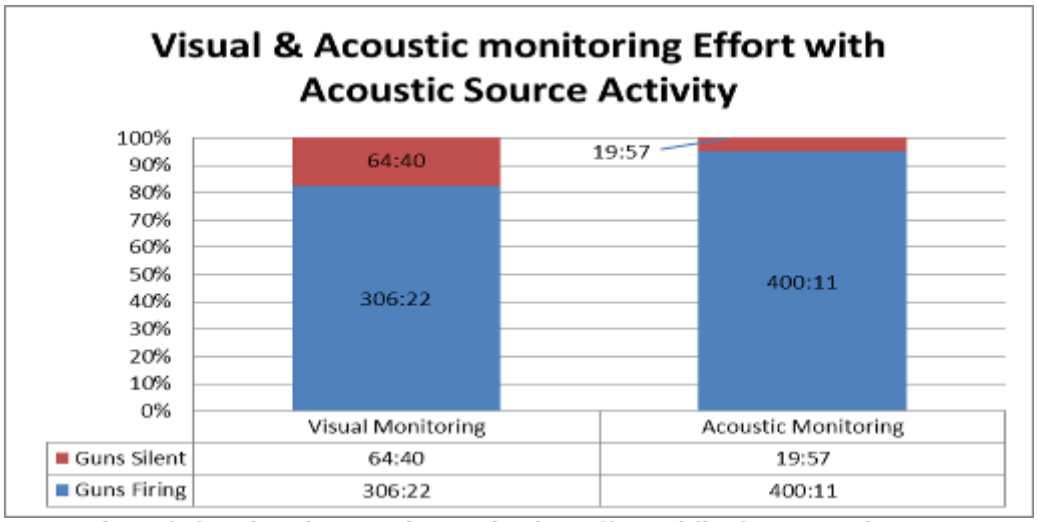

Figure 5. Duration of visual and acoustic monitoring effort while the acoustic source was active vs. silent.

Total visual monitoring effort, separated into monitoring effort while the acoustic source was active and monitoring effort while the source was silent, is listed in Table 5.

Table 5. Total visual monitoring effort.

Visual Monitoring Effort	Duration (hh:mm)
Total monitoring while acoustic source active	306:22
Total monitoring while acoustic source silent	64:40
Total monitoring effort	**371:02**

The PSOs preferred to conduct visual observations from the PSO tower, which provided the PSOs with a 360° view of the water around the vessel and acoustic source. However, visual watches would be conducted from the catwalk or bridge for any health or safety reason or during periods with high winds, large swells, or heavy rain. As Figure 6 demonstrates approximately 91% of visual monitoring was conducted from the PSO tower during the Juan de Fuca Plate marine geophysical survey.

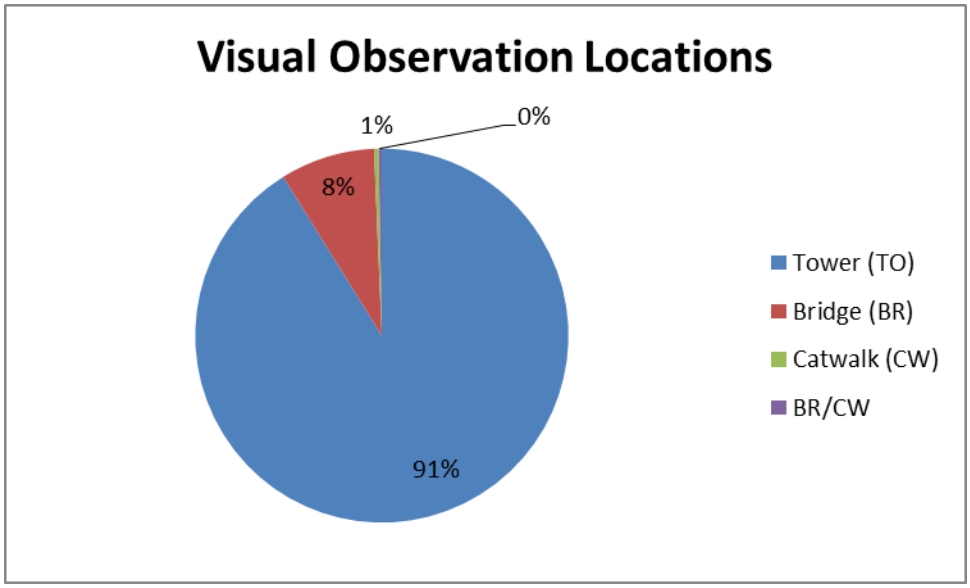

Figure 6. Total visual effort from observation locations on board the R/V *Langseth*.

4.3. ACOUSTIC MONITORING SURVEY SUMMARY

The hydrophone cable was deployed for the first time on 14 June 2012 after the vessel had completed deployment of the source arrays. Acoustic monitoring began immediately at 16:36 UTC and continued throughout the project with PSOs monitoring the hydrophones aurally and monitoring the *Pamguard* detection software visually both day and night. Acoustic monitoring for the project ended at 19:30 on 7 July 2012 when the hydrophone cable was retrieved, just before the completion of the acquisition of the final survey line. Over the course of the project, PSOs conducted 420 hours 08 minutes of acoustic monitoring, all but 20 hours 05 minutes occurred while the acoustic source was active (Table 6).

Table 6. Total passive acoustic monitoring (PAM) effort.

Passive Acoustic Monitoring Effort	Duration (hh:mm)
Total night time monitoring	**136:24**

Total day time monitoring	**283:44**
Total monitoring while acoustic source active	**400:03**
Total monitoring while acoustic source silent	**20:05**
Total acoustic monitoring	**420:08**

The majority of acoustic monitoring downtime (43 hours 10 minutes) was attributed to weather when the cable was retrieved to prevent entanglement with the seismic gear. The cable would remain on board until the sea state had decreased to a sufficient level to ensure the cable was safe to deploy. The hydrophone cable was retrieved in order to deploy and then later retrieve the seismic streamer, accounting for 21 hours 38 minutes of acoustic monitoring downtime. Acoustic monitoring was suspended for a total of 14 hours 55 minutes when the cable was retrieved for numerous instances of seismic repairs and maintenance. Twenty-two minutes of acoustic monitoring downtime can be attributed to entanglement when the hydrophone cable was retrieved to insure it had not been entangled with the XBT wires. A description of each instance of acoustic monitoring downtime is located in Appendix E.

Table 7. Passive acoustic monitoring (PAM) downtime.

Passive Acoustic Monitoring Downtime	Duration (hh:mm)
Weather	**43:10**
Streamer deployment and retrieval	**21:38**
Seismic equipment repairs and maintenance	**14:55**
Entanglement	**00:22**
Total Passive Acoustic Monitoring Downtime	**80:05**

4.4. SIMULTANEOUS VISUAL AND ACOUSTIC MONITORING SUMMARY

While visual observations began at 2:00 UTC 14 June 2012, acoustic observations began later that day at 16:36 UTC, due to the hydrophone cable needing to be deployed after the airgun arrays to avoid entanglement. Of the total observation effort performed by PSOs during this survey, visual monitoring accounted for 47% (371 hours 02 minutes) while acoustic monitoring accounted for 53% (420 hours 08 minutes). As displayed in Figure 7 there were 283 hours 44 minutes of simultaneous visual and acoustic observations conducted during this survey. Simultaneous visual and acoustic monitoring accounted for 68% of total acoustic monitoring and 76% of the total visual observation.

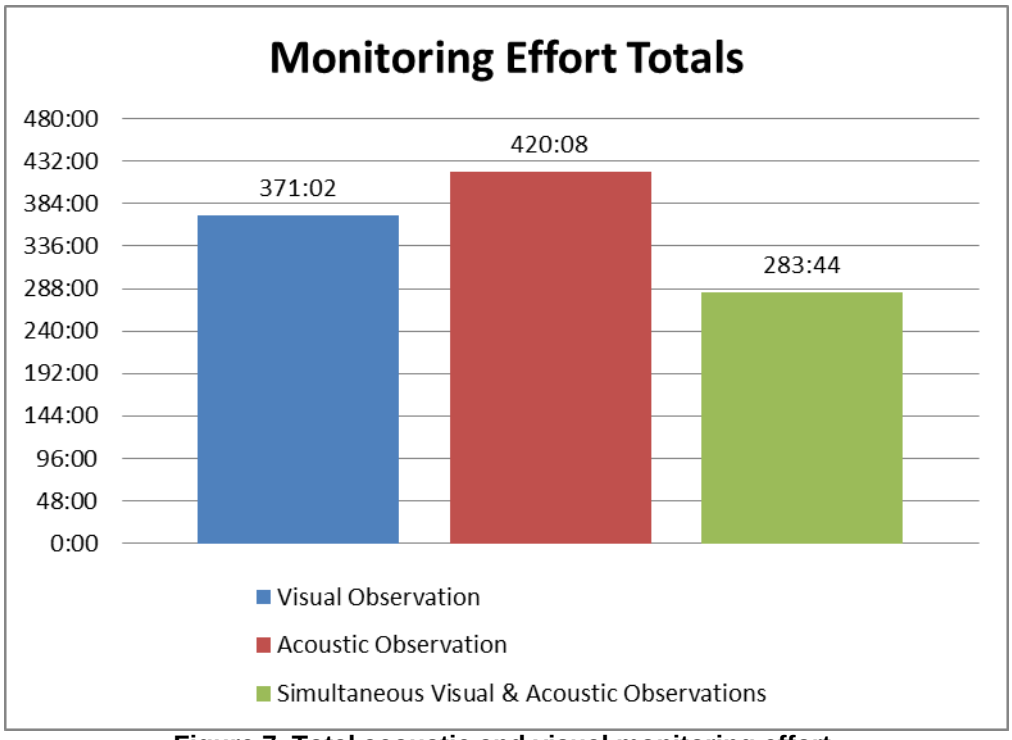

Figure 7. Total acoustic and visual monitoring effort.

4.5. ENVIRONMENTAL CONDITIONS

The majority of visual monitoring effort was conducted during good observation conditions. Throughout the project there was heavy cloud cover, with only a few scattered days of cloud cover under 40%. Periods of fog and light to heavy rain were frequent throughout the survey and did at times affect visual observations. A total of 30 hours of precipitation was recorded, as well as 36 hours of fog. The safety radii were almost always visible, with the exception of just a couple hours during weeks one, two and three. Visibility remained at an average of 7.5 kilometers for the majority of the survey.

The Beaufort sea state ranged from levels 0 through 6 but the average remained at a level 3 throughout the entire survey (Figure 8).

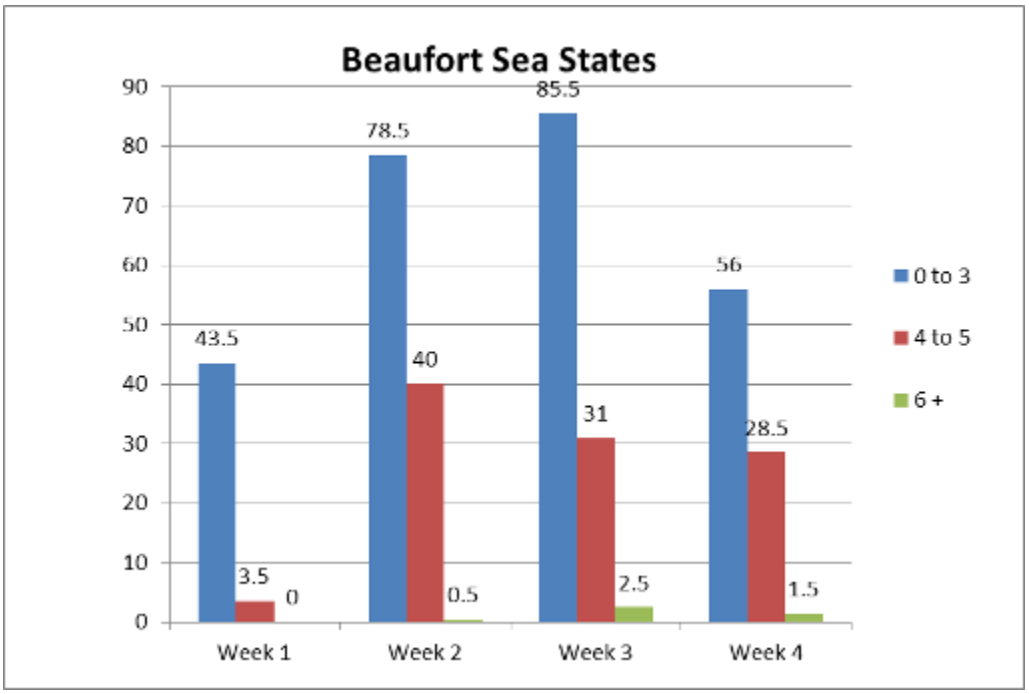

Figure 8. Beaufort sea state during visual monitoring over the marine geophysical survey.

Wind forces remained relatively stable throughout the survey with a minimum of 0 knots present during weeks two, three and four; and a maximum of 29 knots during the fourth week. Forces less than 10 knots were present for 211 hours during the survey, and forces from 11-21 knots were present for 141.5 hours during the survey. Forces greater than 22 knots were only recorded for 16.5 hours during the survey, largely in the final hours of week four (Figure 9).

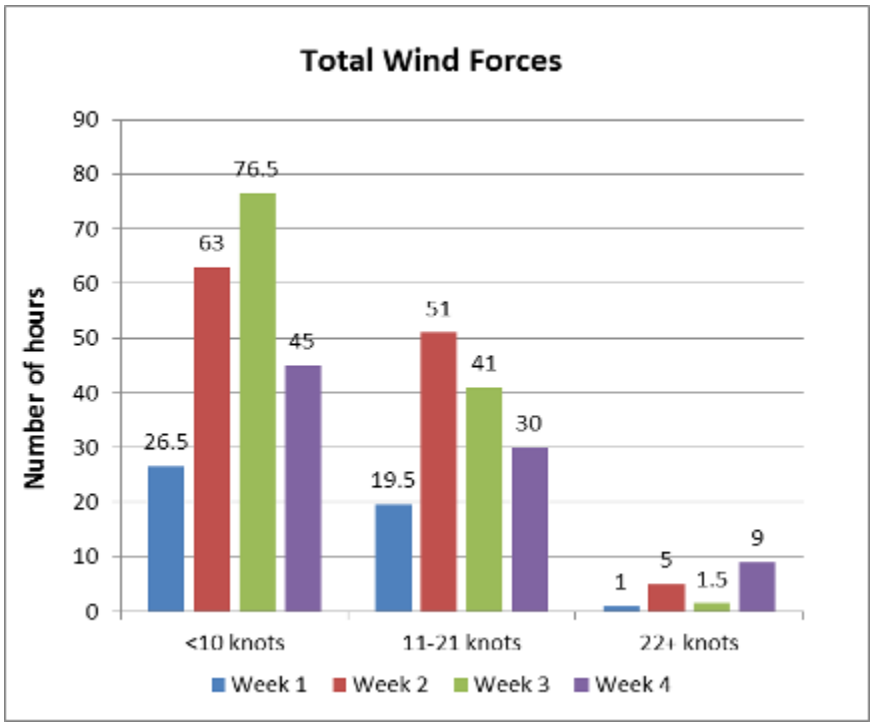

Figure 9. Average wind force each week during visual monitoring.

Swell height also remained relatively stable throughout the survey with 315 hours of swells under two meters, and only 54 hours of swells from 2-4 meters. There were no swells recorded over four meters (Figure 10).

Figure 10. Swell heights while visual monitoring was conducted.

5. MONITORING AND DETECTION RESULTS

5.1. VISUAL DETECTIONS

Visual monitoring conducted during the Juan de Fuca Plate marine geophysical survey resulted in the collection of 121 records of detection for protected species (summarized in Appendix F). Eight species of marine mammal were positively identified, along with unidentified baleen whales, unidentified whales, unidentified small cetaceans, unidentified dolphins, and unidentified pinnipeds. The total number of detection events and total number of animals recorded by species is described in Table 8.

A complete list of bird species and other marine life observed and identified in addition to the approximate number of individuals observed and the number of days on which they were observed can be found in Appendix G.

Table 8. Number of visual detection records collected for each protected species.

	Total Number of Detection Records	Total Number of Animals Recorded
Cetaceans		
Unidentified whale	9	10
Mysticetes		
Fin whale	8	19
Sei whale	2	4
Humpback whale	6	8
Unidentified baleen whale	5	7
Odontocetes		
Northern right whale dolphin	7	231
Pacific white-sided dolphin	15	231
Dall's porpoise	19	144
Unidentified dolphin	3	13
Unidentified small cetacean	2	11
Pinnipeds		
Northern fur seal	31	63
Steller sea lion	2	2
Unidentified pinniped	12	13
TOTAL	**121**	**756**

There were many sightings of protected species during the Juan de Fuca Plate marine geophysical survey with only one day where no protected species were observed (Figure 11). The majority of the sightings occurred during the first half of the survey while close to shore and on the northern end of the survey area. Most of the sightings of small cetaceans and pinnipeds occurred in this northern area. While most sighting of large whales occurred during the second half of the survey while the *Langseth* was in the southern half of the prospect.

Of the 121 protected species detection events during the Juan de Fuca Plate marine geophysical survey, 86 detections (71%) occurred while the acoustic source was active and 35 detections (29%) occurred while the acoustic source was silent. Figure 12 demonstrates the species detected compared to airgun activity.

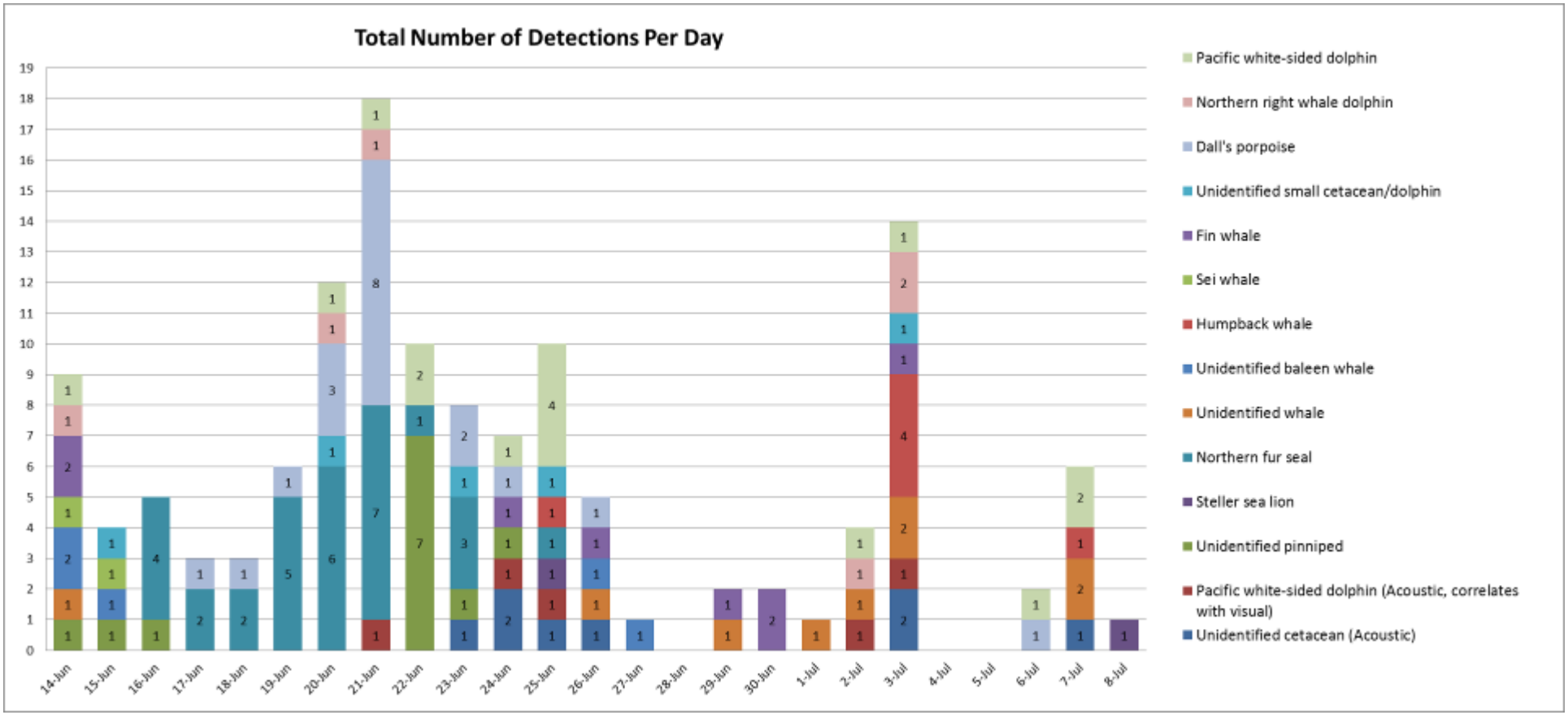

Figure 11. Number of protected species detections each day of the Juan de Fuca Plate marine geophysical survey.

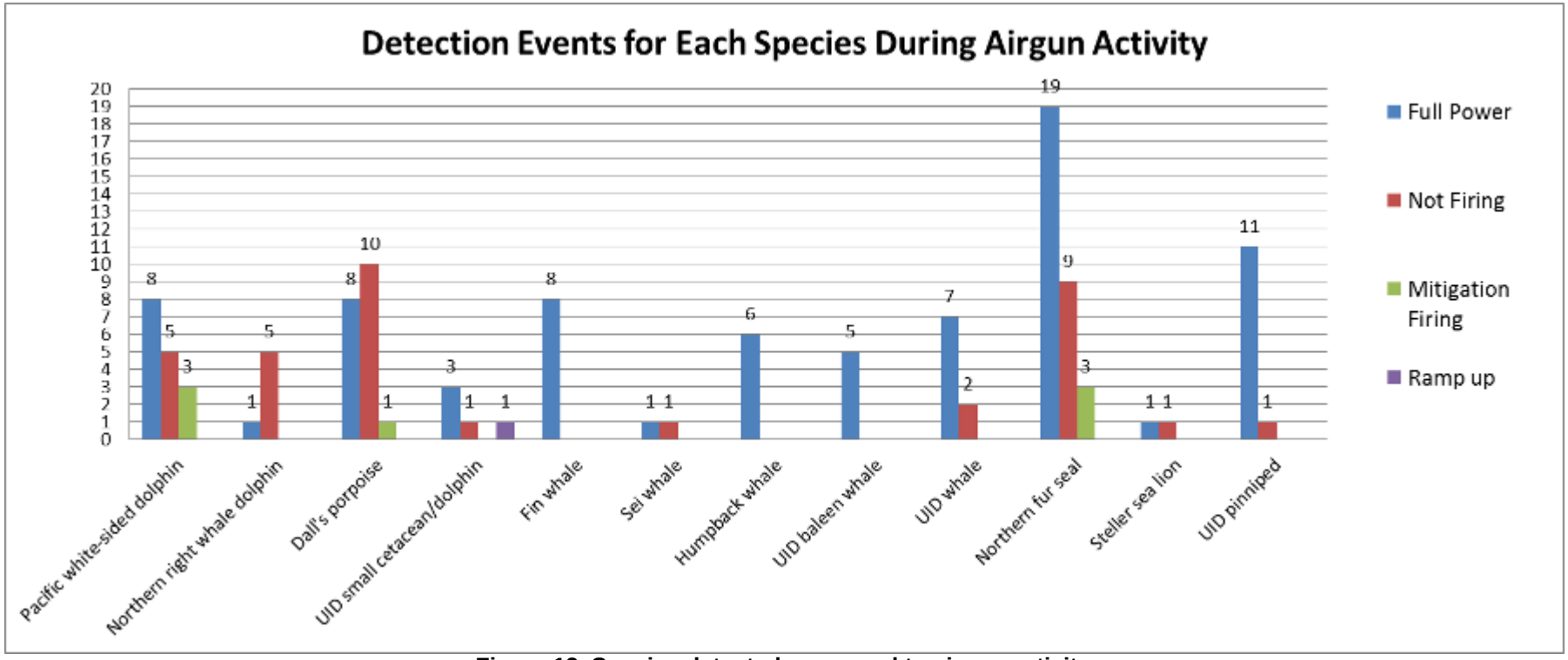

Figure 12. Species detected compared to airgun activity

Table 9 demonstrates the average closest approach of protected species to the source at various volumes.

Table 9. Average closest approach of protected species to the acoustic source at various volumes.

Species Detected	Full Power (6140-6600 in³)		Single Airgun 40 in³		Ramp-up		Not Firing	
	Number of detections	Average closest approach to source (meters)	Number of detections	Average closest approach to source (meters)	Number of detections	Average closest approach to source (meters)	Number of detections	Average closest approach to source (meters)
Fin whale	8	1127	-	-	-	-	-	-
Sei whale	1	2100	-	-	-	-	1	400
Humpback whale	6	2233	-	-	-	-	-	-
Unidentified baleen whale	5	2823	-	-	-	-	-	-
Unidentified whale	7	3281	-	-	-	-	2	3014
Northern right whale dolphin	1	2000	-	-	-	-	7	700
Pacific white-sided dolphin	8	291	3	152	-	-	4	430
Dall's porpoise	8	320	1	250	-	-	10	684
Unidentified dolphin	2	605	-	-	1	3922	-	-
Unidentified small cetacean	1	2850	-	-	-	-	1	240
Northern fur seal	19	112	3	1	-	-	9	117
Steller sea lion	1	300	-	-	-	-	1	250
Unidentified pinniped	11	423	-	-	-	-	1	100

Cetaceans were detected most frequently, consisting of 63% (76 detection records) of the total records. Figure 13 demonstrates the total number of animals observed, per species, during the detection events. The two most abundant species observed were Northern right whale dolphins with seven detections totaling 231 animals and Pacific white-sided dolphins with 15 detections also totaling 231 animals. These dolphins were often observed together in mixed pods. The most detection records were collected for Northern fur seals with 31 detections totaling 63 animals.

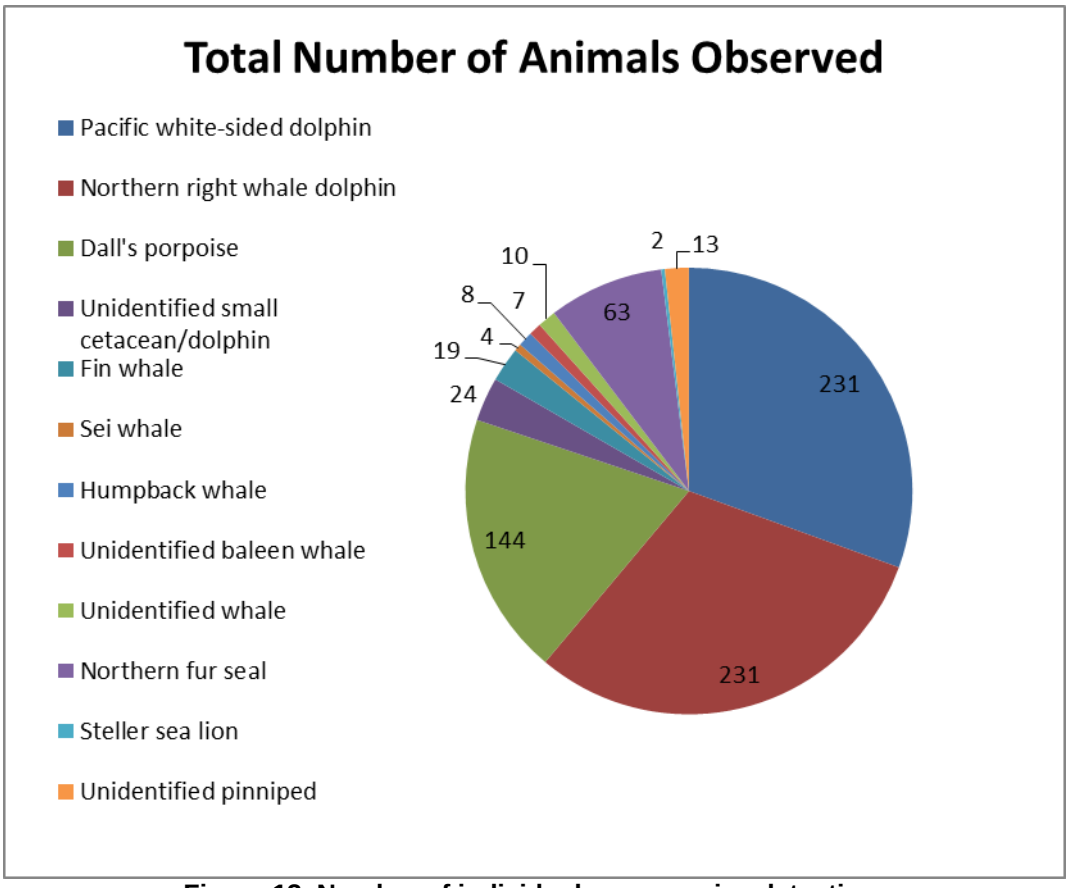

Figure 13. Number of individuals per species detection.

5.1.1. Cetacean Detections

The spatial distribution of cetacean detections can be seen in Figure 14.

5.1.1.1. Fin whale

There were eight sightings of fin whales (*Balaenoptera physalus*) during the survey, totaling for 19 individuals observed. Four of these observations resulted in power-downs, one was observed while the source was already powered down, and three required no mitigation action. There was a total of 1 hour 53 minutes of mitigation down time. The whales were noted to be in depths ranging from 2369 to 2940 meters, and Latitudes between 44.40162˚N to 45.89308˚N. The largest group size was six individuals observed on 14 June. There were four additional observations with two to three individuals, and the remainder of the observations were of one fin whale. The closest approach to the sound source was 80 meters on 26 June.

5.1.1.2. Sei whale

There were two sightings of sei whales (Balaenoptera *borealis*), totaling four individuals observed during the survey. Both of these sightings occurred in the first week, and neither resulted in a mitigation action. The first sighting was of three individuals who came within 400 meters of the vessel however the vessel was in transit so all seismic gear was on board. The second sighting was of one individual well outside of the 180 dB safety radius.

5.1.1.3. Humpback whale

There were eight individual humpback whales (*Megaptera novaeangliae*) observed in six sightings. These all occurred in weeks three and four of the cruise. Three of these

observations resulted in power-downs and three of these required no mitigation action. There was a total of 1 hour 6 minutes of mitigation downtime. The whales were noted to be in depths ranging from 86 to 1266 meters, however all but one sighting occurred in water depths less than 500 meters. Group sizes ranged from one to two individuals; often a mother and calf. The closest approach to the vessel was 220 meters on 3 July.

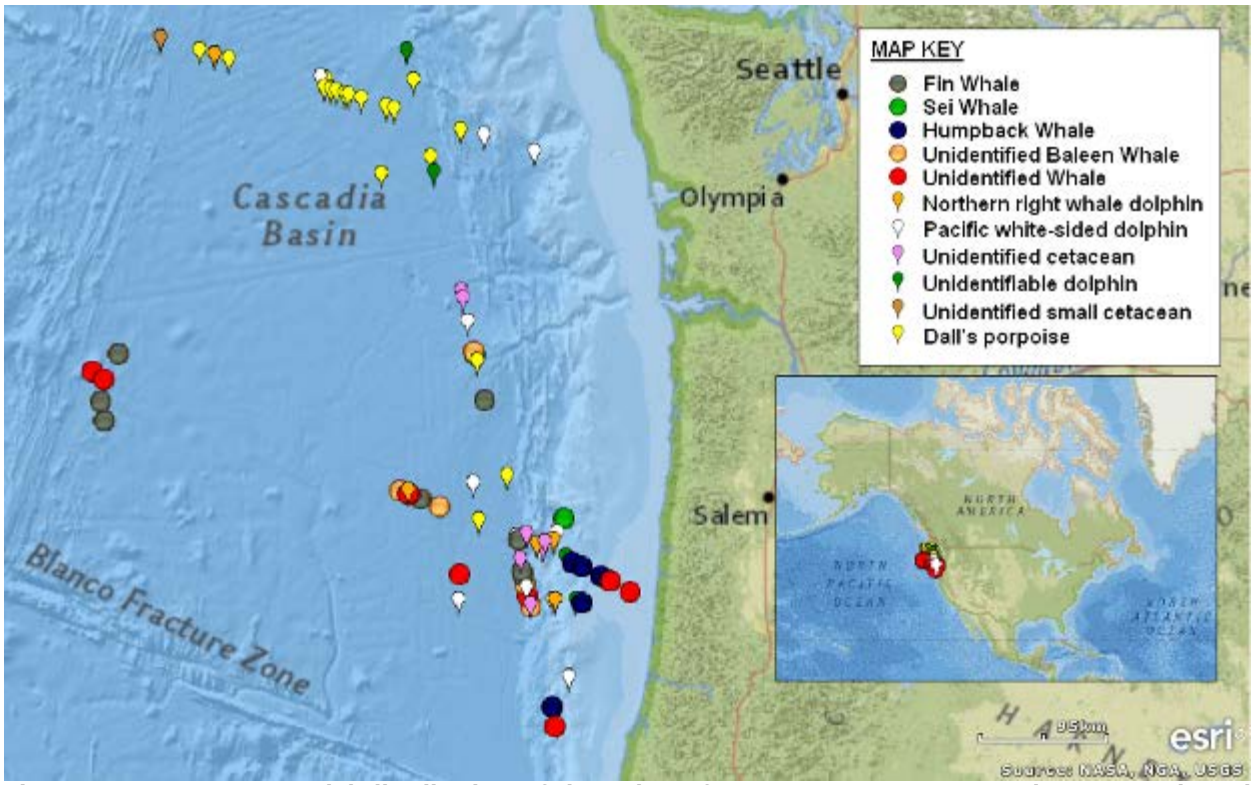

Figure 14. Cetacean spatial distribution of detections from 14 June 2012 – 8 July 2012 on board the *Langseth.*

5.1.1.4. Northern right whale dolphin

There were 231 individual Northern right whale dolphins (*Lissodelphis borealis*) observed in seven sightings. None of these detections led to mitigation actions as the vessel was either in transit, had the acoustic source on board, or was already powered-down due to another visual detection. Large group sizes were observed on 21 June and 3 July, 165 and 28 individuals respectively. It should also be noted that on most occasions they were observed in mixed pods with Pacific white-sided dolphins.

5.1.1.5. Pacific white-sided dolphin

There were 231 individual Pacific white sided dolphins (*Lagenorhynchus obliquidens*) observed in 15 sightings. These detections triggered two power-downs, three shut-downs, and five power-downs that were then followed by shut-downs. There were five sightings that required no mitigation action. There was a total of 9 hours 13 minutes of mitigation down time, accounting for 16.1% of total downtime. On 3 July the dolphins were inside the exclusion zone for an extended period of time, resulting in 3 hours 49 minutes of mitigation down time. The dolphins were noted to be in depths ranging from 400 to 2946 meters. They were noted as close as 1 meter to the vessel and sound source. Two large group sizes were seen on 25 June and 3 July, with 56 and 50 individuals respectively. The other 13 detections had group sizes ranging from 2-27 individuals.

5.1.1.6. Dall's porpoise

There were 144 individual Dall's porpoises (*Phocoenoides dalli*) observed during 19 sightings. The majority of these detections (16) occurred in week two of the survey cruise. These detections led to eight power-downs and three delayed soft-starts. During three of these observations the acoustic source was already shut-down for other detections, and in five observations the acoustic source was not active due to transit or maintenance. There was a total of 2 hours 40 minutes of mitigation downtime. A large group of 30 individuals was observed on 26 June however the most common group size was 4-8 individuals. The closest approach to the vessel was 15 meters on 17 June.

5.1.1.7. Unidentified baleen whale

There were five sightings of unidentified baleen whales and seven individuals observed during the survey. These occurred in week one and three. These detections led to two power-downs and a total of 1 hour 30 minutes of mitigation downtime. Three of these detections required no mitigation action due to their distance from the acoustic source. This large distance prevented observers from making a positive identification.

5.1.1.8. Unidentified whale

There were nine sightings of unidentified whales and 10 individuals observed during the survey. None of these detections required mitigation actions due to their distance from the acoustic source. This large distance prevented observers from making a positive identification.

5.1.1.9. Unidentified cetaceans

There were five sightings of unidentified cetaceans and 24 individuals observed during the survey cruise. Three of these sightings and 13 individuals were unidentified dolphins. Two of these detections led to power-downs and a total of 24 minutes of mitigation downtime. The other three detections required no mitigation action.

5.1.2. Pinniped Detections

The spatial distribution of pinniped detections can be seen in Figure 15.

5.1.2.1. Northern fur seal

Northern fur seals (*Callorhinus ursinus*) were positivity identified on 31 occasions; with a total of 63 individuals observed. The majority of these detections (26 detections and 53 individuals) occurred during the second week of the cruise. These detections led to 12 power-downs, 12 shut-downs and four delayed soft-starts. There were three observations that required no mitigation action due to the acoustic source being on board for maintenance. There was a total of 39 hours 4 minutes of mitigation downtime, accounting for 68.1% of total downtime. In 10 of the total 31 sightings the fur seals were observed 'playing' in the gun strings, resulting in mitigation downtime extending over an hour. The seals were noted to be in depths ranging from 1259 to 2654 meters. They were noted as close as one meter to the vessel and one meter to the sound source.

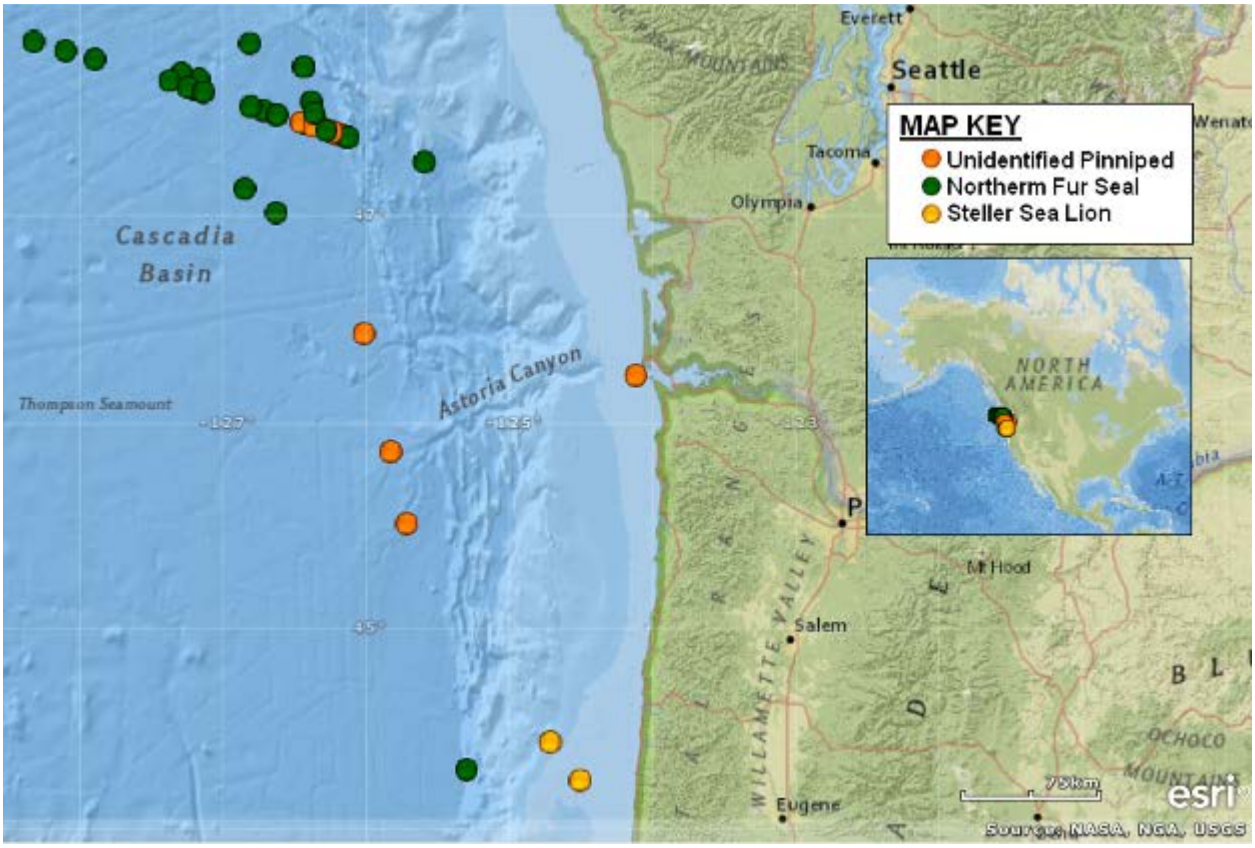

Figure 15. Pinniped spatial distribution of detections from 14 June 2012 – 8 July 2012 on board the *Langseth.*

5.1.2.2. Steller sea lion

Two Steller sea lions (*Eumetopias jubatus*) were observed during the survey. The first sighting occurred on 25 June, while the sound source was active. This resulted in a mitigation power-down, for a total of 13 minutes downtime, before the sea lion was seen to leave the exclusion zone. The sea lions' closest approach to the vessel was 300 meters. The second sighting was on 8 July during transit, so the sound source was not active and no mitigation action was required. This sea lions' closest approach to the vessel was 20 meters.

5.1.2.3. Unidentified pinniped

There were 12 sightings of unidentified pinnipeds and 13 individuals observed during the survey. These detections led to six power-downs and a total of 1 hour 17 minutes of mitigation downtime.

5.2. ACOUSTIC DETECTIONS

5.2.1. Cetacean Detections

There were 14 acoustic detections on the PAM system during the Carbotte survey; nine detections of unidentified cetaceans, four detections of Pacific white-sided dolphins, and one detection of a possible mix of Northern right whale dolphins and Pacific white-sided dolphins. Acoustic detection 1 corresponds with visual detection 47- Northern right whale dolphins and 48- Pacific white-sided dolphins. Acoustic detections 5, 7, 8, 10, and 11, correspond with visual detections 77, 81, 86, 100, and 104, respectfully; pods of Pacific white-sided dolphins.

Multiple high frequency click trains were observed visually on the high frequency click detector

(Figures 16, 17, 18, 19, 21, 22, 23 and 24) for all fourteen detections. Faint whistles were seen on the low frequency *Pamguard* spectrogram (Figure 21) and heard aurally on detections 6, 7, 10 and 11. Detections 1-5, 8-9, and 12-14 were not observed on the low frequency *Pamguard* Spectrogram or Whistle and Moan detector, or heard aurally by the PAM operator.

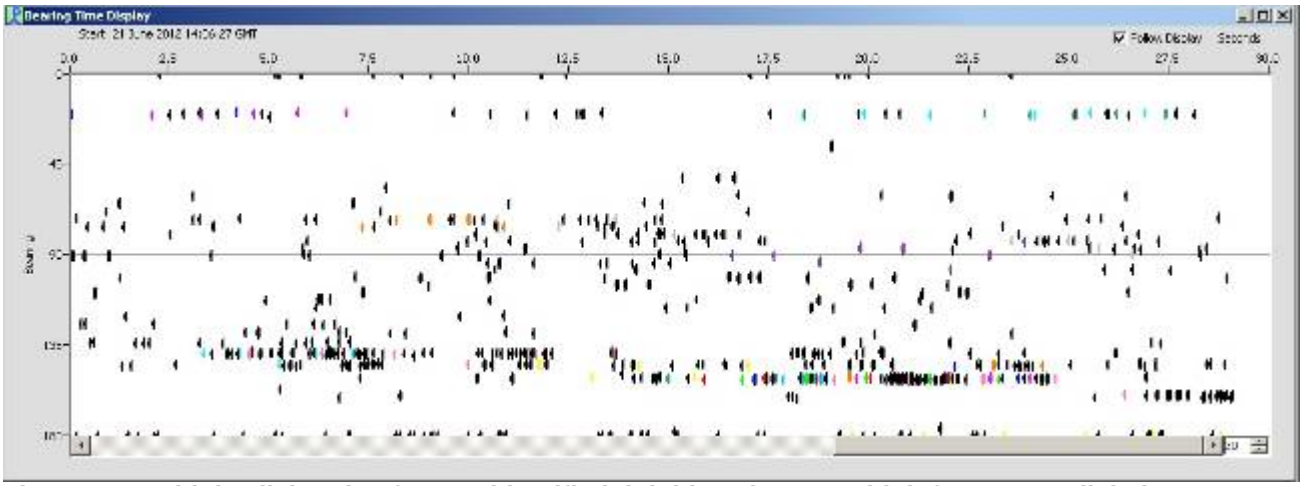

Figure 16. Multiple click trains from unidentified dolphins shown on high frequency click detector on 21 June corresponding with visual detection 47 and 48 of Pacific white-sided dolphins and Northern right whale dolphins (acoustic detection 1).

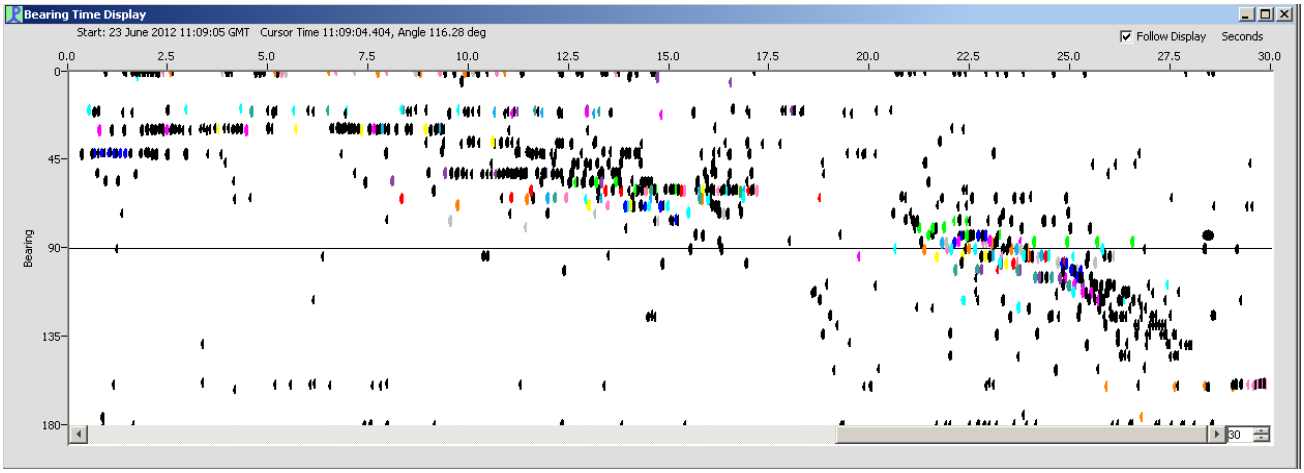

Figure 17. Multiple click trains from unidentified cetaceans shown on high frequency click detector on 23 June (acoustic detection 2).

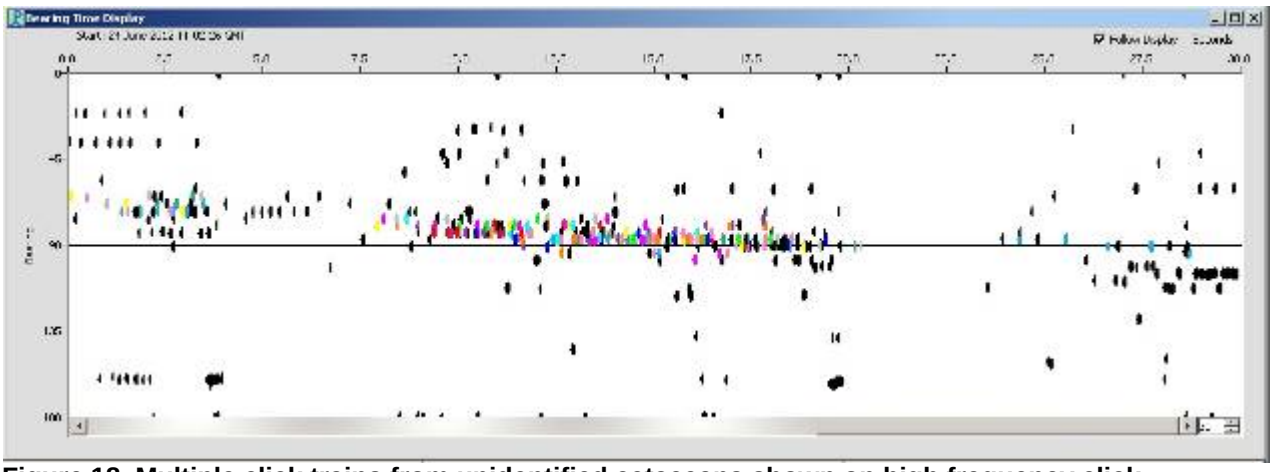

Figure 18. Multiple click trains from unidentified cetaceans shown on high frequency click detector on 24 June (acoustic detection 4).

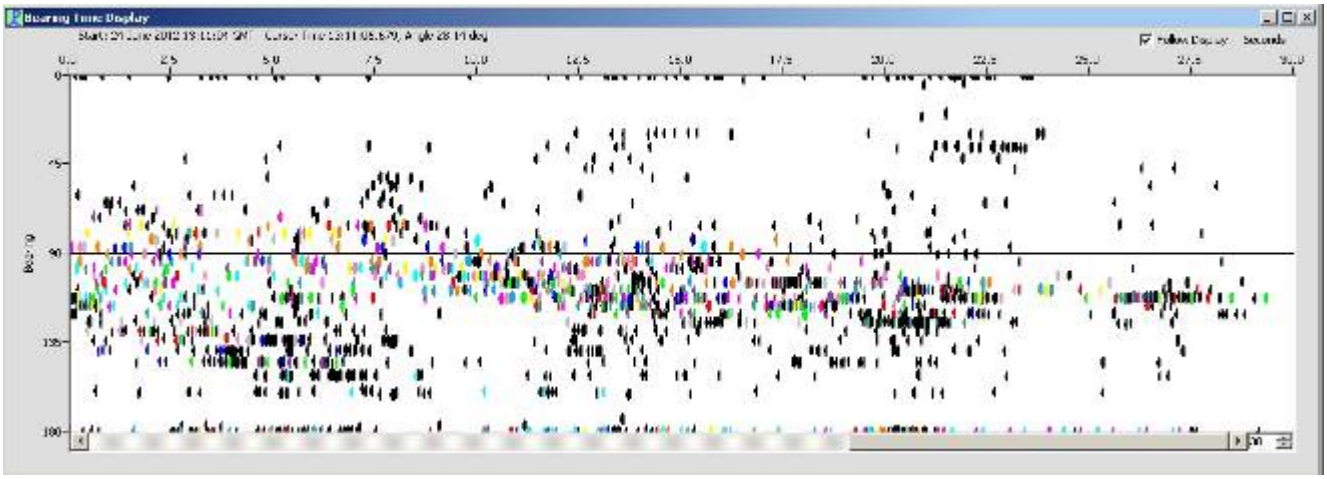

Figure 19. Multiple click trains from unknown number of Pacific white-sided dolphins shown on high frequency click detector on 24 June corresponding with visual detection 77 (acoustic detection 5).

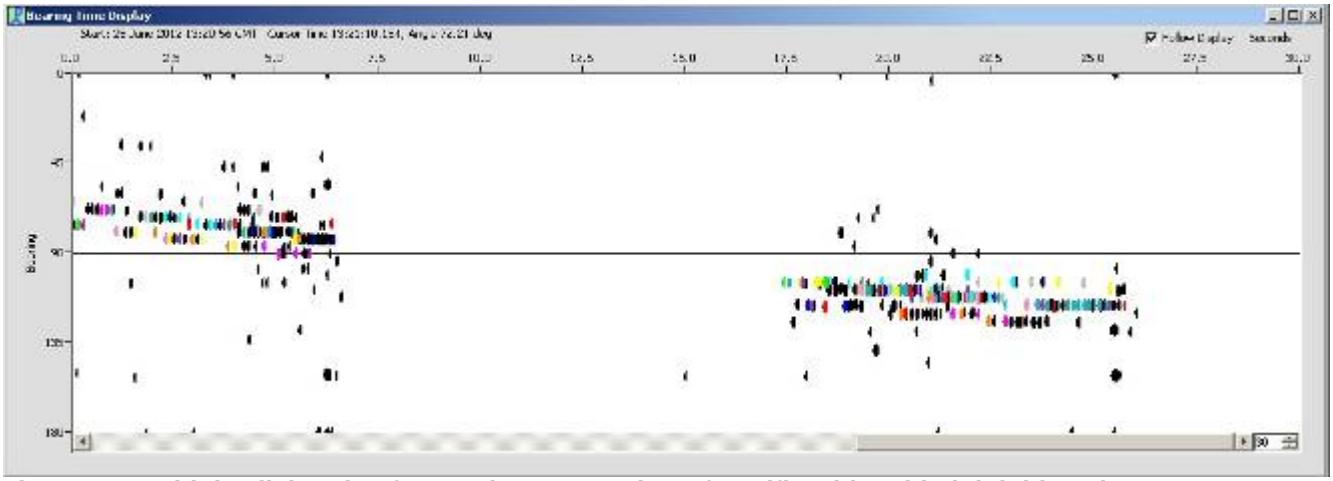

Figure 20. Multiple click trains from unknown number of Pacific white-sided dolphins shown on high frequency click detector on 25 June corresponding with visual detection 81 (acoustic detection 7).

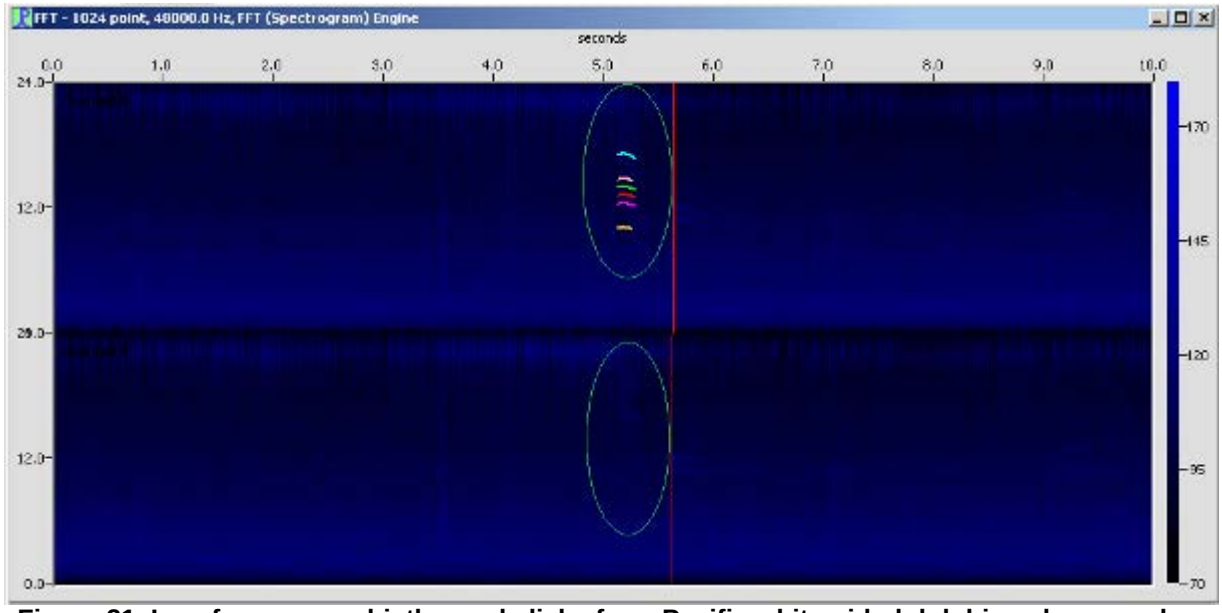

Figure 21. Low frequency whistles and clicks from Pacific white-sided dolphins shown on low frequency spectrogram on 2 July corresponding with visual detection 100 (acoustic detection 10).

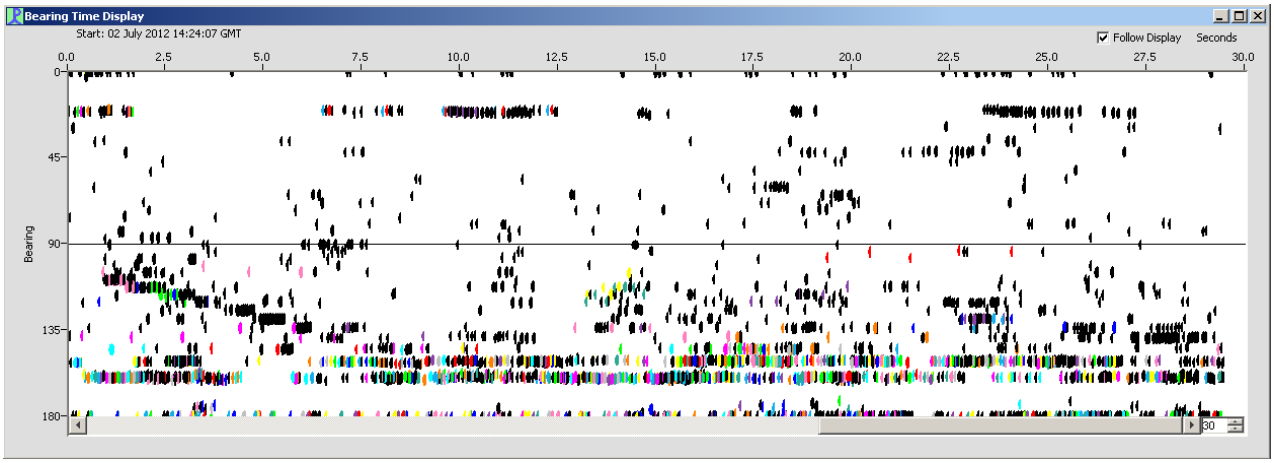

Figure 22. Multiple click trains from Pacific white-sided dolphins shown on high frequency click detector on 2 July corresponding with visual detection 100 (acoustic detection 10).

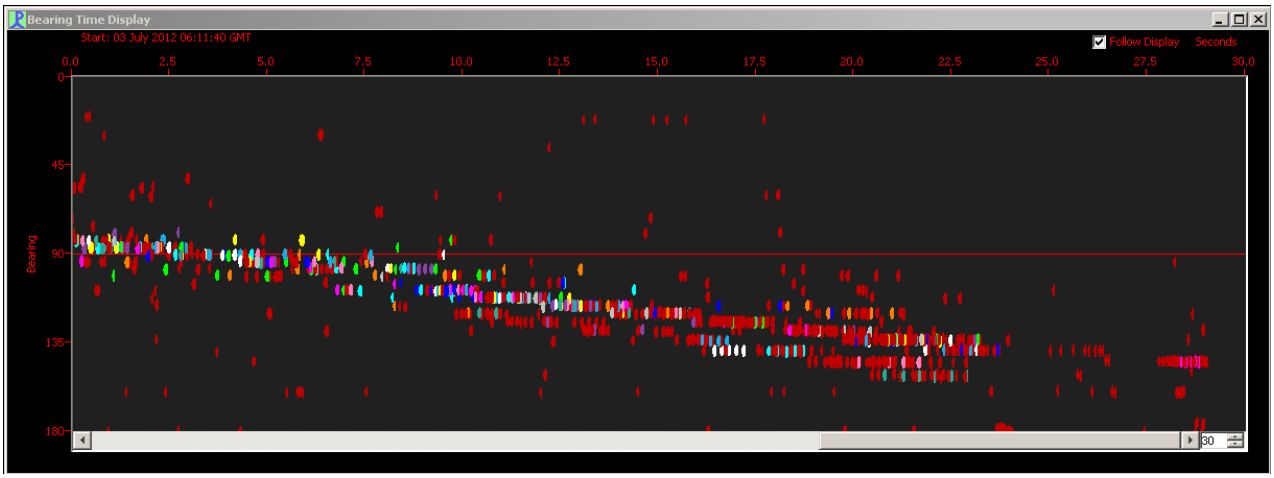

Figure 23. Multiple click trains from unidentified cetacean shown on high frequency click detector on 3 July (acoustic detection 12).

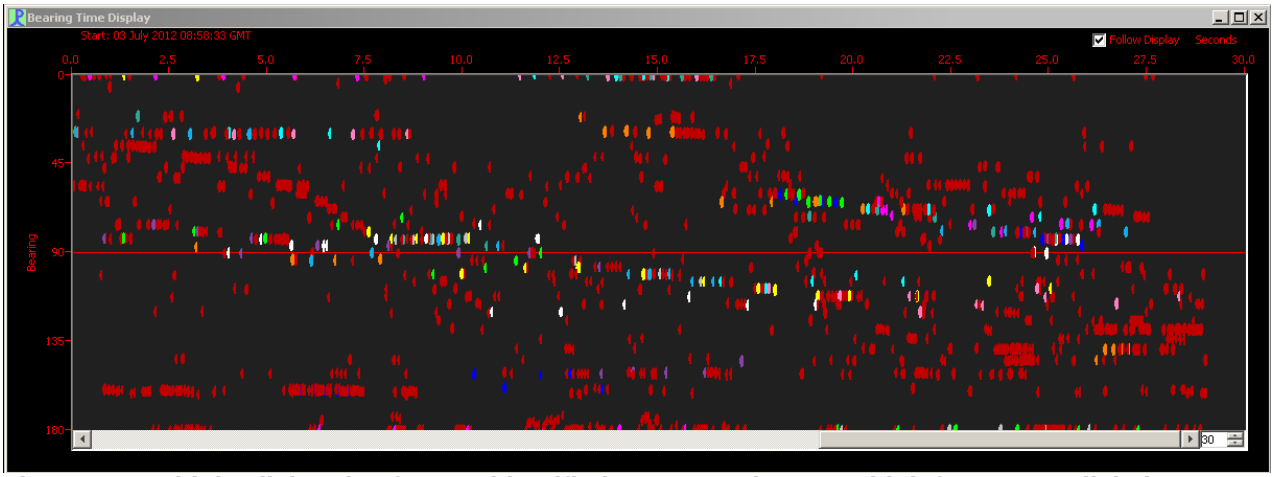

Figure 24. Multiple click trains from unidentified cetacean shown on high frequency click detector on 3 July (acoustic detection 13)

6. MITIGATION ACTION SUMMARY

There were 72 mitigation actions implemented during the Juan de Fuca Plate marine geophysical survey; seven ramp-up delays, 45 power-downs, and 20 shut-downs of the acoustic source were implemented due to protected species being observed within the 180/190 dB safety radii. This total includes all mitigation actions that occurred within Canadian waters which consisted of three mitigation shut-downs due to protected species being observed within 500 meters of the acoustic source and six ramp-up delays due to protected species being observed within 4.4 km of the acoustic source. Additionally, while in Canadian waters a ramp-up was delayed an additional 1 hour 32 minutes due to dense fog obscuring the entire safety radius; this time is not included in the total mitigation downtime. The total duration of downtime caused by mitigation actions (including ramp-up, if required) was 57 hour 20 minutes during the survey. The number and duration of mitigation actions is summarized in Table 10.

Table 10. Number and duration of mitigation actions implemented during the Juan de Fuca Plate marine geophysical survey.

Mitigation Action	Cetaceans		Pinnipeds		Total	
	Number	Duration	Number	Duration	Number	Duration
Delayed Ramp-up	3	0:35	4	5:22	7	5:57
Power-down	26	7:41	19	5:16	45	12:57
Shut-down	8	8:30	12	29:56	20	38:26
Total	**37**	**16:46**	**35**	**40:34**	**72**	**57:20**

While almost the same number of mitigation actions were implemented for cetaceans (37) as for pinnipeds (35) the majority (71%) of mitigation downtime can be attributed to pinnipeds (Table 11). And the vast majority of pinniped downtime can be attributed to Northern fur seals which on multiple occasions would remain within the 190 dB safety radius for hours; once suspending use of the acoustic source overnight. Likewise, all mitigation shut-downs for cetaceans were implemented for Pacific white-sided dolphins which would often approach the airguns closely and attempt to bowride the floats.

Table 11. Mitigation actions and downtime duration by species.

Species	Number of Delayed ramp-ups	Number of Power-downs	Number of Shut-downs	Duration of Downtime	Percentage of Mitigation Downtime
Fin whale	-	4	-	1:53	**3.3%**
Humpback whale	-	3	-	1:06	**1.9%**
Unidentified baleen whale	-	2	-	1:30	**2.6%**
Pacific white-side dolphins	-	7	8	9:13	**16.1%**
Dall's porpoise	3	8	-	2:40	**4.7%**
Unidentified dolphin	-	2	-	0:24	**0.7%**
Northern fur seal	4	12	12	39:04	**68.1%**
Steller sea lion	-	1	-	0:13	**0.4%**
Unidentified pinniped	-	6	-	1:17	**2.2%**

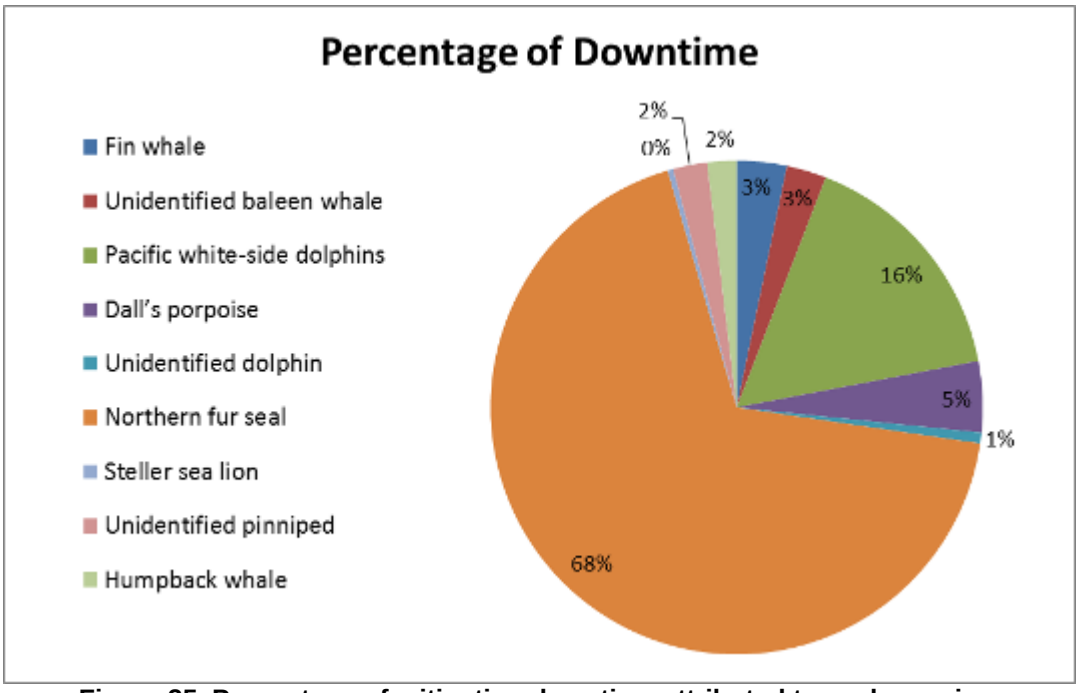

Figure 25. Percentage of mitigation downtime attributed to each species.

Each mitigation action that was implemented during the survey is summarized in Table 12. The total duration of the mitigation event includes the ramp-up to return to full power, if the airguns had been silent for longer than eight minutes.

Table 12. Summary of each mitigation action implemented during the Juan de Fuca Plate marine geophysical survey.

Date	Visual Detection Number	Species	Group Size	Source Activity (initial detection)	Closest Approach to Source/Power Level	Mitigation Action	Total Duration of Mitigation Event
14-Jun	5	Unid. Baleen whale	1	Full power	1050m / Full power	Power down	1:04
15-Jun	9	Fin whale	1	Full power	600m / Full power	Power down	0:15
15-Jun	10	Unid. Pinniped	1	Full power	325m / Mitigation firing	Power down	0:04
16-Jun	14	Unid. Pinniped	1	Full power	232m / Mitigation firing	Power down	0:19
16-Jun	15	Northern fur seal	1	Full power	210m / Mitigation firing	Power down	0:26
16-Jun	16	Northern fur seal	2	Full power	100m / Mitigation firing	Power down	0:40
16-Jun	17	Northern fur seal	3	Mitigation firing	1m / Mitigation firing	Shut down	1:14
16-Jun	18	Northern fur seal	3	Full power	1m / Full power	Shut down	2:29
17-Jun	19	Northern fur seal	5	Full power	1m / Not firing	Power down / Shut down	5:41
18-Jun	22	Northern fur seal	1	Full power	220m / Full power	Power down	0:15
18-Jun	23	Dall's porpoise	2	Full power	250m / Full power	Power down	0:16
18-Jun	24	Northern fur seal	1	Full power	10m / Full power	Power down / Shut down	1:01
19-Jun	25	Northern fur seal	1	Full power	215m / Full power	Power down	0:15
19-Jun	26	Dall's porpoise	4	Full power	100m / Mitigation firing	Power down	0:17
19-Jun	27	Northern fur seal	1	Full power	242m / Full power	Power down	0:15
19-Jun	28	Northern fur seal	3	Full power	1m / Not firing	Shut down	10:42
19-Jun	29	Northern fur seal	1	Full power	20m / Mitigation firing	Power down	0:21
19-Jun	30	Northern fur seal	1	Full power	1m / Not firing	Shut down	1:17
20-Jun	31	Northern fur seal	2	Full power	1m / Full power	Shut down	0:51
20-Jun	32	Northern fur seal	1	Full power	300m / Not firing	Shut down	0:12
21-Jun	43	Northern fur seal	2	Not firing	1m / Not firing	Delayed soft start	3:17

Date	Visual Detection Number	Species	Group Size	Source Activity (initial detection)	Closest Approach to Source/Power Level	Mitigation Action	Total Duration of Mitigation Event
21-Jun	44	Northern fur seal	2	Full power	232m / Full power	Shut down	0:15
21-Jun	45	Dall's porpoise	3	Not firing	1000m / Not firing	Delayed soft start	0:10
21-Jun	46	Northern fur seal	5	Not firing	100m / Not firing	Delayed soft start	1:00
21-Jun	49	Northern fur seal	2	Not firing	150m / Not firing	Delayed soft start	0:18
21-Jun	50	Dall's porpoise	6	Not firing	600m / Not firing	Delayed soft start	0:14
21-Jun	51	Northern fur seal	2	Not firing	5m / Not firing	Delayed soft start	0:47
21-Jun	53	Dall's porpoise	4	Not firing	250m / Not firing	Delayed soft start	0:11
21-Jun	54	Northern fur seal	2	Mitigation firing	1m / Mitigation firing	Shut down	4:31
21-Jun	58	Northern fur seal	1	Full power	100 m / Mitigation firing	Power down	0:07
21-Jun	59	Dall's porpoise	4	Full power	250 m / Mitigation firing	Power down	0:20
22-Jun	61	Unidentified pinniped	1	Full power	300 m / Mitigation firing	Power down	0:17
22-Jun	63	Unidentified pinniped	1	Full power	232 m / Mitigation firing	Power down	0:15
22-Jun	64	Unidentified pinniped	1	Full power	15 m / Mitigation firing	Power down	0:07
22-Jun	67	Northern fur seal	2	Full power	1 m / Full power	Shut down	1:49
22-Jun	68	Pacific white-sided dolphin	10	Full power	10 m / Full power	Shut down	0:22
22-Jun	69	Pacific white-sided dolphin	3	Full power	250 m / Mitigation firing	Power down	0:17
23-Jun	71	Northern fur seal	1	Full power	50 m / Mitigation firing	Power down	0:22
23-Jun	72	Dall's porpoise	10	Full power	290 m / Mitigation firing	Power down	0:25
23-Jun	73	Northern fur seal	1	Full power	100 m / Mitigation firing	Power down	0:17

Date	Visual Detection Number	Species	Group Size	Source Activity (initial detection)	Closest Approach to Source/Power Level	Mitigation Action	Total Duration of Mitigation Event
23-Jun	74	Northern fur seal	1	Full power	150 m / Mitigation firing	Power down	0:17
23-Jun	75	Dall's porpoise	8	Full power	300 m / Full power	Power down	0:17
23-Jun	76	Unidentified dolphin	6	Full power	940 m / Full power	Power down	0:03
24-Jun	77	Pacific white-sided dolphin	25	Full power	30 m / Not firing	Power down / Shut down	0:08
24-Jun	78	Unidentified pinniped	1	Full power	120 m / Full power	Power down	0:15
24-Jun	79	Dall's porpoise	20	Full power	200 m / Mitigation firing	Power down	0:07
24-Jun	80	Fin whale	1	Full power	400 m / Full power	Power down	0:28
25-Jun	81	Pacific white-sided dolphin	12	Full power	1 m / Not firing	Power down / Shut down	1:36
25-Jun	82	Northern fur seal	1	Mitigation firing	1 m / Not firing	Shut down	0:25
25-Jun	83	Pacific white-sided dolphin	8	Mitigation firing	2 m /Not firing	Shut down	0:35
25-Jun	86	Pacific white-sided dolphin	6	Mitigation firing	1 m / Not firing	Shut down	1:16
25-Jun	89	Steller sea lion	1	Full power	300 m / Mitigation firing	Power down	0:13
26-Jun	90	Dall's porpoise	30	Full power	900 m / Full power	Power down	0:06
26-Jun	92	Fin whale	1	Full power	80 m / Mitigation firing	Power down	1:03
30-Jun	98	Fin whale	2	Full power	900 m / Full power	Power down	0:07
2-Jul	100	Pacific white-sided dolphin	27	Full power	2 m / Not firing	Power down / Shut down	0:57
3-Jul	104	Pacific white-sided dolphin	50	Full power	1 m / Not firing	Power down / Shut down	3:49
3-Jul	107	Unidentified dolphin	3	Full power	270 m / Full power	Power down	0:21
3-Jul	108	Humpback whale	1	Full power	220 m / Mitigation firing	Power down	0:21

Date	Visual Detection Number	Species	Group Size	Source Activity (initial detection)	Closest Approach to Source/Power Level	Mitigation Action	Total Duration of Mitigation Event
3-Jul	109	Humpback whale	2	Full power	1200 m / Full power	Power down	0:26
3-Jul	111	Humpback whale	1	Full power	900 m / Mitigation firing	Power down	0:19
6-Jul	114	Dall's porpoise	5	Full power	220 m / Mitigation firing	Power down	0:17
6-Jul	115	Pacific white-sided dolphin	4	Full power	300 m / Mitigation firing	Power down	0:08
7-Jul	118	Pacific white-sided dolphin	4	Full power	3 m / Not firing	Power down / Shut down	0:05

6.1. MARINE MAMMALS KNOWN TO HAVE BEEN EXPOSED TO 160 DB OF RECEIVED SOUND LEVELS

NMFS granted an IHA to L-DEO for a marine seismic survey allowing Level B harassment 'takes' (exposure to sound pressure levels greater than or equal to 160 dB re: 1 µPa (rms)) for 24 marine mammal species: six mysticetes and 12 odontocete species, and four pinniped species. Direct visual observations recorded by PSOs of eight species of marine mammals for which 'takes' were granted in the IHA provide a minimum estimate of the actual number of cetaceans exposed to received sound levels of 180/190 dB and 160 dB.

During the Juan de Fuca Plate marine geophysical survey humpback whales, fin whales, Pacific white sided-dolphins, Dall's porpoises, Northern fur seals, and a Steller sea lion were observed within both the 180/190 dB safety radius and 160 dB safety radius. While Northern right whale dolphins and a sei whale were only observed within the 160 dB safety radius, where Level B harassment is expected to occur, while the acoustic source was active (Table 13).

Table 13. Level B Harassment Takes authorized by NMFS IHA for the Juan de Fuca Plate marine geophysical and number of known individuals exposed to 160 dB and 180/190 dB through visual observations.

Species	IHA Authorized Takes	Number of animals exposed to 180/190 dB	Number of animals exposed to 160 dB
Cetaceans			
Unidentified whales	n/a	0	6
Mysticetes			
North Pacific right whale	0	0	0
Gray whale	10	0	0
Humpback whale	19	4	8
Minke whale	11	0	0
Sei whale	4	0	1
Fin whale	30	15	19

Blue whale	4	0	0
Unidentified baleen whale	n/a	2	6
Odontocetes			
Sperm whale	24	0	0
Unidentified *Kogia spp.*	16	0	0
Cuvier's beaked whale	10	0	0
Baird's beaked whale	27	0	0
Unidentified *Mesoplodon spp.*	40	0	0
Striped dolphin	2	0	0
Short-beaked common dolphin	238	0	0
Pacific white-sided dolphins	806	106	151
Northern right whale dolphin	297	0	173
Risso's dolphin	258	0	0
Killer whale	0	0	0
Harbor porpoise	2,153	0	0
Dall's porpoise	1,935	83	87
Unidentified dolphin	n/a	9	13
Unidentified small cetacean	n/a	0	6
Pinnipeds			
Northern fur seal	1,931	32	35
California sea lion	0	0	0
Steller sea lion	303	1	1
Pacific harbor seal	995	0	0
Northern elephant seal	1,058	0	0
Unidentified pinniped	n/a	6	12

These numbers are very likely to be an underestimate and provide the absolute minimum number of animals actually exposed. When in water shallower than 1000 meters the 160 dB safety radius ranged from ~12.2 km to ~23.5 km making is impossible to observe the entire safety radius. It is also possible that estimated numbers of animals recorded during each sighting event were underestimates, some animals not being seen or having moved away before they were observed. Additionally, there were eight acoustic detections that occurred during the night time hours. These animals were detected on the high frequency click detector, likely placing them within the 160 dB safety radius. During similar acoustic detections that correlated with visual detections the animals were often within a few hundred meters of the acoustic source. Table 14 describes the behavior of all animals, including unidentified species, which were exposed to 160 dB for the duration they were observed.

Table 14. Behavior of species exposed to received sound pressure levels of 160 dB or greater.

Species	Detection No.	No. of Animals	Initial behavior	Initial direction in relation to vessel	Subsequent and Final behavior	Subsequent and Final direction in relation to vessel
Unidentified baleen whale	5	1	Blowing	Parallel, opposite direction	Diving	Parallel, opposite direction
Unidentified whale	6	2	Blowing	Perpendicular, ahead of vessel	Blowing	Perpendicular, ahead of vessel
Unidentified baleen whale	7	3	Blowing	Parallel, opposite direction	Blowing	Parallel, opposite direction

Fin whale	8	6	Blowing	Perpendicular, ahead of vessel	Blowing	Parallel, same direction
Fin whale	9	3	Blowing	Perpendicular, ahead of vessel	Blowing	Parallel, opposite direction
Unidentified pinniped	10	1	Milling	Milling	Milling	Milling
Unidentified small cetacean	11	6	Fast swimming	Perpendicular, ahead of vessel	Fast swimming	Perpendicular, ahead of vessel
Sei whale	12	1	Blowing	Away from vessel	Diving	Perpendicular, behind vessel
Unidentified pinniped	14	1	Milling	Milling	Milling	Milling
Northern fur seal	15	1	Bobbing	Towards vessel	Porpoising	Unknown
Northern fur seal	16	2	Surfacing	Milling	Porpoising	Unknown
Northern fur seal	17	3	Swimming	Milling	Porpoising in airguns	Unknown
Northern fur seal	18	3	Surfacing	Milling	Porpoising in airguns	Unknown
Northern fur seal	19	5	Swimming	Parallel, same direction	Porpoising in airguns	Unknown
Northern fur seal	22	1	Surfacing	Unknown	Diving	Parallel, opposite direction
Dall's porpoise	23	2	Fast swimming	Parallel, same direction	Fast swimming	Towards bow, Away from vessel
Northern fur seal	24	1	Porpoising	Towards vessel	Porpoising in airguns	Towards vessel
Northern fur seal	25	1	Porpoising	Parallel, opposite direction	Porpoising	Unknown
Dall's porpoise	26	4	Fast swimming	Parallel, opposite direction	Fast swimming	Away from vessel
Northern fur seal	27	1	Bobbing	Parallel, opposite direction	Swimming	Unknown
Northern fur seal	28	3	Bobbing	Parallel, same direction	Porpoising in airguns	Unknown
Northern fur seal	29	1	Rolling	Away from vessel	Porpoising	Towards vessel
Northern fur seal	30	1	Bobbing	Towards vessel	Porpoising in airguns	Unknown
Northern fur seal	31	2	Bobbing	Parallel, opposite direction	Porpoising in airguns	Unknown

Northern fur seal	32	1	Rafting	Stationary	Rafting	Stationary
Northern fur seal	44	2	Bobbing	Stationary	Diving	Unknown
Dall's porpoise	53	4	Fast swimming	Perpendicular, ahead of vessel	Fast swimming	Away from vessel
Northern fur seal	54	8	Porpoising	Towards vessel	Porpoising in airguns	Unknown
Northern fur seal	58	1	Swimming	Milling	Swimming	Milling
Dall's porpoise	59	4	Fast swimming	Perpendicular, ahead of vessel	Fast swimming	Away from vessel
Unidentified pinniped	60	1	Swimming	Parallel, opposite direction	Swimming	Parallel, opposite direction
Unidentified pinniped	61	1	Rafting	Stationary	Rafting	Stationary
Unidentified pinniped	62	1	Rafting	Stationary	Rafting	Stationary
Unidentified pinniped	63	1	Rafting	Stationary	Rafting	Stationary
Unidentified pinniped	64	1	Porpoising	Parallel, opposite direction	Porpoising	Towards vessel, away from vessel
Unidentified pinniped	65	1	Rafting	Stationary	Rafting	Stationary
Unidentified pinniped	66	2	Rafting	Stationary	Rafting	Stationary
Northern fur seal	67	2	Swimming	Towards vessel	Porpoising in airguns	Unknown
Pacific white-sided dolphin	68	10	Fast swimming	Towards vessel	Bowriding airguns	Parallel, same direction
Pacific white-sided dolphin	69	3	Slow swimming	Parallel, same direction	Slow swimming	Parallel, opposite direction
Unidentified pinniped	70	1	Porpoising	Perpendicular, behind vessel	Unknown	Unknown
Northern fur seal	71	1	Bobbing	Stationary	Bobbing	Stationary
Dall's porpoise	72	10	Fast swimming	Towards vessel	Fast swimming	Away from vessel
Northern fur seal	73	1	Bobbing	Away from vessel	Porpoising	Away from vessel
Northern fur seal	74	1	Swimming	Away from vessel	Swimming	Away from vessel
Dall's porpoise	75	8	Fast swimming	Parallel, same direction	Fast swimming	Parallel, same direction

Unidentified dolphin	76	6	Swimming	Perpendicular, ahead of vessel	Swimming	Perpendicular, ahead of vessel
Pacific white-sided dolphin	77	25	Swimming	Perpendicular, ahead of vessel	Swimming	Towards airguns / Parallel, opposite direction
Unidentified pinniped	78	1	Porpoising	Parallel, same direction	Porpoising	Parallel, same direction
Dall's porpoise	79	20	Fast swimming	Towards vessel	Fast swimming	Variable
Fin whale	80	1	Blowing	Perpendicular, ahead of vessel	Blowing, diving	Away from vessel
Pacific white-sided dolphin	81	12	Swimming	Parallel, opposite direction	Bowriding airguns	Parallel, opposite direction
Northern fur seal	82	1	Porpoising	Porpoising in airguns	Diving	
Pacific white-sided dolphin	83	8	Porpoising	Parallel, opposite direction	Bowriding airguns	Away from vessel
Pacific white-sided dolphin	86	6	Porpoising	Parallel, opposite direction	Bowriding airguns	Parallel, opposite direction
Unidentified dolphin	87	4	Feeding	Variable	Feeding	Variable
Humpback whale	88	1	Blowing	Perpendicular, ahead of vessel	Diving	Perpendicular, ahead of vessel
Steller sea lion	89	1	Swimming	Parallel, same direction	Rolling	Away from vessel
Dall's porpoise	90	30	Fast swimming	Towards vessel	Fast swimming	Variable
Unidentified baleen whale	91	1	Blowing	Parallel, same direction	Diving	Parallel, opposite direction
Fin whale	92	1	Blowing	Perpendicular, ahead of vessel	Diving, circling vessel	Parallel, same direction
Unidentified baleen whale	94	2	Blowing	Parallel, opposite direction	Diving	Parallel, opposite direction
Unidentified whale	95	1	Blowing	Unknown	Blowing	Unknown
Fin whale	96	2	Blowing	Parallel, opposite direction	Blowing	Parallel, opposite direction
Fin whale	97	1	Blowing	Parallel, opposite direction	Blowing	Parallel, opposite direction

Fin whale	98	2	Blowing	Towards vessel	Diving	Parallel, opposite direction
Unidentified whale	99	1	Blowing	Unknown	Blowing	Unknown
Pacific white-sided dolphin	100	27	Porpoising	Towards vessel	Bowriding airguns	Perpendicular, behind vessel
Northern right whale dolphin	102	8	Porpoising	Parallel, opposite direction	Porpoising	Perpendicular, behind vessel
Northern right whale dolphin	103	165	Leaping	Parallel, opposite direction	Feeding	Perpendicular, behind vessel
Pacific white-sided dolphin	104	50	Feeding	Parallel, opposite direction	Bowriding airguns	Unknown
Fin whale	105	3	Blowing	Towards vessel	Blowing	Parallel, opposite direction
Unidentified dolphin	107	3	Bowriding	Parallel, same direction	Unknown	Unknown
Humpback whale	108	1	Breaching	Parallel, opposite direction	Rolling	Variable
Humpback whale	109	2	Blowing	Parallel, opposite direction	Fluking	Parallel, same direction
Humpback whale	110	1	Blowing	Parallel, opposite direction	Fluking	Away from vessel
Humpback whale	111	1	Blowing	Perpendicular, ahead of vessel	Diving	Parallel, opposite direction
Unidentified whale	112	1	Blowing	Unknown	Blowing	Unknown
Unidentified whale	113	1	Blowing	Unknown	Blowing	Unknown
Dall's porpoise	114	5	Fast swimming	Parallel, same direction	Fast swimming	Away from vessel
Pacific white-sided dolphin	115	4	Slow swimming	Parallel, opposite direction	Slow swimming	Away from vessel
Humpback whale	117	2	Blowing	Parallel, opposite direction	Breaching	Towards vessel, away from vessel
Pacific white-sided dolphin	118	4	Porpoising	Towards vessel	Bowriding airguns	Parallel, same direction

6.1.1. Cetaceans

6.1.1.1. Fin whale

There were eight sightings of fin whales (*Balaenoptera physalus*) totalling 19 animals that were observed within the 160 dB safety radius; 15 of these animals were observed to be exposed to received sound pressure levels of 180 dB or greater. Of the 19 animals observed six were identified as juveniles. During four of the eight detection events the whales were observed to approach the vessel. Two adults and one juvenile were observed approaching the vessel but began moving away when they were 900 meters from the vessel. The other three whales that approached the vessel were observed to be alone and would often approach the vessel within a couple hundred meters; one whale circling the vessel multiple times and remaining with the vessel for almost two hours.

6.1.1.2. Sei whale

One sei whale (*Balaenoptera* borealis) was observed within the 160 dB safety radius. The whale was first observed traveling away from the vessel before turning around and crossing the stern of the vessel, while remaining outside of the 180 dB safety radius.

6.1.1.3. Humpback whale

There were six sightings of humpback whales (*Megaptera novaeangliae*) totaling eight animals that were observed within the 160 dB safety radius; four of these animals were observed to be exposed to received sound levels of 180 dB or greater. Two of the animals were identified as juveniles. During two of the six sightings the whales were observed to exhibit active behavior such at breaching, flipper slapping, and rolling. Mitigation actions were implemented during three of the sightings.

6.1.1.4. Unidentified baleen whale

There were four sightings of unidentified baleen whales totalling six animals that were observed within the 160 dB safety radius; two of these animals observed within the 180 dB safety radius. One of these animals was identified as a juvenile. Dorsal fins were observed during these sightings and all of these whales were either fin or sei whales but species could not be determined due to the distance or brevity of the sighting. A mitigation action was implemented during one of the sightings.

6.1.1.5. Unidentified whale

There were five sightings of unidentified whales totalling six animals that were observed to be exposed to received sound pressure levels greater than 160 dB. None of these animals were observed within the 180 dB safety radius. During all of the sightings only the blow was visible.

6.1.1.6. Northern right whale dolphin

There were two sightings of Northern right whale dolphins (*Lissodelphis borealis*) totalling 173 animals observed within the 160 dB safety radius; none being observed within the 180 dB safety radius. At least five of these animals were identified as juveniles.

The first sighting was of a small pod traveling with a larger pod of Pacific white-sided dolphins, and while many of the Pacific white-sided dolphins approached the vessel the Northern right whale dolphins continued on their course passing the vessel. The second sighting was of a large pod of very active Northern right whale dolphins traveling with a smaller pod of Pacific white-sided dolphins. The Northern right whale dolphins were observed breaching, belly-flopping, side-slapping, and lobtailing continuously for close to an hour.

6.1.1.7. Pacific white-sided dolphin

There were 10 sightings of Pacific white-sided dolphins (*Lagenorhynchus obliquidens*) totalling 151 animals that were observed within the 160 dB safety radius; 106 of these animals observed within the 180 dB safety radius. At least eight of these animals were identified as juveniles. During eight of the ten detections the dolphins were observed to bowride the airgun floats. Often traveling with larger pods, a small group of animals would break off and swim to the airguns. They would then remain bowriding for any length of time between five minutes to 2.5 hours. All 10 sightings resulted in mitigation actions; five sightings resulting in multiple mitigation actions. Five of these sightings also correlated with acoustic detections.

6.1.1.8. Dall's porpoise

There were nine sightings of Dall's porpoises (*Phocoenoides dalli*) totalling 87 animals were observed within the 160 dB safety radius; 84 of these animals observed within the 180 dB safety radius. One of these animals was observed to be a juvenile. All nine sightings resulted in mitigation actions. During all sightings the porpoises were observed to travel very quickly often changing course.

6.1.1.9. Unidentified dolphin / small cetacean

There were three sighting of unidentified dolphins and one sighting of an unidentified small cetacean totalling 19 animals, were observed within the 160 dB safety radius; nine of these animals observed within the 180 dB safety radius. Two of the sightings resulted in mitigation actions.

6.1.2. Pinnipeds

6.1.2.1. Northern fur seal

There were 22 sightings of Northern fur seals (*Callorhinus ursinus*) totalling 35 animals were observed within the 160 dB safety radius; 32 of these animals observed within 180 dB safety radius. All 22 sightings resulted in mitigation actions. During 10 of the sightings the seals approached the vessel and airgun floats remaining swimming amongst them for any length of time from a few minutes to over five hours. During one sighting the seals were still near the guns at dusk resulting in the acoustic source being shut-down overnight.

6.1.2.2. Steller sea lion

There was one sighting of a Steller sea lion (*Eumetopias jubatus*) observed within the 180 dB safety radius. This sighting resulted in a power-down of the acoustic source. The sea lion was observed swimming slowly, parallel to the vessel. As the vessel passed it was observed rolling lifting it's flippers above the water, then continued swimming slowly away from the vessel.

6.1.2.3. Unidentified pinniped

There were 11 sightings of unidentified pinnipeds (mostly otariids) totalling 12 animals observed within the 160 dB safety radius; six of these animals observed within the 180 dB safety radius. Six of these sighting resulted in mitigation actions. Due to distance or brevity these pinnipeds could not be positively identified, but many occurred in areas with high densities of Northern fur seals.

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

In order to minimize the Level-B incidental taking of marine mammals and sea turtles during the

Juan de Fuca Plate marine geophysical survey, mitigation measures were implemented whenever these protected species were seen near or within the safety radii designated in the IHA and LOA. Many mitigation actions were implemented during this survey with power-downs, shut-downs and delayed soft-starts being implemented for mysticetes, odontocetes, and pinnipeds.

Additional mitigation measures specific to the Juan de Fuca Plate survey required that if a North Pacific right whale (*Eubalaena japonica*) or a killer whale (*Orcinus orca*) were sighted, the airgun array would be shut-down regardless of the distance of the animal(s) to the sound source and that the array would not resume firing until 30 minutes after the last documented sighting of the whale. The acoustic array was also to be shut-down if a killer whale was acoustically detected on the PAM system. Waiting 30 minutes after the animals was last acoustically detected before resuming use of the acoustic source. While neither of these species was positively identified during the Juan de Fuca Plate survey, numerous large unidentified whales were observed.

7. ACKNOWLEDGEMENTS

The Protected Species Observers on board *Langseth* during the Juan de Fuca Plate marine geophysical survey in the northeastern Pacific Ocean would like to thank the National Science Foundation and Lamont-Doherty Earth Observatory for the opportunity to work on this project. It was a pleasure to work with Dr. Suzanne Carbotte, as well as Meagan Cummings, the Marine Environmental Safety Coordinator for L-DEO. We would also like to thank the marine crew and science team on board the *R/V Langseth* for their assistance and hospitality.

We would like to thank the following individuals for their considerable help in making the program a success.

- Meagan Cummings and Jeff Rupert from L-DEO and Holly Smith from NSF for their assistance, planning and preparation for the cruise.
- Rebecca Snyder from RPS for her support and installation of the PAM system.
- Matthew Dellinger from RPS for providing logistical support for the project.
- We also thank Meagan Cummings and Anne Unietis for reviewing this report.

We would like to extend our sincere thanks and gratitude to everyone who helped support this project as it would not have been possible without the efforts and assistance of the many individuals and organizations involved.

8. LITERATURE CITED

LGL Ltd., Environmental Research Associates, 2012. “Environmental Assessment of a Marine Geophysical Survey by the *R/V Marcus G. Langseth* in the Northeastern Pacific Ocean, June-July 2012”.

APPENDIX A: Incidental Harassment Authorization issued by NMFS and Letter of Advice issued by DFO.

APPENDIX B: Basic Summary Data Form

BASIC DATA FORM				
LDEO Project Number		MGL1211		
Seismic Contractor		Lamont-Doherty Earth Observatory of Columbia University		
Area Surveyed During Reporting Period		Juan de Fuca Plate in the Northeast Pacific Ocean		
		Approximately between 43 to 48°N and 124 to 130°W		
Survey Type		2D marine seismic / OBS		
Vessel and/or Rig Name		*R/V Marcus G. Langseth*		
Permit Number		IHA granted by NMFS on 13 June 2012 LOA granted by DFO on 22 May 2012		
Location / Distance of Airgun Deployment		232 meters aft of PSO tower		
Water Depth	**Min**	~50m		
	Max	~3000m		
Dates of project		14 June 2012	THROUGH	8 July 2012
Total time airguns operating – all power levels:		447 hours 35 minutes		
Time airguns operating at full power on survey lines:		384 hours 03 minutes		
Time airguns operating at partial power on survey lines:		6 hour 17 minutes		
Time airguns operating at full/partial power on line changes:		26 hours 29 minutes		
Amount of time mitigation gun (40 in³) operations:		22 hours 36 minutes		
Amount of time in ramp-up:		8 hour 10 minutes		
Number daytime ramp-ups:		14		
Number of night time ramp-ups:		1		
Number of ramp-ups from mitigation source:		10		
Amount of time conducted in airgun testing:		None		
Duration of visual observations:		371 hours 02 minutes		
Duration of observations while airguns firing:		306 hours 22 minutes		
Duration of observation during airgun silence:		64 hours 40 minutes		
Duration of acoustic monitoring:		420 hours 08 minutes		
Duration of acoustic monitoring while airguns firing:		400 hours 11 minutes		
Duration of acoustic monitoring during airgun silence:		19 hours 57 minutes		
Duration of simultaneous acoustic and visual monitoring:		283 hours 44 minutes		
Lead Protected Species Observer:		Heidi Ingram		
Protected Species Observers:		Jami Allen		
		Katie Douglas		
		Tatiana Moreno		
Acoustic Observer:		Emily Ellis		
Number of Marine Mammals Visually Detected:		121		
Number of Marine Mammals Acoustically Detected:		14		
Number of acoustic detections confirmed by visual sighting:		0		
Number of visual sighting confirmed by acoustic detection:		5		
Number of Sea Turtles detected:		0		
List Mitigation Actions (eg. Power-downs, shut-downs, ramp-up delays)		45 power-downs, 20 shut downs, 7 ramp-up delays		
Duration of operational downtime due to mitigation:		57 hours 20 minutes		

APPENDIX C: Passive Acoustic Monitoring System Specifications

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 200 kHz	(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

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 on board connection	
Connector Diameter	64mm

Inboard Deck Cable

Deck cable specification

Length	1m
Diameter	14mm
Connectors	39 pin ITT male
Flying lead for on board connection	
Connector Diameter	64mm

APPENDIX D: PAM Hydrophone Deployment and retrieval procedure on the *R/V Marcus Langseth*

The hydrophone deployment procedure is a "living" document and may be altered at any time to reflect changes in deployment over time.

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 D.1). 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.

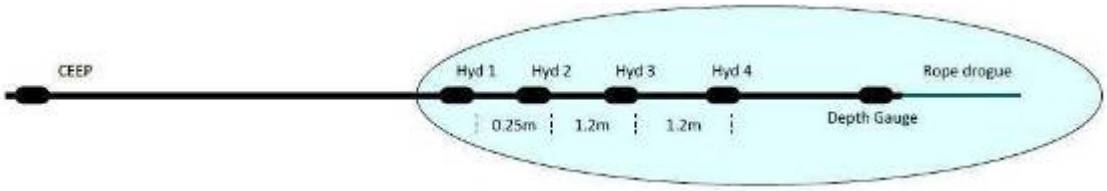

Figure D.1: Diagram of Linear Hydrophone Array.

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 D. 2). 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. Both the deck cable in use and the spare are run from the main lab out to out to the gun deck just in case one failed because the cable had to be run through the bulk head which can only be done while in port. The 250m hydrophone cable is wound on a section of a deckhead winch on the port side of the gun deck (Figure D. 3). 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 D.4). An 8m rope drogue was secured to the end of the hydrophone cable with zip ties with a 9kg shackle secured to the end of the rope drogue with a knot and tape (Figure D.5). Second four lengths of chain weighing approximately 2.5kg each were secured on the cable with tape, 3m, 45m, 96, and 132m up from the depth gauge (Figure D.6). The hydrophone is deployed approximately 150m from the stern and 50m before the center of string. Being that the hydrophone cable is free and independent of the guns the cable is always retrieved before port gun strings are moved.

Figure D.2: PAM Laptops and data processing unit setup.

Figure D.3: Hydrophone cable on winch.

Figure D.4: Hydrophone cable secured by a yale grip to the port sponson.

Figure D.5: Rope drogue and first chain weight secured near hydrophone elements.

Figure D.6: One of the four lengths of chain used to weigh down the cable.

Deployment

- Make sure the data processing unit is off.
- Make sure the deck cable is disconnected from the hydrophone cable.
- Make sure chains on the hydrophone cable are secure.
- Lower the rope drogue and end of the hydrophone cable over the stern and on the port side of the yellow umbilicals and the spreader rope (rope through stern chock) making sure the elements don't hit against the vessel.
- Feed out the hydrophone from the winch.
- Shut off winch controls, connect hydrophone cable to deck cable, and turn on data processing unit.

Retrieval

- Make sure data processing unit is off.
- Make sure the deck cable is disconnected to the hydrophone cable.
- Retrieval is the opposite of deployment.
- Make sure the hydrophone elements don't hit against the stern and store them loosely around the winch.

HSE

All PPE required while on gun deck, including coveralls, hardhat, steel toe boots, safety glasses and gloves. Working close to the side, pinch points at the winch, trip hazards, and potential for jellyfish tentacles on the cable upon retrieval are potential hazards.

APPENDIX E: Passive Acoustic Monitoring Downtime

Passive Acoustic Monitoring Downtime

Date	Monitoring Suspended	Date	Monitoring Resumed	Duration acoustic monitoring suspended	Comments
2012-06-17	17:17	2012-06-17	23:02	5:45	Hydrophone cable retrieved in order to retrieve gun arrays for maintenance
2012-06-18	09:38	2012-06-19	20:44	35:06	Hydrophone cable retrieved due to a shallow depth and risk of entanglement with the seismic gear. Remained on board until environmental conditions improved.
2012-06-20	13:15	2012-06-21	04:45	15:30	Hydrophone cable retrieved prior to the gun arrays in order to deploy the seismic streamer in preparation of the acquisition of the MCS lines.
2012-06-21	12:05	2012-06-21	12:27	0:22	Hydrophone cable retrieved to insure it was not entangled with the XBTs.
2012-06-22	15:52	2012-06-22	17:19	1:27	Hydrophone cable retrieved to help manoeuvring during turn; retrieving gun arrays for maintenance.
2012-06-25	16:39	2012-06-25	18:53	2:14	Hydrophone cable retrieved in order to retrieve gun arrays for maintenance
2012-06-28	12:37	2012-06-28	15:06	2:29	Hydrophone cable retrieved in order to retrieve gun array 3 for maintenance
2012-06-29	04:55	2012-06-29	07:55	3:00	Hydrophone cable retrieved in order to retrieve gun arrays for maintenance
2012-07-01	13:03	2012-07-01	19:11	6:08	Hydrophone cable retrieved prior to the gun arrays in order to retrieve seismic streamer in preparation of the acquisition of the southern OBS lines.
2012-07-03	13:00	2012-07-03	21:04	8:04	Hydrophone cable retrieved due to a shallow depth and risk of entanglement with the seismic gear. Remained on board until environmental conditions improved.
				80:05	Total downtime

APPENDIX F: Summary of visual detections of protected species during the Juan de Fuca Plate marine geophysical survey.

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position	Source Activity Initial Detection	Movement/ Behaviour		CPA Source / Source Activity	Mitigation Action	Comments
1	14-Jun	03:24	Unidentified pinniped	1	46.23333°N 124.11742°W	Not firing	AV	NS DI	100m / Not firing	None	Observed while in transit to survey site.
2	14-Jun	12:19	Sei whale	3	44.78968°N 124.98333°W	Not firing	PV/OD	NS BV DV	400m / Not firing	None	Observed while in transit to survey site.
3	14-Jun	13:05	Pacific white-sided dolphin	8	44.67172°N 125.05217°W	Not firing	PV/SD	FT PO	1m / Not firing	None	Observed while in transit to survey site.
4	14-Jun	13:22	Northern right whale dolphin	8	44.62117°N 125.08165°W	Not firing	TV	FT PO	1m / Not firing	None	Observed while in transit to survey site.
5	14-Jun	18:26	Unidentified baleen whale	1	44.19173°N 125.29758°W	Firing full power	PV/OD	BV DI DV	1050m / Full power	Power down	Whale last observed within safety radius. Waited 30 min. before ramping up.
6	14-Jun	21:18	Unidentified whale	2	44.26412°N 125.33168°W	Firing full power	PE/AH	BV NS	4150m / Full power	None	Animals exposed to 160 dB received sound.
7	14-Jun	22:25	Unidentified baleen whale	3	44.35033°N 125.35803°W	Firing full power	PV/OD	BV NS DV	2000m / Full power	None	Animals exposed to 160 dB received sound.
8	14-Jun	23:13	Fin whale	6	44.40162°N 125.37355°W	Firing full power	PE/AH	BV ST DV	2500m / Full power	None	Animals exposed to 160 dB received sound.
9	14-Jun	23:35	Fin whale	3	44.43188°N 125.38278°W	Firing full power	PE/AH	BV DV NS	600m / Full power	Power down	One animal entered 180 dB safety radius, the other two remained outside.
10	15-Jun	14:13	Unidentified pinniped	1	45.51232°N 125.71802°W	Firing full power	MI	MI	325m / Mitigation Firing	Power down	Otariid observed leaving 190 dB safety radius after 4 minutes.

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position	Source Activity Initial Detection	Movement/ Behaviour		CPA Source / Source Activity	Mitigation Action	Comments
11	15-Jun	18:29	Unidentified small cetacean	6	45.82267°N 125.81600°W	Firing full power	PE/AH	SV	2850m / Full power	None	Animals exposed to 160 dB received sound. Likely Dall's porpoises.
12	15-Jun	19:21	Sei whale	1	45.88878°N 125.83712°W	Firing full power	AV PE/BH	BV DI DV FT	2100m / Full power	None	Animal exposed to 160 dB received sound.
13	15-Jun	19:39	Unidentified baleen whale	1	45.90860°N 125.84353°W	Firing full power	UN	BV	5500m / Full power	None	
14	16-Jun	02:49	Unidentified pinniped	1	46.43545°N 126.01527°W	Firing full power	MI	MI	232m / Mitigation Firing	Power down	Pinniped last seen within safety radius, waited 15 min. before the acoustic source resumed full power.
15	16-Jun	16:53	Northern fur seal	1	47.46162°N 126.35738°W	Firing full power	TV	MI PO FT	210m / Mitigation firing	Power down	Seal last seen within safety radius, waited 15 min. before the acoustic source resumed full power.
16	16-Jun	20:08	Northern fur seal	2	47.70258°N 126.43470°W	Firing full power	MI	MI PO	100m / Mitigation firing	Power down	After power down of acoustic source, additional seals arrived resulting shut down, det. 17.
17	16-Jun	20:48	Northern fur seal	3	47.70258°N 126.43470°W	Mitigation firing	MI	MI PO	1m / Mitigation firing	Shut down	Seals last seen within 190 dB safety radius, waited 15 min. before ramping up.
18	16-Jun	22:13	Northern fur seal	3	47.81277°N 126.81277°W	Firing full power	MI	MI PO	1m / Full power	Shut down	Seals last seen within 190 dB safety radius, waited 15 min. before ramping up.
19	17-Jun	12:47	Northern fur seal	5	47.12687°N 126.84827°W	Full power	MI	PO	1 m / Not firing	Power / Shut down	Power down of the acoustic source followed by a shut-down 14 minutes later.
20	17-Jun	17:56	Dall's porpoise	8	47.05133°N 126.72663°W	Not firing	TV	FT	15 m / Not firing	None	Array already shut-down for detection 19.

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position	Source Activity Initial Detection	Movement/ Behaviour		CPA Source / Source Activity	Mitigation Action	Comments
21	17-Jun	19:09	Northern fur seal	1	47.01210°N 126.62947°W	Not firing	MI	NS	200 m / Not firing	None	Acoustic arrays on board for maintenance.
22	18-Jun	14:41	Northern fur seal	1	47.25397°N 125.59337°W	Full power	UN	DI	220 m / Full power	Power down	Last seen in safety radius. Waited 15 min. before resuming full power.
23	18-Jun	18:17	Dall's porpoise	2	47.33645°N 125.96833°W	Full power	PV/SD	FT AV	250 m / Full power	Power down	Last seen in safety radius. Waited 15 min. before resuming full power.
24	18-Jun	22:54	Northern fur seal	1	47.43638°N 126.42968°W	Full power	TV	PO FT	10 m / Full power	Power / Shut down	Shut down lasted less than 8 minutes. Able to resume use of the acoustic source without ramp up.
25	19-Jun	00:57	Northern fur seal	1	47.48027°N 126.63672°W	Full power	PV/OD	PO FT	215 m / Full power	Power down	Last seen in safety radius. Waited 15 min. before resuming full power.
26	19-Jun	01:24	Dall's porpoise	4	47.49003°N 126.68328°W	Full power	PV/OD	FT	100 m / Mitigation firing	Power down	Last seen in safety radius. Waited 15 min. before resuming full power.
27	19-Jun	01:44	Northern fur seal	1	47.49780°N 126.72008°W	Full power	PV/OD	MI	242 m / Full power	Power down	Last seen in safety radius. Waited 15 min. before resuming full power.
28	19-Jun	02:33	Northern fur seal	3	47.51603°N 126.80670°W	Full power	PV/SD TV	PO	1 m / Not firing	Shut down	Seals still near arrays at dark. Acoustic arrays shut down overnight.
29	19-Jun	20:23	Northern fur seal	1	47.58630°N 127.14453°W	Full power	AV TV	R PO	20 m / Mitigation firing	Power down	Last seen in safety radius. Waited 15 min. before resuming full power.
30	19-Jun	21:02	Northern fur seal	1	47.59785°N 127.20110°W	Full power	TV	PO	1 m / Not firing	Shut down	Last seen in safety radius. Waited 15 min. before ramp up.
31	20-Jun	3:37	Northern fur seal	2	47.73800°N 127.89333°W	Full power	PV/OD	PO	1 m / Full power	Shut down	Last seen in safety radius. Waited 15 min. before ramp up. (Canadian waters)

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position	Source Activity Initial Detection	Movement/ Behaviour		CPA Source / Source Activity	Mitigation Action	Comments
32	20-Jun	13:53	Northern fur seal	1	47.94945°N 128.98730°W	Full power	SA	BA	300 m / Not firing	Shut down	Approached EOL, airguns remained off.
33	20-Jun	15:03	Northern fur seal	3	47.96455°N 128.93882°W	Not firing	SA	BA	250 m / Not firing	None	
34	20-Jun	16:11	Dall's porpoise	4	47.92983°N 128.83382°W	Not firing	PV/OD	FT	150 m / Not firing	None	
35	20-Jun	16:11	Unidentified small cetacean	5	47.92983°N 128.83382°W	Not firing	PE/AH	ST	240 m / Not firing	None	
36	20-Jun	16:14	Northern fur seal	1	47.92803°N 128.82805°W	Not firing	SA	BA ST	80 m / Not firing	None	
37	20-Jun	17:06	Northern fur seal	1	47.90123°N 128.73030°W	Not firing	SA	BA	20 m / Not firing	None	
38	20-Jun	20:08	Dall's porpoise	8	47.84908°N 128.46018°W	Not firing	PE/AH	FT	1200 m / Not firing	None	
39	20-Jun	22:06	Pacific white-sided dolphin	10	47.82208°N 128.32058°W	Not firing	TV	PO SA FT	250 m / Not firing	None	
40	20-Jun	22:06	Northern right whale dolphin	6	47.82208°N 128.32058°W	Not firing	TV	PO FT	250 m / Not firing	None	
41	20-Jun	22:06	Northern fur seal	1	47.82208°N 128.32058°W	Not firing	PV/OD	NS PO	250 m / Not firing	None	
42	20-Jun	23:40	Dall's porpoise	5	47.79512°N 128.18362°W	Not firing	PE/AH	FT BR	250 m / Not firing	None	
43	21-Jun	00:48	Northern fur seal	2	47.77828°N 128.09807°W	Not firing	TV	NS R	1 m / Not firing	Delayed soft start	Seals last seen in safety radius at 2:22. Soft start delayed to 3:22.

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position	Source Activity Initial Detection	Movement/ Behaviour		CPA Source / Source Activity	Mitigation Action	Comments
44	21-Jun	12:47	Northern fur seal	2	47.64582°N 127.16657°W	Full power	TV	SA DI	232 m / Full power	Shut down	Ramp up delayed by dense fog from 13:02 to 13:50. Canadian waters.
45	21-Jun	13:40	Dall's porpoise	3	47.66580°N 127.25882°W	Not firing	PV/OD	FT	900 m / Not firing	Delayed soft start	Ramp up delayed by more animals. Canadian waters.
46	21-Jun	13:50	Northern fur seal	5	47.67255°N 127.28948°W	Not firing	AV	PO NS	100 m / Not firing	Delayed soft start	Ramp up delayed by fog from 14:50 to 15:08.
47	21-Jun	13:55	Northern right whale dolphin	28	47.67632°N 127.30780°W	Not firing	PV/OD	PO FT	1200 m / Not firing	None	
48	21-Jun	13:55	Pacific white-sided dolphin	6	47.67632°N 127.30780°W	Not firing	PV/OD	PO FT	1200 m / Not firing	None	
49	21-Jun	15:08	Northern fur seal	2	47.63722°N 127.37227°W	Not firing	MI	ST	150 m / Not firing	Delayed soft start	Ramp up delayed by fog from 15:26 to 16:02.
50	21-Jun	16:02	Dall's porpoise	6	47.61298°N 127.27378°W	Not firing	TV	FT	600 m / Not firing	Delayed soft start	Ramp up delayed by more animals.
51	21-Jun	16:16	Northern fur seal	2	47.60668°N 127.24297°W	Not firing	TV	NS	5 m / Not firing	Delayed soft start	Ramp up delayed by more animals.
52	21-Jun	16:36	Dall's porpoise	5	47.59977°N 127.20927°W	Not firing	PV/OD	FT	300 m / Not firing	None	
53	21-Jun	17:03	Dall's porpoise	4	47.58892°N 127.15702°W	Mitigation firing	PE/AH	FT	250 m / Mitigation firing	Delayed soft start	Ramp up delayed by more animals.
54	21-Jun	17:14	Northern fur seal	8	47.58445°N 127.13543°W	Mitigation firing	TV	PO	1 m / Not firing	Shut down	Mitigation gun shut down.

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position	Source Activity Initial Detection	Movement/ Behaviour		CPA Source / Source Activity	Mitigation Action	Comments
55	21-Jun	17:56	Dall's porpoise	3	47.57203°N 127.07477°W	Not firing	PE/BV	FT	550 m / Not firing	None	
56	21-Jun	18:21	Dall's porpoise	7	47.56500°N 127.04092°W	Not firing	PV/OD	FT	400 m / Not firing	None	
57	21-Jun	19:53	Dall's porpoise	8	47.54028°N 126.92203°W	Not firing	PV/OD	FT	250 m / Not firing	None	
58	21-Jun	23:22	Northern fur seal	1	47.47713°N 126.62135°W	Full power	MI	ST	100 m / Mitigation firing	Power down	Seal observed leaving 190 dB safety radius.
59	21-Jun	23:31	Dall's porpoise	4	47.47397°N 126.60602°W	Full power	PE/AH	FT	250 m / Mitigation firing	Power down	Porpoises last observed within 180 dB safety radius, waited 15 minutes before returning to full power.
60	22-Jun	01:03	Unidentified pinniped	1	47.44175°N 126.45493°W	Full power	PV/OD	BA	600 m / Full power	None	
61	22-Jun	01:54	Unidentified pinniped	1	47.42240°N 126.36495°W	Full power	SA	BA	300 m / Mitigation firing	Power down	Seal last observed within 190 dB safety radius, waited 15 minutes before returning to full power.
62	22-Jun	03:05	Unidentified pinniped	1	47.39702°N 126.24752°W	Full power	SA	BA	800 m / Full power	None	
63	22-Jun	03:12	Unidentified pinniped	1	47.39217°N 126.22470°W	Full power	SA	BA	232 m / Mitigation firing	Power down	Seal last observed within 190 dB safety radius, waited 15 minutes before returning to full power.
64	22-Jun	03:40	Unidentified pinniped	1	47.38530°N 126.19282°W	Full power	PV/OD	PO	15 m / Mitigation firing	Power down	Seal observed leaving 190 dB safety radius.

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position	Source Activity Initial Detection	Movement/ Behaviour		CPA Source / Source Activity	Mitigation Action	Comments
65	22-Jun	03:54	Unidentified pinniped	1	47.38003°N 126.16908°W	Full power	SA	BA	900 m / Full power	None	
66	22-Jun	04:09	Unidentified pinniped	2	47.37440°N 126.14290°W	Full power	PV/OD	PO	678 m / Full power	None	
67	22-Jun	04:17	Northern fur seal	2	47.37102°N 126.12668°W	Full power	TV	PO	1 m / Not firing	Shut down	
68	22-Jun	12:42	Pacific white-sided dolphin	10	47.19702°N 125.26565°W	Full power	PV/SD	FT	10 m / Full power	Shut down	Dolphins last observed within safety radius. Waited 15 minutes before returning to full power.
69	22-Jun	22:23	Pacific white-sided dolphin	3	47.30365°N 125.74953°W	Full power	PV/SD	ST	250 m / Mitigation firing	Power down	Dolphins last observed within safety radius, waited 15 minutes before resuming full power.
70	23-Jun	03:16	Unidentified pinniped	1	47.39545°N 126.23907°W	Full power	PE/BV	PO	450 m / Full power	None	
71	23-Jun	03:38	Northern fur seal	1	47.40413°N 126.27868°W	Full power	SA	BA	50 m / Mitigation firing	Power down	Seal last observed within 190 dB safety radius, waited 15 minutes before returning to full power.
72	23-Jun	16:23	Dall's porpoise	10	47.65658°N 126.42038°W	Full power	TV	FT	290 m / Mitigation firing	Power down	Last observed within safety radius, waited 15 minutes before returning to full power.
73	23-Jun	17:55	Northern fur seal	1	47.53915°N 126.38250°W	Full power	AV	NS	100 m / Mitigation firing	Power down	Last observed within 190 dB safety radius, waited 15 minutes before returning to full power.
74	23-Jun	18:35	Northern fur seal	1	47.48677°N 126.36555°W	Full power	AV	NS	150 m / Mitigation firing	Power down	Last observed within 190 dB safety radius, waited 15 minutes before returning to full power.

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position	Source Activity Initial Detection	Movement/ Behaviour		CPA Source / Source Activity	Mitigation Action	Comments
75	23-Jun	22:36	Dall's porpoise	8	47.16045°N 126.25657°W	Full power	PV/SD	FT	300 m / Full power	Power down	Last observed within safety radius, waited 15 minutes before returning to full power.
76	23-Jun	23:52	Unidentified dolphin	6	47.06615°N 126.22465°W	Full power	PE/AV	NS	940 m / Full power	Power down	Observed leaving safety radius.
77	24-Jun	13:07	Pacific white-sided dolphin	25	46.08500°N 125.90107°W	Full power	PE/AV	FT PO	30 m / Not firing	Power / Shut down	Correlates with acoustic detection 5. Observed leaving safety radii.
78	24-Jun	16:09	Unidentified pinniped	1	45.86283°N 125.82890°W	Full power	PV/SD	PO	120 m / Full power	Power down	Last observed within safety radius. Waited 15 min. before resuming full power.
79	24-Jun	16:43	Dall's porpoise	20	45.82302°N 125.81612°W	Full power	TV	FT	200 m / Mitigation firing	Power down	Observed leaving safety radius.
80	24-Jun	19:33	Fin whale	1	45.58385°N 125.74088°W	Full power	PE/AV	BV DI DV	400 m / Full power	Power down	Observed outside 180 dB safety radius.
81	25-Jun	13:12	Pacific white-sided dolphin	12	44.29707°N 125.34132°W	Full power	PV/OD	BR	1 m / Not firing	Power / Shut down	
82	25-Jun	14:49	Northern fur seal	1	44.29698°N 125.29962°W	Mitigation firing	PV/SD	PO	1 m / Mitigation firing	Shut down	
83	25-Jun	17:35	Pacific white-sided dolphin	8	44.21248°N 125.09103°W	Mitigation firing	PV/OD	PO BR	1 m / Not firing	Shut down	
84	25-Jun	17:40	Pacific white-sided dolphin	56	44.21325°N 125.06827°W	Not firing	V	FF	1200 m / Not firing	None	Large mixed pod.
85	25-Jun	17:40	Northern right whale dolphin	15	44.21325°N 125.06827°W	Not firing	V	FF	1200 m / Not firing	None	Large mixed pod.

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position	Source Activity Initial Detection	Movement/ Behaviour		CPA Source / Source Activity	Mitigation Action	Comments
86	25-Jun	18:29	Pacific white-sided dolphin	6	44.21283°N 125.98885°W	Mitigation firing	PV/OD	BR	1 m / Not firing	Shut down	
87	25-Jun	19:34	Unidentified dolphin	4	44.21112°N 124.87432°W	Ramp-up	V	FF	3922 m / Ramp-up	None	
88	25-Jun	20:07	Humpback whale	1	44.21630°N 124.81205°W	Full power	PE/AV	BV DI	2600 m / Full power	None	
89	25-Jun	23:05	Steller sea lion	1	44.24177°N 124.50650°W	Full power	PV/SD	NS	300 m / Mitigation firing	Power down	Observed leaving 190 dB safety radius.
90	26-Jun	19:43	Dall's porpoise	30	44.75787°N 125.79735°W	Full power	TV	FT FF	900 m / Full power	Power down	Observed leaving 180 dB safety radius.
91	26-Jun	20:44	Unidentified baleen whale	1	44.86895°N 126.16873°W	Full power	PV/SD	BV DI	2164 m / Full power	None	
92	26-Jun	22:40	Fin whale	1	44.92267°N 126.35307°W	Full power	PE/AH	BV DI	80 m / Mitigation firing	Power down	Observed leaving and re-entering 180 dB safety radius.
93	26-Jun	23:48	Unidentified whale	1	44.95113°N 126.45207°W	Full power	UN	BV	4619 m / Full power	None	
94	27-Jun	1:08	Unidentified baleen whale	2	44.97925°N 126.54925°W	Full power	PV/OD	BV DV	3500 m / Full power	None	
95	29-Jun	16:41	Unidentified whale	1	45.77597°N 129.48597°W	Full power	UN	BV	1100 m / Full power	None	
96	29-Jun	20:33	Fin whale	2	45.89308°N 129.23473°W	Full power	PV/SD PV/OD	BV DI	2450 m / Full power	None	

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position	Source Activity Initial Detection	Movement/ Behaviour		CPA Source / Source Activity	Mitigation Action	Comments
97	30-Jun	21:04	Unidentified baleen whale	1	45.44768°N 129.37053°W	Full power	PV/OD	BV	600 m / Mitigation firing	Power down	Observed leaving 180 dB safety radius.
98	30-Jun	22:55	Fin whale	2	45.57510°N 129.40285°W	Full power	TV V	BV DV	900 m / Full power	Power down	Observed leaving 180 dB safety radius.
99	1-Jul	01:01	Unidentified whale	1	45.72342°N 129.37373°W	Full power	UN	BV	1600 m / Full power	None	
100	2-Jul	14:12	Pacific white-sided dolphin	27	44.95695°N 126.47022°W	Full power	TV	BR	2 m / Not firing	Power /Shut down	Observed leaving 180 dB safety radii. Correlates to acoustic detection 10.
101	2-Jul	14:16	Unidentified whale	1	44.95695°N 126.47022°W	Not firing	UN	BV	1932 m / Mitigation firing	None	
102	2-Jul	14:19	Northern right whale dolphin	8	44.95695°N 126.47022°W	Mitigation firing	PV/OD	PO	400 m / Mitigation firing	None	
103	3-Jul	00:56	Northern right whale dolphin	165	44.65190°N 125.43635°W	Full power	PV/OD	FF	1800 m / Mitigation firing	None	
104	3-Jul	00:56	Pacific white-sided dolphin	50	44.65190°N 125.43635°W	Full power	PV/OD TV	BR FF	1 m / Not firing	Power /Shut down	Observed leaving 180 dB safety radii. Correlates to acoustic detection 11.
105	3-Jul	01:10	Fin whale	3	44.64503°N 125.41322°W	Full power	PV/OD	BV DV	850 m / Not firing	None	
106	3-Jul	03:38	Northern right whale dolphin	1	44.59458°N 125.24535°W	Not firing	PV/OD	PO	350 m / Not firing	None	

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position	Source Activity Initial Detection	Movement/ Behaviour		CPA Source / Source Activity	Mitigation Action	Comments
107	3-Jul	13:19	Unidentified dolphin	3	44.50957°N 124.96788°W	Full power	UN	BR	270 m / Full power	Power down	Last observed within 180 dB safety radius.
108	3-Jul	14:01	Humpback whale	1	44.49048°N 124.90573°W	Full power	PV/OD	SA	220 m / Mitigation firing	Power down	Observed leaving 180 dB safety radius.
109	3-Jul	15:07	Humpback whale	2	44.46218°N 124.81168°W	Full power	PV/OD	DV DF	1200 m / Full power	Power down	Observed leaving 180 dB safety radius.
110	3-Jul	17:10	Humpback whale	1	44.39945°N 124.63185°W	Full power	PV/OD	BV DF	4096 m / Full power	None	
111	3-Jul	17:58	Humpback whale	1	44.37053°N 124.55793°W	Full power	PE/AH	DV DI	900 m / Mitigation firing	Power down	Observed leaving 180 dB safety radius.
112	3-Jul	18:11	Unidentified whale	1	44.36312°N 124.53892°W	Full power	UN	BV	2600 m / Full power	None	
113	3-Jul	20:18	Unidentified whale	1	44.29000°N 124.35212°W	Full power	UN	BV	4096 m / Full power	None	
114	6-Jul	15:58	Dall's porpoise	5	45.05500°N 125.52638°W	Full power	PV/SD	FT	220 m / Mitigation firing	Power down	Last observed within safety radius. Waited 15 min. before resuming full power.
115	6-Jul	19:02	Pacific white-sided dolphins	4	45.00418°N 125.85063°W	Full power	PV/OD	ST	300 m / Mitigation firing	Power down	Observed leaving 180 dB safety radius.
116	6-Jul	02:11	Unidentified whale	1	44.41042°N 125.97965°W	Full power	PV/SD	BV	4800 m / Full power	None	
117	7-Jul	17:54	Humpback whale	2	43.50032°N 125.09390°W	Full power	PV/OD	SA	2100 m / Full power	None	
118	7-Jul	19:47	Pacific white-sided dolphin	4	43.35500°N 125.04940°W	Full power	TV	PO BR	3 m / Not firing	Power / Shut down	End of survey 19:52, acoustic source remained off.

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position	Source Activity Initial Detection	Movement/ Behaviour		CPA Source / Source Activity	Mitigation Action	Comments
119	7-Jul	20:44	Unidentified whale	1	43.36422°N 125.07017°W	Not firing	UN	BV	4096 m / Not firing	None	In transit to port.
120	7-Jul	22:57	Pacific white-sided dolphin	2	43.68402°N 124.93805°W	Not firing	TV	FT	270 m / Not firing	None	In transit to port.
121	8-Jul	03:47	Steller sea lion	1	44.43347°N 124.71362°W	Not firing	PV/OD	FT	250 m / Not firing	None	In transit to port.

Summary of acoustic detections of protected species during the Juan de Fuca Plate marine geophysical survey.

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position	Source Activity Initial Detection	Acoustic Detection Details	CPA Source / Source Activity	Mitigation Action	Comments
1	21-Jun	14:07	Unidentified dolphin	unknown	47.67632°N 127.30780°W	Not firing	Multiple click trains on HF click detector	Unknown	None	Correlates with visual detections 47 & 48. Mixed pod of Northern right whale and Pacific white-sided dolphins.
2	23-Jun	11:08	Unidentified cetacean	unknown	47.84860°N 126.48313°W	Full power	Multiple click trains on HF click detector	Unknown	None	Detection occurred at night. No visual correlation.
3	24-Jun	10:26	Unidentified cetacean	unknown	46.28365°N 125.96532°W	Full power	Multiple click trains of HF click detector	unknown	None	Occurred at night time, no visual correlation.
4	24-Jun	11:01	Unidentified cetacean	unknown	46.23837°N 125.95050°W	Full power	Multiple click trains of HF click detector	unknown	None	Occurred at night time, no visual correlation.
5	24-Jun	13:09	Pacific white-sided dolphins	25	46.08500°N 125.90107°W	Mitigation firing	Multiple click trains of HF click detector	30 m / Not firing	Power / Shut down	Correlates to visual detection 77.
6	25-Jun	10:36	Unidentified cetacean	unknown	44.49033°N 125.40048°W	Full power	Multiple click trains of HF click detector. Faint whistle audible.	unknown	None	Occurred at night time, no visual correlation.
7	25-Jun	13:13	Pacific white-sided dolphins	12	44.29707°N 125.34132°W	Full power	Multiple click trains of HF click detector. Faint whistle audible.	1 m / Not firing	Shut down	Correlates to visual detection 81.
8	25-Jun	18:53	Pacific white-sided dolphins	6	44.21283°N 125.98885°W	Mitigation firing	Click trains on HF click detector.	1 m / Not firing	Shut down	Correlates to visual detection 86.

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position	Source Activity Initial Detection	Acoustic Detection Details	CPA Source / Source Activity	Mitigation Action	Comments
9	26-Jun	10:30	Unidentified cetacean	unknown	44.56988°N 125.18817°W	Full power	Click trains on HF click detector.	unknown	None	Occurred at night time, no visual correlation.
10	2-Jul	14:12	Pacific white-sided dolphins	27	44.95695°N 126.47022°W	Full power	Multiple click trains on HF click detector. Short downsweeps ranging from ~5-24 kHz observed on LF spectrogram.	2 m / Not firing	Power / Shut down	Correlates with visual detection 100.
11	3-Jul	01:13	Pacific white-sided dolphins	50	44.65190°N 125.43635°W	Mitigation firing	Multiple click trains on HF click detector. Short noise pulses ranging from ~5-24 kHz observed on LF spectrogram.	1 m / Not firing	Power / Shut down	Correlated with visual detection 104.
12	3-Jul	06:11	Unidentified cetacean	UN	44.60972°N 125.16577°W	Full power	Multiple click trains detected on HF click detector.	Unknown	None	Detection occurred at night time. No visual correlation.
13	3-Jul	07:45	Unidentified cetacean	UN	44.66388°N 125.34302°W	Full power	Multiple click trains detected on HF click detector.	Unknown	None	Detection occurred at night time. No visual correlation.
14	7-Jul	08:38	Unidentified cetacean	UN	44.18158°N 125.30640°W	Full power	Multiple click trains detected on HF click detector.	Unknown	None	Detection occurred at night time. No visual correlation.

APPENDIX G: Species of birds and other wildlife observed during the Juan de Fuca Plate marine geophysical survey.

Common Name	Family	Genus	Species	Approximate Number of Individuals Observed	Approximate Number of Days Species Was Observed
Black-footed albatross	Diomedeidae	*Phoebastria*	*nigripes*	**160**	**19**
Rhinoceros Auklet	Alcidae	*Cerorhinca*	*monocerata*	**8**	**2**
Unidentified cormorant	Phalacrocoracidae			**1**	**500+**
Rock Dove	Columbidae	*Columba*	*clivia*	**1**	**1**
Mourning Dove	Columbidae	*Zenaida*	*macroura*	**3**	**3**
Unidentified duck	Anatide			**1**	**1**
Northern Fulmar	Procellariidae	Fulmarus	*glacialis*	**12**	**5**
Sooty Shearwater	Procellariidae	Puffinus	*griseus*	**5**	**1**
Short –tailed shearwater	Procellariidae	*Puffinus*	*tenuirostris*	**17**	**2**
Leach's Storm-Petrel	Hydrobatidae	*Oceanodroma*	*leucorhoa*	**70**	**5**
Unidentified Petrel	Hydrobatidae			**85**	**4**
Black-headed Gulls	Laridae	*Larus*	*ridibumdus*	**1**	**1**
Ring-billed Gull	Laridae	*Larus*	*delawarensis*	**1**	**1**
Herring Gull	Laridae	*Larus*	*argentatus*	**2**	**2**
Black-legged Kittiwake	Laridae	*Rissa*	*tridactyla*	**2**	**1**
Arctic Tern	Laridae	*Sterna*	*paradisaea*	**7**	**2**
Unidentified Tern	Laridae			**8**	**3**
Common Murre	Alcidae	*Uria*	*aalge*	**14**	**3**
Brown pelican	Pelecanidae	*Pelecanus*	*occidentalis*	**300+**	**1**
Song Sparrow	Emberizidae	*Melospiza*	*melodia*	**2**	**1**
Greater Scaup	Anatidae	Aythya	*marila*	**1**	**1**

Common Name	Family	Genus	Species	Approximate Number of Individuals Observed	Approximate Number of Days Species Was Observed
Blue Shark	Carcharhinidae	*Carcharhinus*	*leucas*	**3**	**2**
Unidentified Shark				**4**	**3**
Ocean sunfish	Molidea	*Mola*	*mola*	**1**	**2**
Unidentified Tuna	Scombridae			**1**	**1**