Protected Species Mitigation and Monitoring Report

Cascadia Subduction Margin Geohazards
Grays Harbor, Washington

12 July 2012 - 23 July 2012

R/V Marcus G. Langseth
and
Northern Light

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 Cascadia subduction margin off Grays Harbor, Washington. The purpose of the survey was to address key scientific issues regarding the location, physical state, fluid budget, and associated methane systems of the subducting plate boundary and overlying crust. The *Langseth* left Astoria, Oregon on 12 July 2012 and began the survey on 13 July 2012. The survey was completed on 23 July 2012 and the *Langseth* arrived back in Astoria on 24 July 2012.

L-DEO submitted an application to the National Marine Fisheries Service (NMFS) for a permit to harass marine mammals, incidental to the marine geophysical survey. An Incidental Harassment Authorization (IHA) was granted on 10 July 2012 (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 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. Additionally, the support vessel, *Northern Light*, assisted with protected species observations, particularly for Southern resident killer whales.

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

PSOs on the *Langseth* undertook a combination of visual and acoustic watches, conducting a total of 196 hours 14 minutes of visual observations and 152 hours 03 minutes of acoustic monitoring over the course of the survey.

This visual monitoring effort on the *Langseth* produced a project total of 92 protected species detection records; 84 for cetaceans and eight for pinnipeds. Of the 84 cetacean records collected, 52 records were collected for mysticetes, 27 records were collected for odontocetes, and five records of unidentified large cetaceans. No killer whales were observed during this survey. Of the eight pinniped records collected, four records were collected for phocids and four records were collected for otariids. There were three acoustic detections using the passive acoustic monitoring (PAM) system; all correlating with visual detections of small odontocetes.

The visual monitoring effort on the *Northern Light* produced a project total of 174 protected species detections; 140 for cetaceans and 34 for pinnipeds. Of the 174 cetacean records collected, 69 records were collected for mysticetes, 68 records were collected for odontocetes, and three records of unidentified large whales. Of the 34 pinniped records collected, 17 records were collected for phocids and 17 records were collected for otariids. Some of these detection records are duplicates with the animals being recorded by observers on both the *Langseth* and *Northern Light*. There were five acoustic detections using the PAM system.

Detections of protected species resulted in 28 mitigation actions being implemented; 16 power-downs, nine shut-downs, and three delayed ramp-ups of the acoustic source. This resulted in a total of 19 hours 11 minutes of mitigation downtime. A known 438 cetaceans and two pinnipeds

were exposed to received sound levels equal to or greater than 160 dB of sound from the acoustic source, constituting a level B harassment take as defined by NMFS. Cetacean level B harassment 'takes' included 24 humpback whales, 18 fin whales, 31 Dall's porpoises, nine harbor porpoises, 155 Pacific white-sided dolphins, 190 Northern right whale dolphins, 10 Risso's dolphins, and five unidentified baleen whale. Pinniped level B harassment 'takes' included one Steller sea lion and one Northern fur seal.

The total duration of downtime caused by mitigation actions (including ramp-up, if required) was 19 hour 11 minutes during the survey. The number and duration of mitigation actions is summarized in Table 10.

A portion of the survey occurred in a humpback whale feeding area, with numerous humpbacks being observed during shoreward turns. While heading shoreward on transect lines the *Northern Light* would notify the *Langseth* when there were high densities of humpback whales ahead and the *Langseth* would power-down the acoustic source before entering shallower water to avoid having multiple 'takes' of humpback whales, often ending survey lines and turning early. Only one turn was made in shallow water during nighttime hours and on this occasion the acoustic source was powered-down to a single airgun when the vessel moved into water shallower than 100 meters.

All 28 mitigation actions were implemented for cetaceans (Table 11). The majority of mitigation downtime (55.6%) can be attributed to humpback whales. Due to originally being allotted 11 'takes' for humpback whales much of this downtime can be attributed to trying to avoid 'takes' of humpback whales. With many humpbacks observed in the area the acoustic source was powered-down during the shallower inshore turns of the survey to avoid exceeding allowable 'takes'. While powered-down if a humpback was observed to be likely to enter the 160 dB safety radius the acoustic source would be shut-down. On 20 July, NMFS issued more 'takes' for humpback whales and while the acoustic source was still powered-down during inshore turns the acoustic source was not shut-down to avoid 'takes'. The exceeded take report can be found in Appendix G.

A substantial amount of mitigation downtime (23.9%) can also be attributed to Pacific white-sided dolphins. During five of the nine Pacific white-sided dolphins they approached the airguns and attempted to bowride the floats. Additionally, the allotted 'takes' for Northern right whale dolphins were exceeded by seven animals on 22 July when an pod of ~35 animals was observed within the 160 dB safety radius. The number of 'takes' was also reached for fin whales on 22 July. There were no more sightings of either species while the acoustic source was active.

A project summary sheet of observation, detection, and operational totals for the *Langseth* 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 Cascadia Subduction Margin Geohazards (Holbrook) marine geophysical survey on board the *R/V Langseth* from 12 July to 24 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 10 July 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.

2.1. PROJECT OVERVIEW AND LOCATION

The survey was conducted in the northeastern Pacific Ocean, off the coast of Washington. The survey took place in the approximate area of 46 to 47.5° North and 124 to 126.5° West, where water depths ranged from ~50 m to >2650 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. 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 results of this 2-D seismic survey will be used to study the Cascadia subduction margin which is of great scientific and societal interest, as it is capable of very large (~9 MW) earthquakes, creates volcanic hazards in the Cascades, and hosts periodic episodic tremor and slip episodes. A total of 1,323.9 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 13 July and continued until 23 July 2012.

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 15 meters for approximately half of the survey and nine meters for the second half of the survey on the multi-channel survey lines (MCS) and were situated 232 meters from the Navigational Reference Point (NRP), which was located on the PSO observation tower.

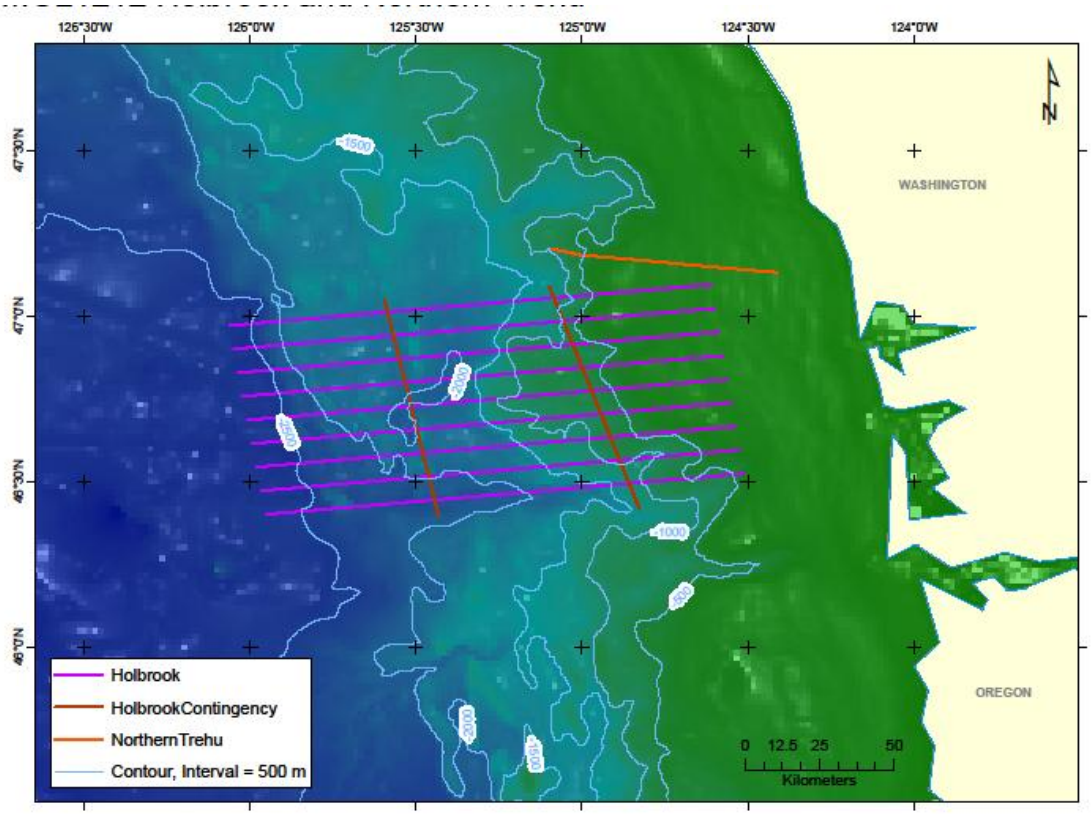

Figure 1. Location of the Cascadia Subduction Margin Geohazards (Holbrook) marine geophysical survey in the Northeast Pacific Ocean.

Each source array utilized a mixture of Bolt 1500LL and Bolt 1900LLX airguns ranging in volume from the smallest airgun of 40 in³ to 360 in³. 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 in³. The full power source of four sub-arrays (36 airguns) had a total discharge volume of 6,600 in³ 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 50 meters, equating to approximately 20 seconds at typical survey speed. 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.

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 requirements that were issued to the L-DEO by NMFS, 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, PSOs collected and analyzed necessary data mandated by the IHA for this report including but not limited to:

- Dates, times and locations, heading, speed, weather, sea conditions (including Beaufort sea state and wind force), and related activities during all seismic operations and marine mammal detections.
- Species, number, location, distance from the vessel, and behavior of any marine mammals, as well as associated seismic activity including the number of power-downs and shut-downs, were observed and logged throughout all monitoring actions.
- An estimate of the number, decided by species, of marine mammals that: (A) are known to have been exposed to the seismic activity (based on visual observation) at received levels greater than or equal to 160 dB re 1 µPa (rms), 180 dB re 1 µPa (rms) and/or 190 dB re 1 µPa (rms) along with a discussion of any specific behaviors those individuals exhibited; and (B) may have been exposed (based on 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. R/V LANGSETH 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. The PSOs on board were NMFS 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. 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 5:04 to 5:29 local time, while end of observation times ranged from 21:50 to 22:07 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 breaks when PSOs would each 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.

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. 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	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)	15	Shallow (<100)	865	2,750	26,350
		Intermediate (100-1,000)	690	1,975	15,650
		Deep (>1,000)	520	1,200	4,490

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. R/V LANGSETH 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.

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 200kHz) and the fourth element is for sampling lower frequencies (75Hz to 30kHz). 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.

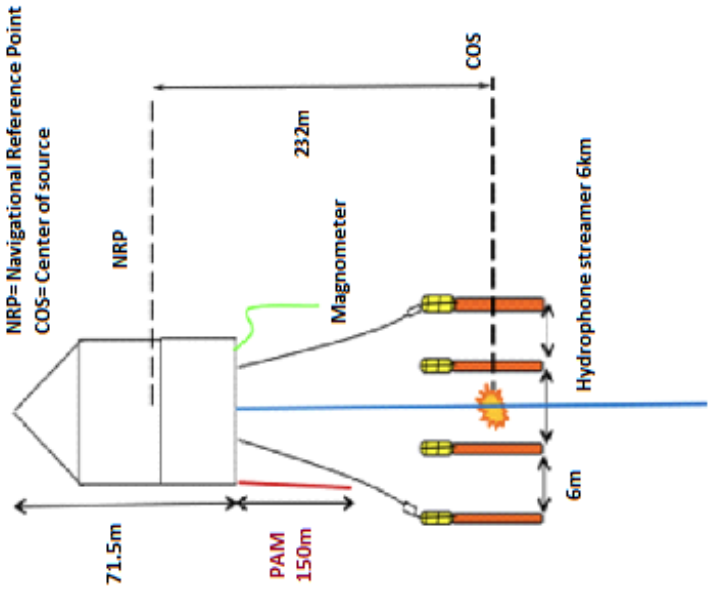

Figure 3. Location of the hydrophone deployment.

3.3. NORTHERN LIGHT VISUAL MONITORING SURVEY METHODOLOGY

The *Northern Light* is equipped with a flying bridge that enabled observers to see around the entire vessel. The bridge is about 4.9-5.5 m (16-18 ft) above the water line. Observations of animals at a distance of approximately 5 to 6 km are possible with the naked eye in optimal conditions. Three visual PSO's and one PAM operator were based on this vessel with reticule binoculars (7×50 Fujinon) allowing observations to about 3-4 km or further in optimal conditions. Observations for marine mammals, particularly Southern Resident killer whales, began immediately as the *Northern Light* transits to the Cascadia Subduction Margin survey starting point and continued during pre-surveys before airgun operations began as well as during airgun operations.

When the *Langseth* began the seismic survey and in the area of the continental shelf, the support vessel *Northern Light* monitored north of the *Langseth* approximately 5 km away in the same zig-zag fashion as the pre-survey to monitor the 160 dB exclusion zone around the *Langseth*.

The *Northern Light* has a length of 22.6 m (74 ft), a beam of 5.88 m (19 ft) and a draft of 1.52 m

(5 ft). This ship is powered by 2- 770 HP GM V-12 turbo-charged diesel engines. The *Northern Light* cruises at 17.6 km/hr (9.5 nm/hr) and has a maximum speed of 4.6 km/h (23 nm/hr), however, it travelled no more than 9.5-10 nm/hr during surveying to improve visibility of marine mammals and sea turtle observations but stay near the *Langseth*.

The *Northern Light* would notify the *Langseth* when there was a protected species of interest inside or nearing the 160 dB safety radius. While heading shoreward on transect lines the *Northern Light* would notify the *Langseth* when there were high densities of humpback whales ahead so the *Langseth* could power-down the acoustic source before entering shallower water to avoid having multiple 'takes' of humpback whales. While in port to refuel or weather advisories the PSOs on the *Northern Light* would send an updated form to the *Langseth* detailing all detections.

3.4. NORTHERN LIGHT ACOUSTIC MONITORING SURVEY METHODOLOGY

During the Cascadia subduction margin survey a static passive acoustic monitoring (PAM) system, *Ziphius*, was utilized on the scout vessel *Northern Light* in accompaniment with visual observations. Acoustic monitoring is thought to be a viable source of monitoring in environments of reduced visibility including hours of darkness. The PAM operator monitored for protected species daily from 06:00 to 12:00 UTC when permissible. The PAM operator visually monitored a laptop running *PAMGUARD* and aurally monitored audio using *Sennheiser* headphones connected directly into the data processing unit. The data processing unit processes the raw data from the hydrophones through the laptops internal sound card for low frequency detections and an external sound card, *National Instruments DAQ* card, for high frequency detections. *National Instruments DAQ* sound cards sample raw audio at 500 kHz and are used to detect beaked whales, *Kogia* species, porpoise, and delphinid (echolocation) clicks up to 250 kHz. Although the static PAM system is primarily setup to monitor for mysticetes, the low frequency moans and creaks produced by mysticetes are often masked by vessel noise and can be difficult to detect.

The *Seiche Measurements* PAM system on board the *Northern Light* contains a 100 meter hydrophone cable that remains ready to be deployed for monitoring during hours of darkness and, if needed, during periods of reduced visibility. One hydrophone element with a frequency response of 20Hz to 150Hz is positioned at the end of the 100 meter cable which is then plugged into a transducer converting sound pressure waves to electrical signals. These electrical signals are carried to the low frequency (LF) laptop and *PAMGUARD* which is monitored by the PAM operator once the cable has been deployed. One sound card is linked to monitor low frequencies (0 to 24 kHz) and one to monitor high frequencies (up to 250 kHz). *PAMGUARD v. 1.11.02* is the operating system available for spectrally interfacing the range of sounds and is currently considered the world's standard for acoustic detection, identification and localization. When deployed, the hydrophone cable is towed behind the *Northern Light* 25 meters at an approximate depth of 3 meters. A 1.5 kilogram weight was added to the end of the hydrophone cable to increase the depth of the hydrophone when in tow.

Due to technical issues with the PAM laptop, beginning on 20 July 2012 and continuing through the remainder of the project, *PAMGUARD* was no longer available for use, thereby rendering the PAM operator unable to record data or create screen grabs depicting vocalizations of protected species from the spectrogram. However, the PAM operator was still able to acoustically monitor for protected species due to the headphones being connected directly into the data processing unit. Passive acoustic monitoring for *Northern Light* was in operation a total of 37 hours.

4. R/V LANGSETH MONITORING EFFORT SUMMARY

4.1. SURVEY OPERATIONS SUMMARY

The *R/V Langseth* departed Astoria, Oregon for the seismic survey site at 16:00 UTC on 12 July 2012. The seismic gear was deployed and use of the acoustic source commenced at 3:39 UTC on 13 July. Acquisition began on the first MCS survey line began at 9:38 UTC on 13 July. Acquisition of the MCS survey lines was completed at 16:03 UTC on 23 July. At this time the seismic gear was brought on board and some multibeam data was collected before the *Langseth* began the transit to Astoria, Oregon arriving at 17:00 UTC on 24 July 2012. Table 2 outlines the dates and times of acquisition for each survey line.

Table 2. Cascadia subduction margin geohazards marine geophysical survey multi-channel seismic survey lines acquired.

Survey Line	Date Acquisition Commenced	Time Acquisition Commenced	Date Acquisition Completed	Time Acquisition Completed
MGL1212MCS11 Seq001	13-Jul-2012	09:38	13-Jul-2012	17:26
MGL1212T01 Seq002	14-Jul-2012	01:26	14-Jul-2012	03:33
MGL1212MCS01 Seq003	14-Jul-2012	13:10	14-Jul-2012	06:00
MGL1212MCS01A Seq004	14-Jul-2012	13:10	15-Jul-2012	0:42
MGL1212MCS03 Seq005	15-Jul-2012	05:15	15-Jul-2012	18:37
MGL1212MCS05 Seq006	16-Jul-2012	01:04	16-Jul-2012	15:13
MGL1212MCST02 Seq007 (Mitigation gun)	16-Jul-2012	17:39	16-Jul-2012	19:38
MGL1212MCS07 Seq008	16-Jul-2012	23:12	17-Jul-2012	10:38
MGL1212MCST03 Seq009	17-Jul-2012	10:55	17-Jul-2012	12:47
MGL1212MCS09 Seq010	17-Jul-2012	15:35	18-Jul-2012	00:15
MGL1212MCS08 Seq011	18-Jul-2012	23:11	19-Jul-2012	04:28
MGL1212MCST04 Seq012	19-Jul-2012	05:49	19-Jul-2012	07:30
MGL1212MCS06 Seq013	19-Jul-2012	07:44	19-Jul-2012	20:58
MGL1212MCST05 Seq014 (Mitigation gun)	19-Jul-2012	22:09	19-Jul-2012	23:51
MGL1212MCS04 Seq015	20-Jul-2012	02:20	20-Jul-2012	15:10
MGL1212MCST06 Seq016	20-Jul-2012	15:21	20-Jul-2012	16:57
MGL1212MCS02 Seq017	20-Jul-2012	17:08	21-Jul-2012	04:09
MGL1212MCS03A Seq018	21-Jul-2012	05:08	21-Jul-2012	08:48
MGL1212MCST07 Seq019 (Mitigation gun)	21-Jul-2012	08:59	21-Jul-2012	11:34
MGL1212NTMCS01 Seq020	21-Jul-2012	12:57	21-Jul-2012	21:42
MGL1212MCST08 Seq021	21-Jul-2012	21:55	22-Jul-2012	00:04
MGL1212MCS10 Seq022	22-Jul-2012	00:19	22-Jul-2012	11:11
MGL1212MCS09A Seq023	22-Jul-2012	15:25	22-Jul-2012	21:32
MGL1212MCS09B Seq024	23-Jul-2012	00:17	23-Jul-2012	07:25
MGL1212MCS09C Seq025	23-Jul-2012	10:42	23-Jul-2012	16:03

The acoustic source was active throughout the survey, with few periods of source silence, for a total of 220 hours 13 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 in³ mitigation airgun (Figure 4). The mitigation source was used during mitigation power-downs initiated for protected species inside the safety radius, for mechanical/technical reasons, and for acquisition during inshore turns to limit 'takes' of protected species and was active for 38 hours

20 minutes during the survey. Full power source operations, while online, accounted for 66% (145 hours 17 minutes) of airgun activity during the project. Also because the data was still usable while shooting at partial power (volume ranging from 1650 in³ to 4950 in³) portions of survey lines were sometimes shot using partial power while maintenance was performed on an array, accounting for 14 hours 43 minutes of array activity. Line changes were all shot at full or partial power, totalling 15 hours 10 minutes of array activity. Additionally, the full volume of the acoustic source (36 airguns firing) ranged from 6520 in³ to 6600 in³, caused by various guns of different sizes being changed out on the arrays.

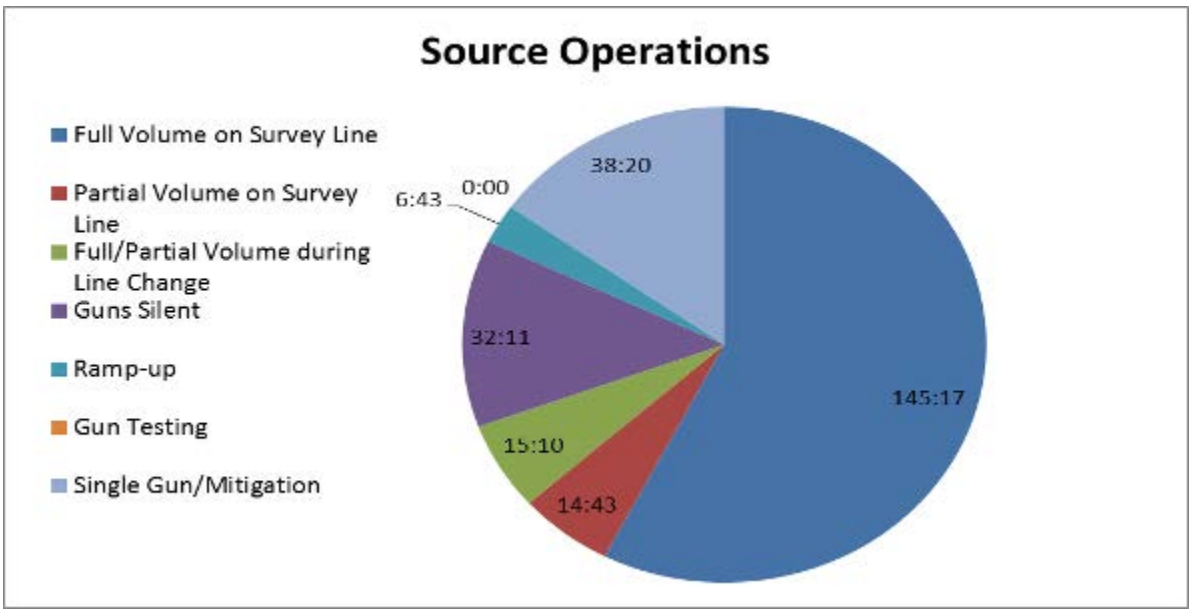

Figure 4. Total acoustic source operations.

The acoustic source was ramped up 10 times over the course of the survey in order to commence full power survey operations (Table 3). Additionally, there were two partial ramp-ups; one caused by a protected species entering the safety radii requiring a power-down of the acoustic source and other when it became apparent that the seismic gear was severely tangled in fishing line. The ramp-ups occurred over a duration ranging from 31 minutes to 46 minutes. The longer ramp-ups were caused by continuing acquisition while ramping up and using the 50 meter shot point interval. 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 3. Total acoustic source operations during the Cascadia subduction margin marine geophysical survey.

Acoustic Source Operations	Number	Duration (hh:mm)
Gun Tests		**0:00**
Ramp-up	**10**	**6:43**
Day time ramp-ups from silence	**3**	
Day time ramp-ups from mitigation	**6**	
Night time ramp-ups from mitigation	**1**	
Full power survey acquisition		**145:17**

Partial power survey acquisition		**14:43**
Full/partial power line changes		**15:10**
Single airgun (40 in³)		**38:20**
Total time acoustic source was active		**220:13**

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 16:00 UTC on 12 July 2012 and continued until 4:50 UTC on 24 July 2012 the evening before the vessel arrived in Astoria, Oregon at the completion of the survey project. Visual monitoring was over a period of about 12 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 16 hours 40 minutes of visual observations per day.

Visual watches were held by two PSOs except during the scheduled meal hours for lunch and dinner when a single PSO continued visual monitoring, in addition to acoustic monitoring conducted by the PAM operator on duty while each PSO rotated for a meal break. Single PSO visual observations during these periods lasted a maximum of 45 minutes. 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.

The acoustic source was active during the majority of visual monitoring (78%) and the majority of acoustic monitoring (97%), as shown in Figure 5.

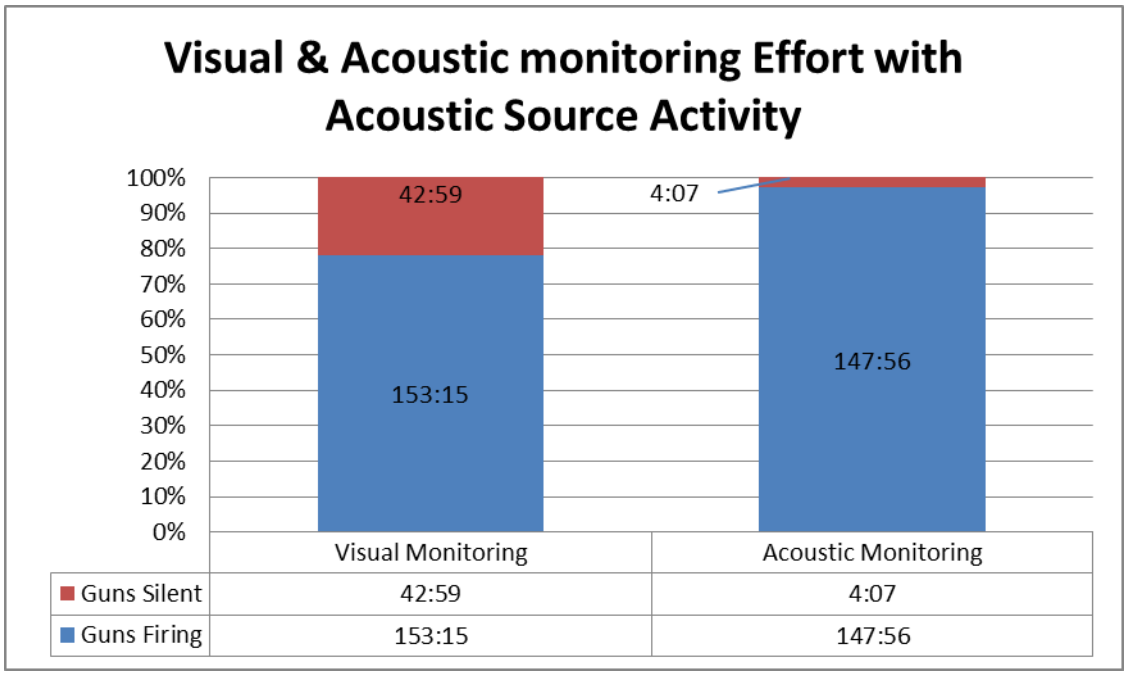

Figure 5. Duration of visual and acoustic monitoring effort while the acoustic source was active vs. silent.

Total visual monitoring effort, divided by monitoring effort while the acoustic source was active and monitoring effort while the source was silent, is listed in Table 4.

Table 4. Total visual monitoring effort.

Visual Monitoring Effort	Duration (hh:mm)
Total monitoring while acoustic source active	153:15
Total monitoring while acoustic source silent	42:59
Total monitoring effort	**196:14**

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 87% of visual monitoring was conducted from the PSO tower during the Juan de Fuca Plate marine geophysical survey.

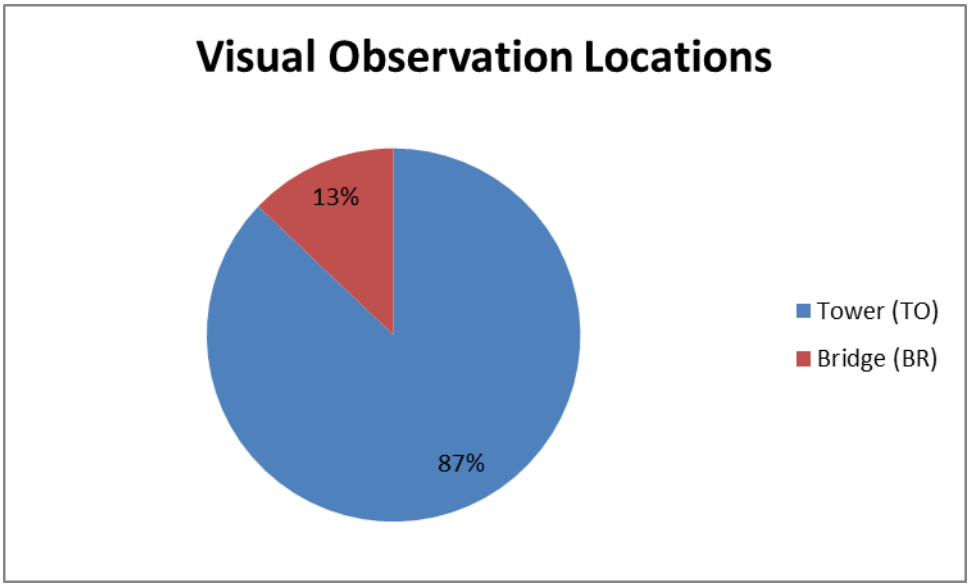

Figure 6. Total visual effort from observation locations on board the *R/V Langseth*.

4.3. ACOUSTIC MONITORING SURVEY SUMMARY

The hydrophone cable was deployed for the first time on 13 July after the vessel had completed deployment of the source arrays. Acoustic monitoring began at 7:45 UTC on 13 July 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 9:44 UTC on 23 July when the hydrophone cable was retrieved, just before the acquisition of the final survey line. Over the course of the project, PSOs conducted 152 hours 03 minutes of acoustic monitoring, all but 4 hours 07 minutes occurred while the acoustic source was active (Table 5).

Table 5. Total passive acoustic monitoring (PAM) effort.

Passive Acoustic Monitoring Effort	Duration (hh:mm)
Total night time monitoring	**48:15**
Total day time monitoring	**103:48**

Total monitoring while acoustic source active	**147:56**
Total monitoring while acoustic source silent	**04:07**
Total acoustic monitoring	**152:03**

The majority of acoustic monitoring downtime (57 hours 40 minutes) was attributed to poor weather when the cable was retrieved to prevent entanglement with the seismic gear. The cable remained on board until the sea state had decreased to a sufficient level to ensure the cable was safe to deploy. Acoustic monitoring was suspended for a total of 31 hours 33 minutes, when the cable was retrieved twice for seismic repairs and maintenance. Twenty-three minutes of acoustic monitoring downtime can be attributed to entanglement when the hydrophone cable was retrieved to insure it had not been entangled with fishing line. A power outage on 13 July caused acoustic monitoring to be suspended for 20 minutes (Table 6). A description of each instance of acoustic monitoring downtime is located in Appendix E.

Table 6. Passive acoustic monitoring (PAM) downtime.

Passive Acoustic Monitoring Downtime	Duration (hh:mm)
Weather	**57:40**
Seismic equipment repairs and maintenance	**31:33**
Entanglement	**00:23**
Power outage	**00:20**
Total Passive Acoustic Monitoring Downtime	**89:56**

4.4. SIMULTANEOUS VISUAL AND ACOUSTIC MONITORING SUMMARY

While visual observations began at 16:00 UTC 12 July 2012, acoustic observations began at 7:45 UTC on 13 July 2012, 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 56% (196 hours 14 minutes) while acoustic monitoring accounted for 44% (152 hours 03 minutes). As displayed in Figure 7 there were 103 hours 48 minutes of simultaneous visual and acoustic observations conducted during this survey. Simultaneous visual and acoustic monitoring accounted for 68% of total acoustic monitoring and 53% of the total visual observation.

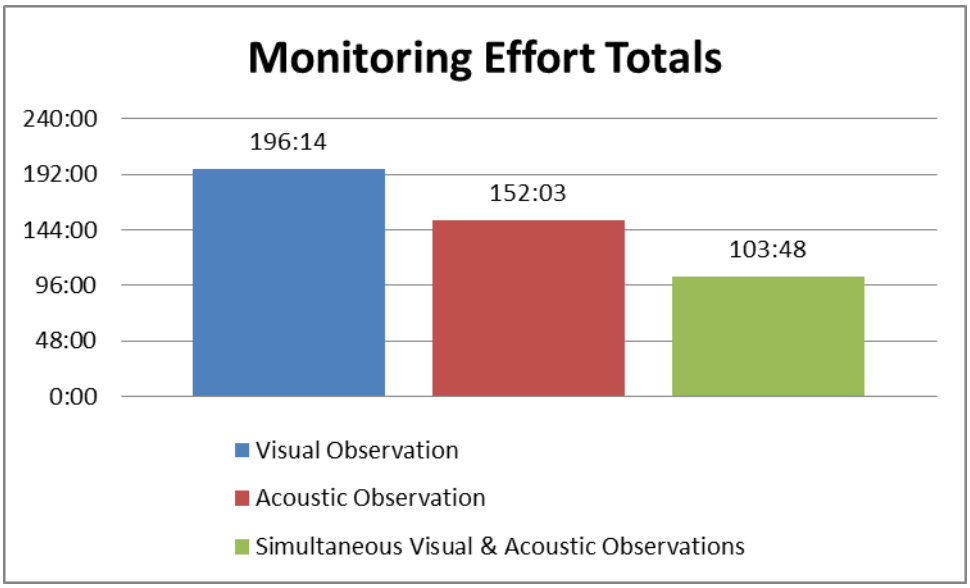

Figure 7. Total acoustic and visual monitoring effort.

4.5. ENVIRONMENTAL CONDITIONS

The majority of visual monitoring effort was conducted during favorable observation conditions. Throughout the project there was a continuous heavy cloud cover of nearly 100%. Periods of fog and light to heavy rain were present throughout the survey and did at times affect visual observations. A total of 3 hours of precipitation was recorded, as well as 60 hours of fog and 35 hours of glare. The 180/190 dB safety radii were almost always visible, with the exception of 30 minutes on 20 July. Visibility remained at an average of 7 kilometers for the survey.

The Beaufort Sea State ranged from levels 0 through 7, but the average was 3 over the entire survey (Figure 8).

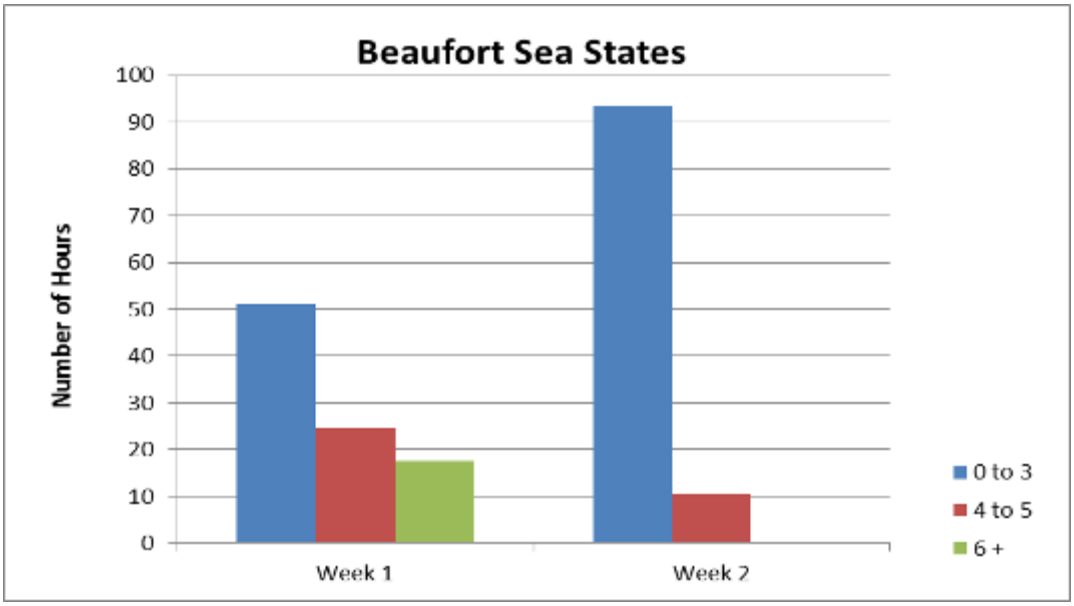

Figure 8. Beaufort sea state during visual monitoring over the marine geophysical survey.

Wind forces remained relatively stable throughout the survey with a minimum of 0 knots and a maximum of 32 knots. The average wind force was 10.5 knots over the entire survey. Forces less than 10 knots were present for 103 hours 30 minutes during the cruise, and forces from 11-21 knots were present for 78 hours 30 minutes during the cruise. Forces greater than 22 knots were only recorded for 15 hours during the cruise (Figure 9).

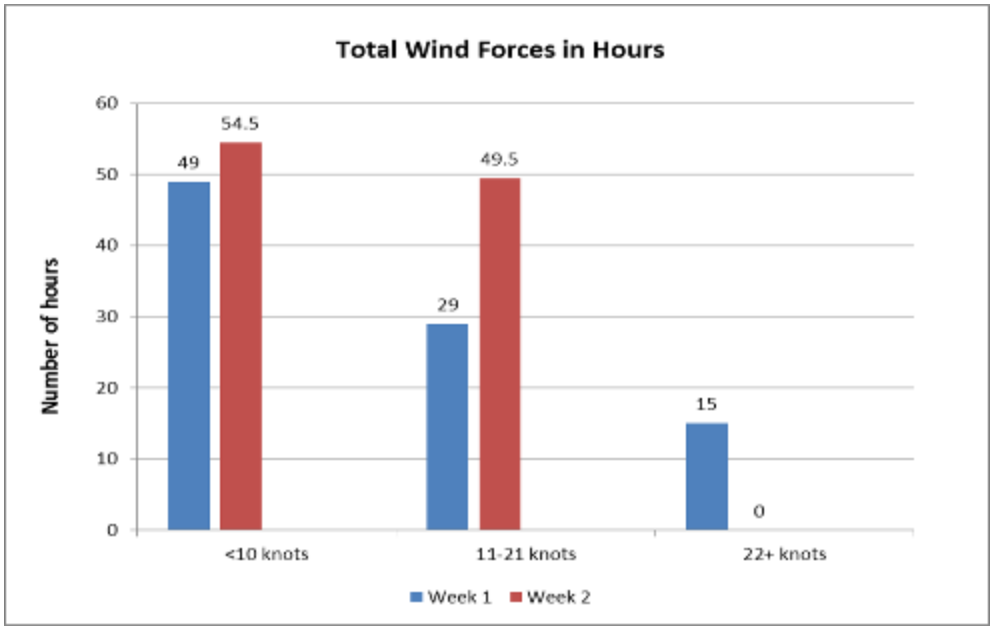

Figure 9. Average wind force each week during visual monitoring.

Swell height also remained relatively stable throughout the survey with 129 hours of swells under 2 meters, and 68 hours of swells from 2-4 meters. There were no swells recorded over 4 meters (Figure 10). July 14 and 15 saw the majority of the 2-4 meter swells. The conditions over these two days did impact the effectiveness of our observation at greater distances.

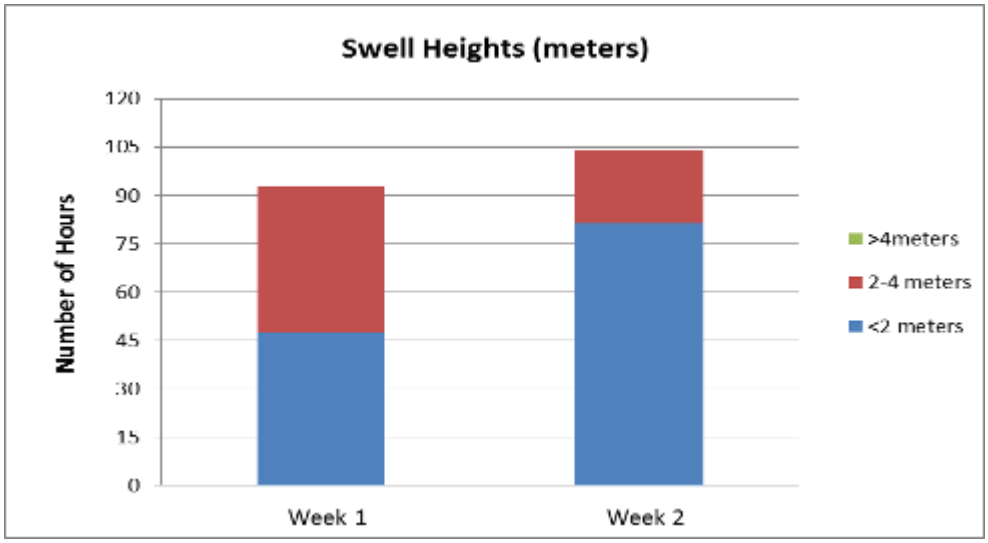

Figure 10. Swell heights while visual monitoring was conducted.

5. R/V LANGSETH MONITORING AND DETECTION RESULTS

5.1. VISUAL DETECTIONS

Visual monitoring conducted during the Cascadia subduction margin marine geophysical survey resulted in the collection of 92 records of detection for protected species by observers on the *R/V Langseth* (summarized in Appendix F). Ten species of marine mammals were positively identified, observations were also made of unidentified baleen whales and unidentified whales. The total number of detection events and total number of animals recorded by species is described in Table 7.

A complete list of birds and other marine animals 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 7. Number of visual detection records collected for each protected species on the *R/V Langseth*.

	Total Number of Detection Records	Total Number of Animals Recorded
Cetaceans		
Unidentified whale	5	6
Mysticetes		
Fin whale	12	26
Humpback whale	34	83
Unidentified baleen whale	6	8
Odontocetes		
Northern right whale dolphin	5	217
Pacific white-sided dolphin	9	182
Risso's dolphin	2	21
Dall's porpoise	9	32
Harbor porpoise	2	9
Pinnipeds		
Northern fur seal	1	1
Steller sea lion	3	6
Harbor seal	4	5
TOTAL	**92**	**596**

There were many sightings of protected species during the Cascadia subduction margin marine geophysical survey with multiple detections of protected species occurring every day of the survey (Figure 11). The most detections occurred on 12 July when there were 19 detections of seven different protected species. This was while the *Langseth* was in transit to the survey site. All pinnipeds observed during this survey occurred while the vessel was in transit on 12 July.

Of the 92 protected species detection events during the Cascadia subduction margin marine geophysical survey, 65 detections (71%) occurred while the acoustic source was active and 27 detections (29%) occurred while the acoustic source was silent. Figure 12 demonstrates the species detected compared to airgun activity.

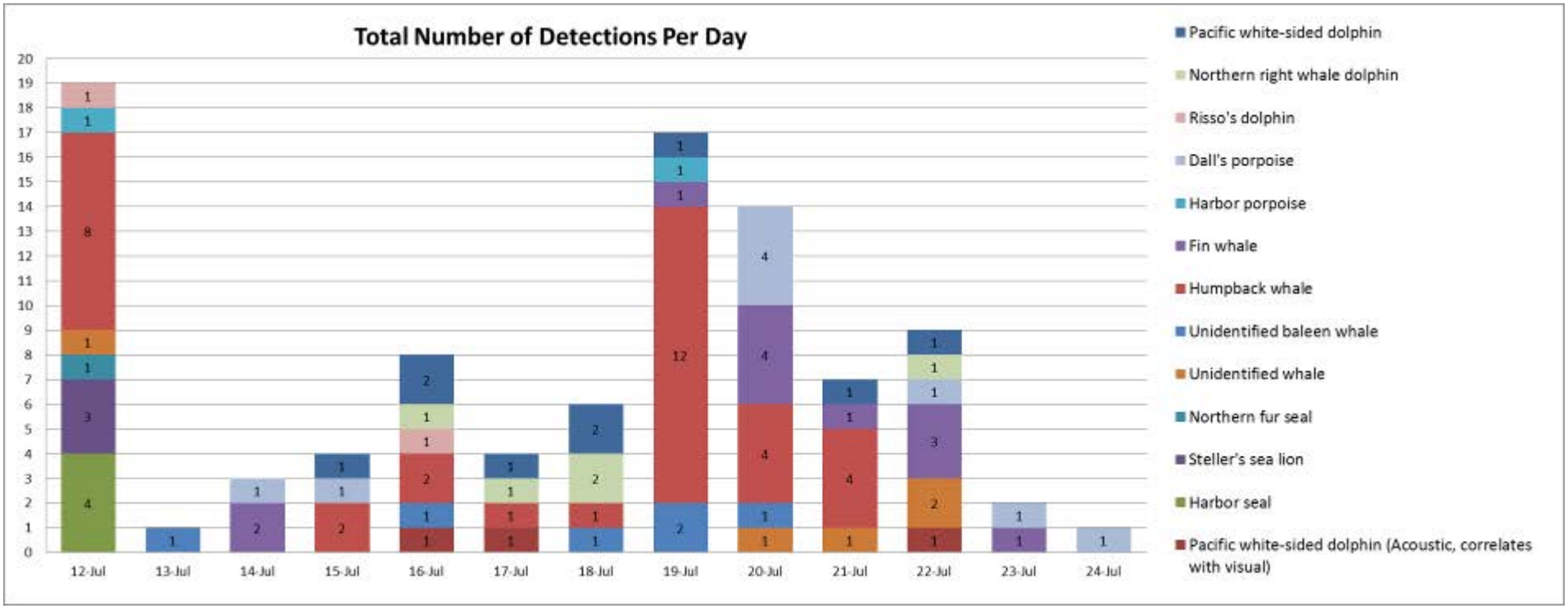

Figure 11. Number of protected species detections each day of the Cascadia subduction margin marine geophysical survey on the *R/V Langseth*.

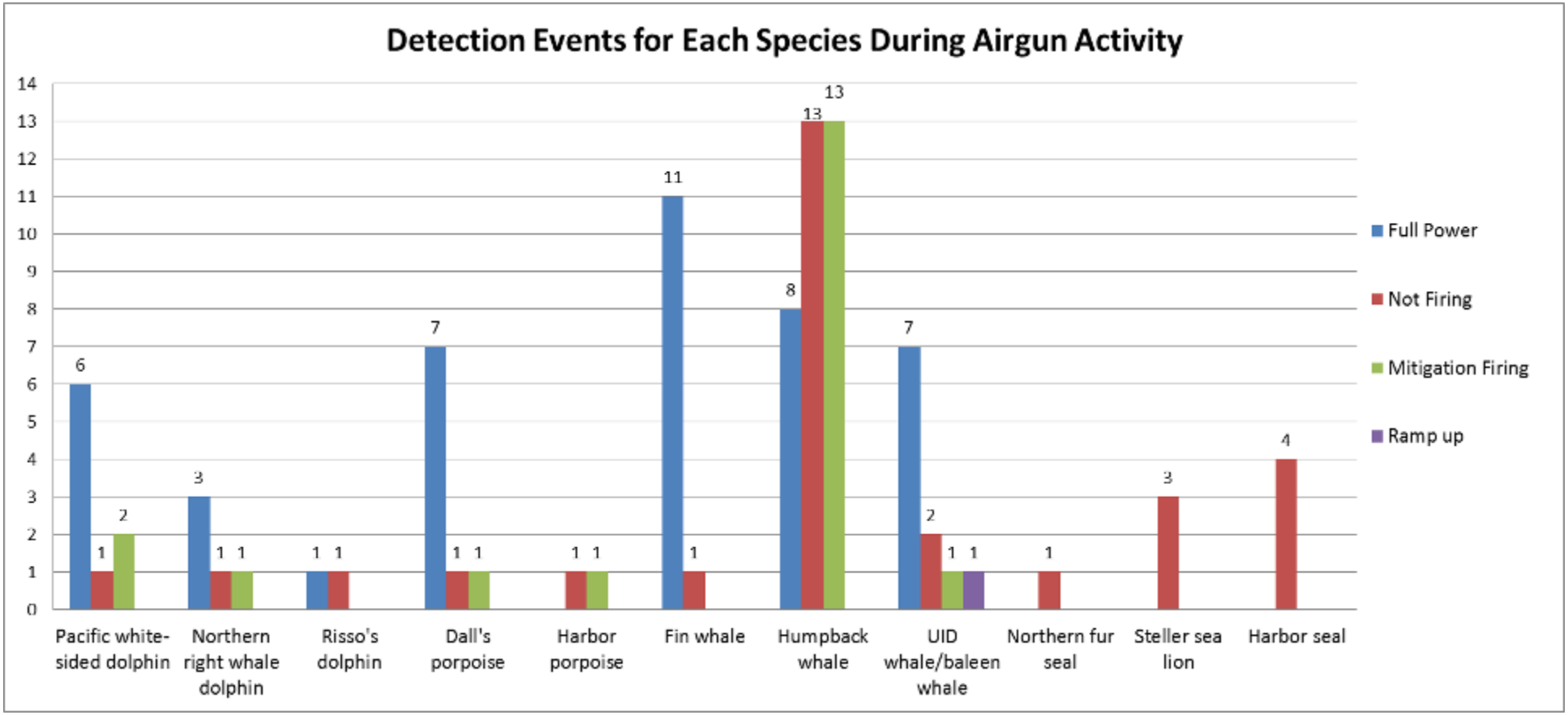

Figure 12. Species detected compared to airgun activity.

Table 8 demonstrates the average closest approach of protected species to the source at various volumes.

Table 8. Average closest approach of protected species to the acoustic source at various volumes.

Species Detected	Full Power (6520-6600 in³)		Single Airgun 40 in³		Ramp-up or Partial Power		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	11	2289	-	-	-	-	1	2000
Humpback whale	8	3126	15	1754	-	-	11	1259
Unidentified baleen/whale	7	3791	1	800	1	1300	2	2843
Northern right whale dolphin	3	1293	1	583	-	-	1	1089
Pacific white-sided dolphin	6	1201	2	55	-	-	1	1089
Risso's dolphin	1	800	-	-	-	-	1	600
Dall's porpoise	6	1273	1	800	1	505	1	230
Harbor porpoise	-	-	1	600	-	-	1	300
Harbor seal	-	-	-	-	-	-	4	131
Northern fur seal	-	-	-	-	-	-	1	300
Steller sea lion	-	-	-	-	-	-	3	317

Cetaceans were detected most frequently, consisting of 91% (84 detection records) of the total records. Figure 13 demonstrates the total number of animals observed, per species, during the detection events. The most detection records collected for a species was 34 records for humpback whales, totaling 83 animals. However, the species with the largest number of individuals observed was Northern right whales dolphins with 217 animals observed in five detection events.

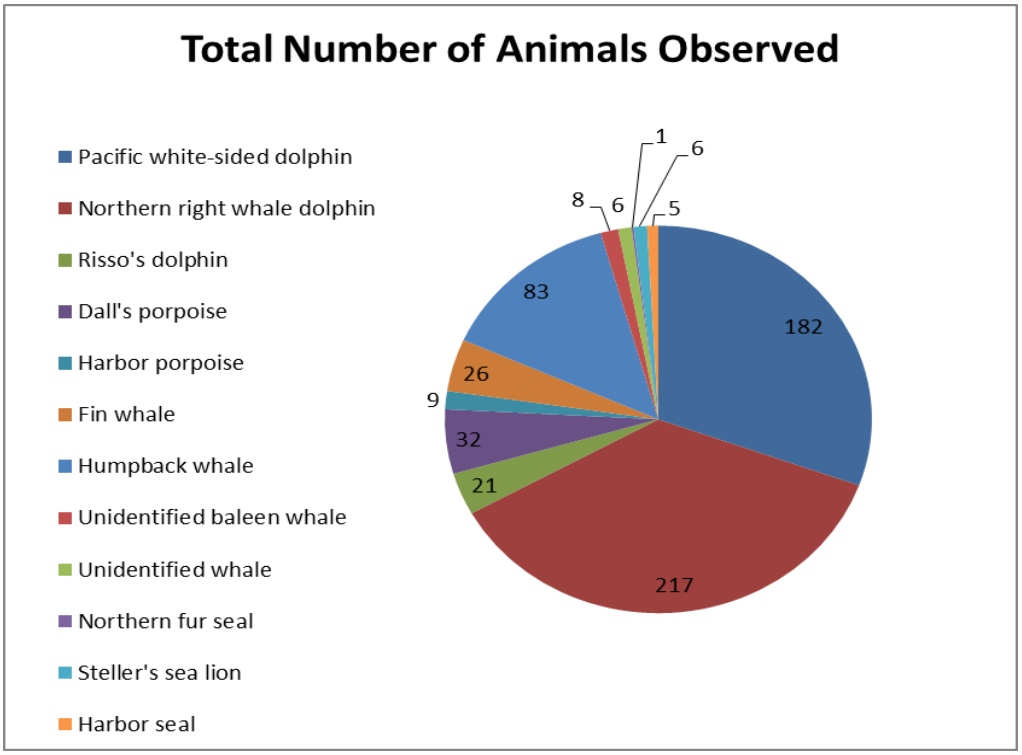

Figure 13. Number of individuals per species detection on the *R/V Langseth*.

The spatial distribution of marine mammal detections on the *Langseth* can be seen in Figure 14.

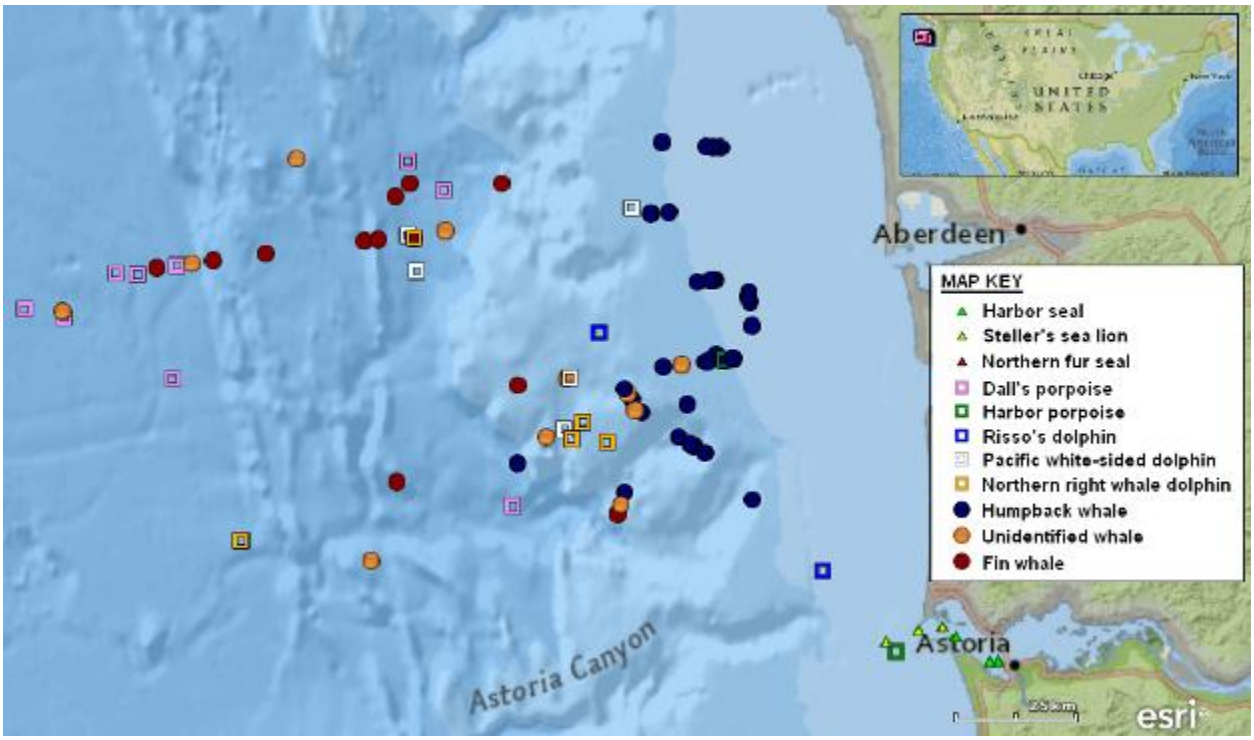

Figure 14. Marine mammal spatial distribution of detections from 12 July 2012 – 24 July 2012 on board the *R/V Langseth*.

5.1.1. Cetacean Detections

5.1.1.1. Fin whale

There were 12 sightings of fin whales (*Balaenoptera physalus*) during the survey, totaling 26 individuals observed. Four of these observations resulted in power-downs, for a total of 1 hour 37 minutes of mitigation downtime. This accounts for 8.4% of the overall mitigation downtime. The whales were noted to be in depths ranging from 976 to 2562 meters. The largest group size was four individuals observed on 14 July. There were three sightings consisting of three individuals, two sightings consisting of two individuals, and six sightings consisting of just one individual. The closest approach to the sound source was 100 meters on 22 July.

5.1.1.2. Humpback whale

There were 34 sightings of humpback whales (*Megaptera novaeangliae*) during the survey, totaling 83 individuals observed. Four of these observations resulted in shut-downs, one sighting resulted in a power-down, and three sightings led to delayed ramp-ups. There was a total of 10 hours 40 minutes of mitigation downtime. This accounts for 55.6% of the overall mitigation downtime. The whales were noted to be in depths ranging from 74 to 1626 meters, however only four sightings occurred in water depths greater than 600 meters. Average group size was 1 – 3 individuals. The closest approach to the vessel was 50 meters on 15 July.

5.1.1.3. Northern right whale dolphin

There were 217 individual Northern right whale dolphins (*Lissodelphis borealis*) observed during five sightings. Only one of these sightings resulted in a power-down, leading to just two minutes of mitigation downtime. These animals were typically seen in large groups from 25 – 80 individuals. It should also be noted that in 80% of sightings the Northern right whale dolphins were observed in mixed pods with Pacific white-sided dolphins.

5.1.1.4. Pacific white-sided dolphin

There were 182 individual Pacific white-sided dolphins (*Lagenorhynchus obliquidens*) observed during nine sightings. These detections resulted in three power-downs and five shut downs. There was a total of 4 hours 35 minutes of mitigation downtime, accounting for 23.9% of total mitigation downtime.

The dolphins were noted to be in depths ranging from 152 to 2478 meters. They were observed to swim 1-5 meters from the acoustic source in five separate sightings. In three of these close range sightings, acoustic detections of the animals were made as well as visual. One large group size was seen on 16 July with 65 individuals. There were an additional four sightings with 14–30 animals. The remainder of the detections were of 2-6 individuals.

5.1.1.5. Risso's dolphin

There were 21 individual Risso's dolphins (*Grampus griseus*) observed during two sightings. One of these sightings required a power-down, and resulted in 12 minutes of mitigation downtime. During the first sighting there were 11 animals observed at a depth of 66 meters. During the second sighting there were 10 animals observed at a depth of 327 meters. The closest approach to the vessel was 600 meters on 12 July.

5.1.1.6. Dall's porpoise

There were 32 individual Dall's porpoises (*Phocoenoides dalli*) observed during nine sightings.

These detections led to five power-downs, and 1 hour of mitigation downtime. This accounted for 5.2% of overall mitigation downtime. The animals were noted to be in depths ranging from 1742 to 2650 meters, and group size ranged from 2-6 individuals. The closest approach to the vessel was 200 meters on 22 July.

5.1.1.7. Harbor porpoise

There were nine individual Harbor porpoises (*Phocoena phocoena*) observed during two sightings. Neither of these sightings resulted in a mitigation action. During the first sighting, five animals were observed at a depth of 66 meters. During the second sighting four animals were observed at a depth of 123 meters. The closest approach to the vessel was 300 meters on 12 July.

5.1.1.8. Unidentified baleen whale

There were six sightings of unidentified baleen whales totaling eight individuals observed during the survey. These detections led to one power-down and a total of 1 hour 5 minutes of mitigation downtime. This accounted for 5.6% of the overall mitigation downtime.

5.1.1.9. Unidentified whale

There were five sightings of unidentified whales totaling six individuals observed during the survey cruise. None of these detections required a mitigation action due to their distance from the sound source. This large distance prevented observers from making a positive identification.

5.1.2. Pinniped Detections

5.1.2.1. Harbor seal

There were five individual harbor seals (*Phoca vitulina*) observed during four sightings. All of these sightings occurred on 12 July while in transit to the survey sight at 66 meters of depth. None of these sightings resulted in mitigation actions.

5.1.2.2. Steller sea lion

Six individual Steller sea lions (*Eumetopias jubatus*) were observed during three sightings throughout the survey. One sighting was of three animals hauled out on a channel marker. All of these sightings occurred on 12 July while in transit to the survey sight at 66 meters of depth. None of these sightings resulted in mitigation actions.

5.1.2.3. Northern fur seal

There was only one sighting of one individual Northern fur seal (*Callorhinus ursinus*) during the survey. This sighting occurred on 12 July while in transit to the survey sight and no mitigation action was required.

5.2. ACOUSTIC DETECTIONS

5.2.1. Cetacean Detections

There were 3 acoustic detections on the PAM system during the Holbrook survey; all corresponding with visual detections of Pacific white-sided dolphins.

Multiple high frequency click trains were observed visually on the high frequency click detector for all 3 detections. Faint whistles were seen on the low frequency *Pamguard* spectrogram and heard aurally during detection 2 (Figure 16). Detections 1 (Figure 15) and 3 were not observed on the low frequency *Pamguard* Spectrogram or Whistle and Moan detector, or heard aurally by the PAM operator.

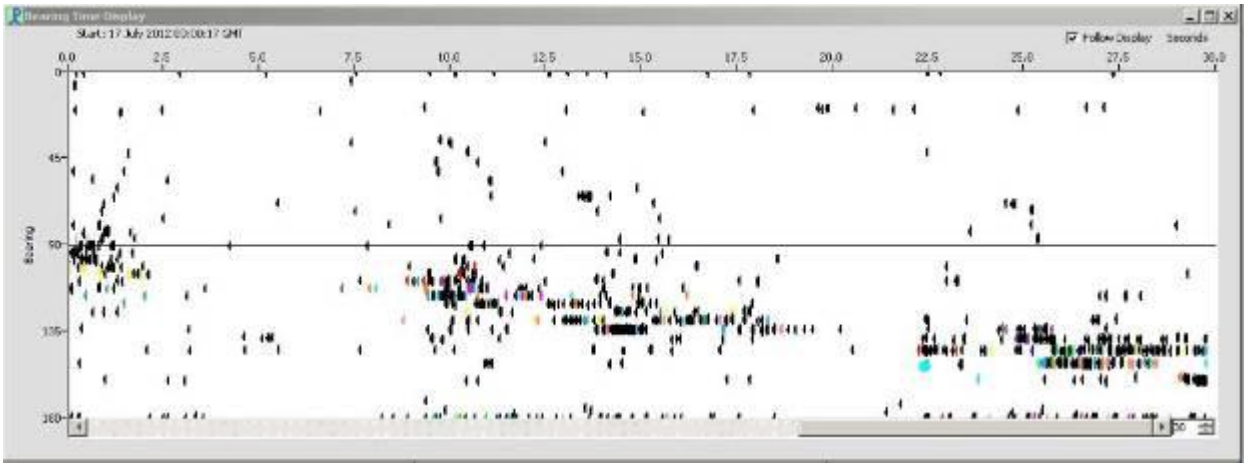

Figure 15. Multiple click trains from Pacific white-sided dolphins shown on high frequency click detector on 17 July corresponding with visual detection 34 (acoustic detection 1).

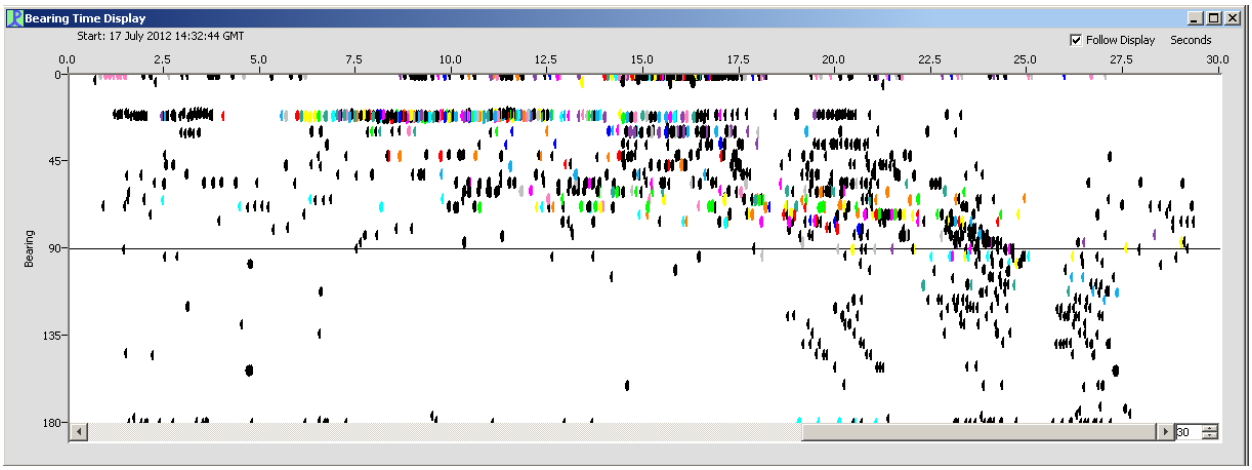

Figure 16. Multiple click trains from dolphins shown on high frequency click detector on 17 July corresponding with visual detections 35 & 36 of Pacific white-sided and Northern right whale dolphins (acoustic detection 2).

6. NORTHERN LIGHT MONITORING AND DETECTION RESULTS

6.1. VISUAL DETECTIONS

Visual monitoring conducted during the Cascadia subduction margin marine geophysical survey resulted in the collection of 174 records of detection for protected species by observers on the *Northern Light* (summarized in Appendix F). Thirteen species of marine mammals were positively identified, observations were also made of unidentified whales and unidentified otariids. The total number of detection events and total number of animals recorded by species is described in Table 9.

Table 9. Number of visual detection records collected for each protected species on the *Northern Light*.

	Total Number of Detection Records	Total Number of Animals Recorded
Cetaceans		
Unidentified whale	3	3
Mysticetes		
Gray whale	2	3
Fin whale	2	2
Humpback whale	64	130
Common minke whale	1	1
Odontocetes		
Northern right whale dolphin	3	61
Pacific white-sided dolphin	6	280
Risso's dolphin	1	10
Dall's porpoise	7	22
Harbor porpoise	51	76
Pinnipeds		
Northern fur seal	5	5
Steller sea lion	8	11
Harbor seal	12	13
Northern elephant seal	5	5
TOTAL	**174**	**626**

There were many sightings of protected species during the Cascadia subduction margin marine geophysical survey with multiple detections of protected species occurring every day of the survey (Figure 17). The most detections occurred on 11 July when there were 38 detections of five different protected species. This was while the *Northern Light* was conducting a pre-survey while in transit to the survey site. On 21 July there eight sightings of humpback whales from the *Northern Light*; seven of these sightings occurred within ~8 km of the *Langseth* and are likely duplicated sightings.

Of the 174 protected species detection events during the Cascadia subduction margin marine geophysical survey, 112 detections (64%) occurred while the acoustic source on the *Langseth* was active and 62 detections (36%) occurred while the acoustic source was silent. Many of the detections that occurred while the acoustic source was active were well outside of the 160 dB safety radius.

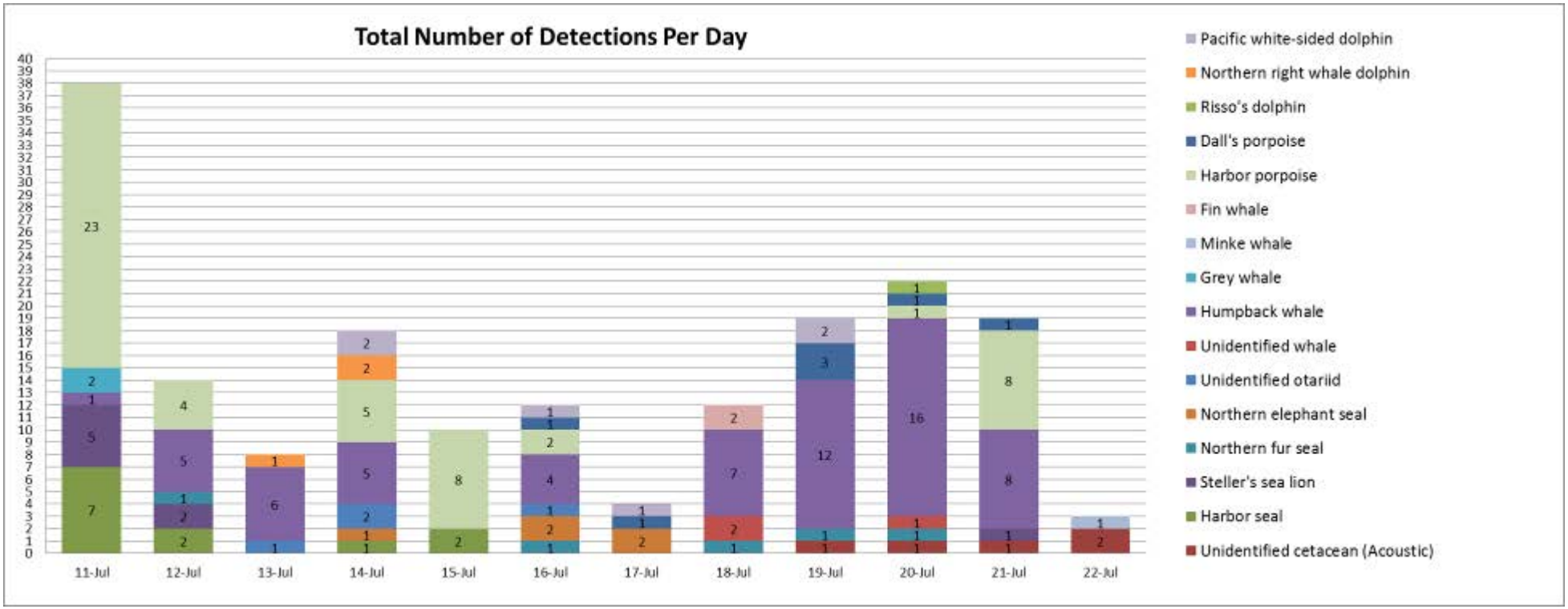

Figure 17. Number of protected species detections each day of the Cascadia subduction margin marine geophysical survey on the *Northern Light*.

Cetaceans were detected most frequently, consisting of 91% (140 detection records) of the total records. Figure 18 demonstrates the total number of animals observed, per species, during the detection events. The most detection records collected for a species was 64 records for humpback whales, totaling 130 animals. However, the species with the largest number of individuals observed was Pacific white-sided dolphins with 280 animals observed during six detection events.

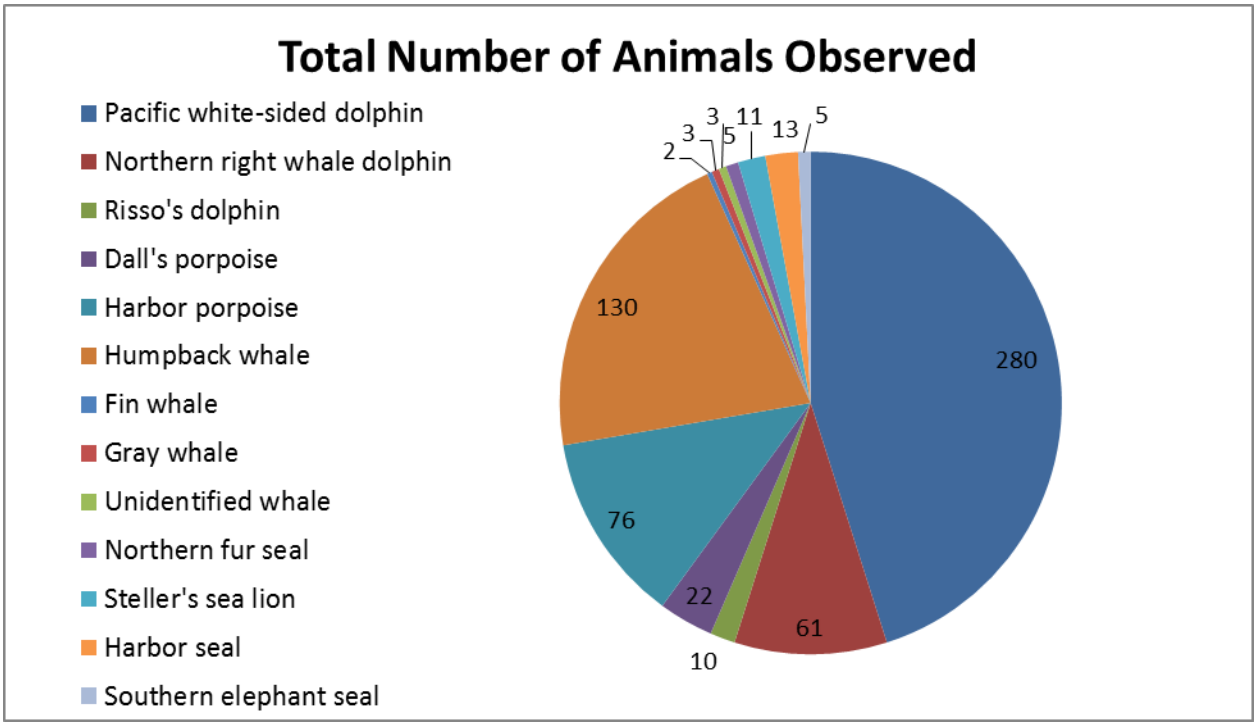

Figure 18. Number of individuals per species detection on the *Northern Light*.

The spatial distribution of marine mammal detections on the *Northern Light* can be seen in Figure 19.

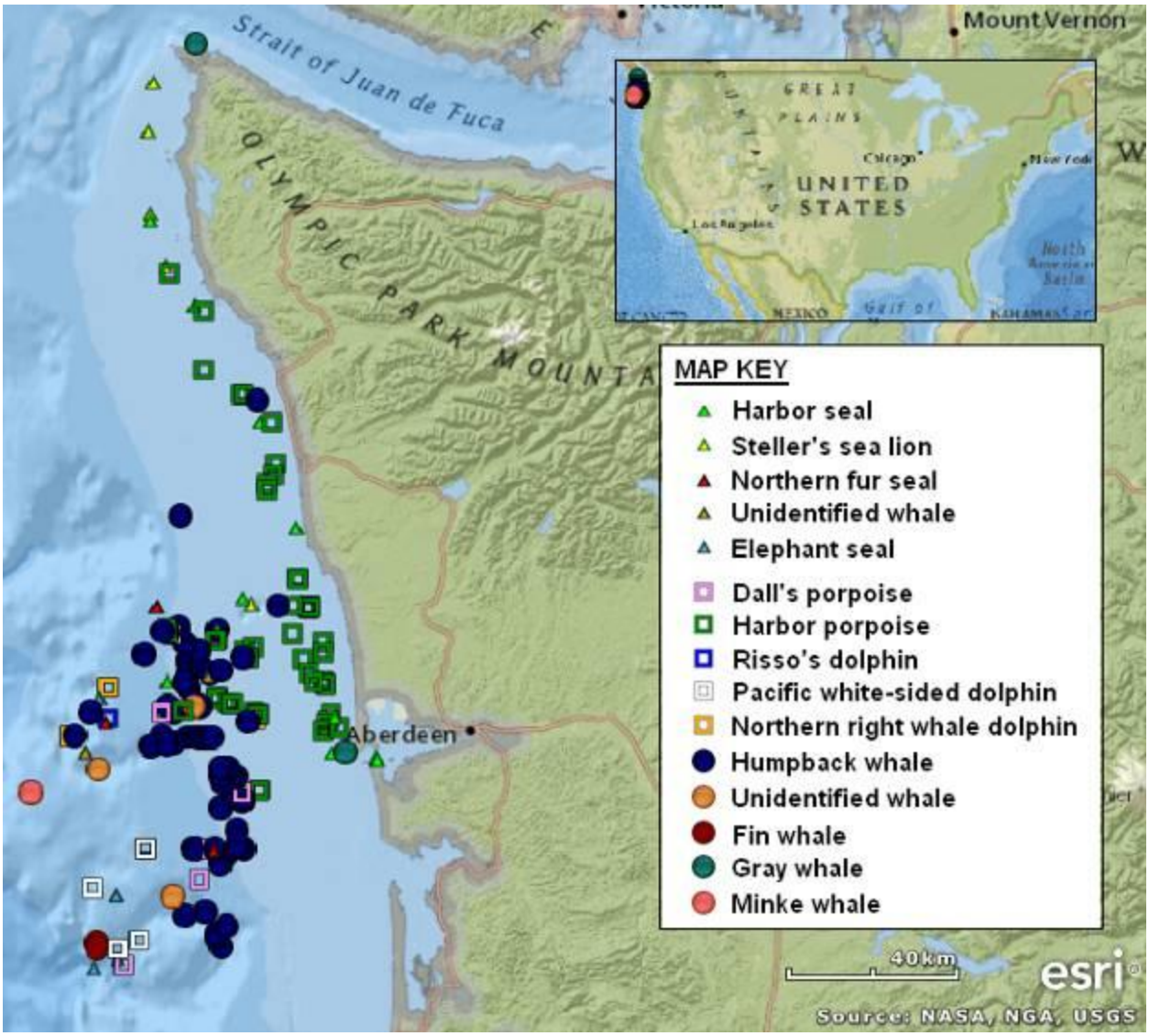

Figure 19. Marine mammal spatial distribution of detections from 11 July 2012 – 22 July 2012 on board the *Northern Light*.

6.2. ACOUSTIC DETECTIONS

Throughout the Cascadia subduction margin survey, the *Northern Light* had five acoustic detections of protected species, all of which were unidentified delphinid detections. On 19 July 2012 from 07:23 to 07:51 UTC, delphinid whistles and pulses were aurally detected and then confirmed using the spectrogram display of the *PAMGUARD* software. See figure 20 below for spectrogram screen grab of unidentified delphinid detection on 19 July 2012. One acoustic detection of unidentified delphinids occurred on 20 July 2012 from 07:42 to 07:49 UTC. Another brief unidentified delphinid acoustic detection took place on 21 July 2012 at 09:38 UTC. The remaining two acoustic detections of unidentified delphinids occurred on 22 July 2012, one from 06:52 to 07:41 UTC and one from 09:22 to 09:25 UTC. No visual confirmation was available for the remaining 4 acoustic detections due to a software malfunction of the PAM laptop computer.

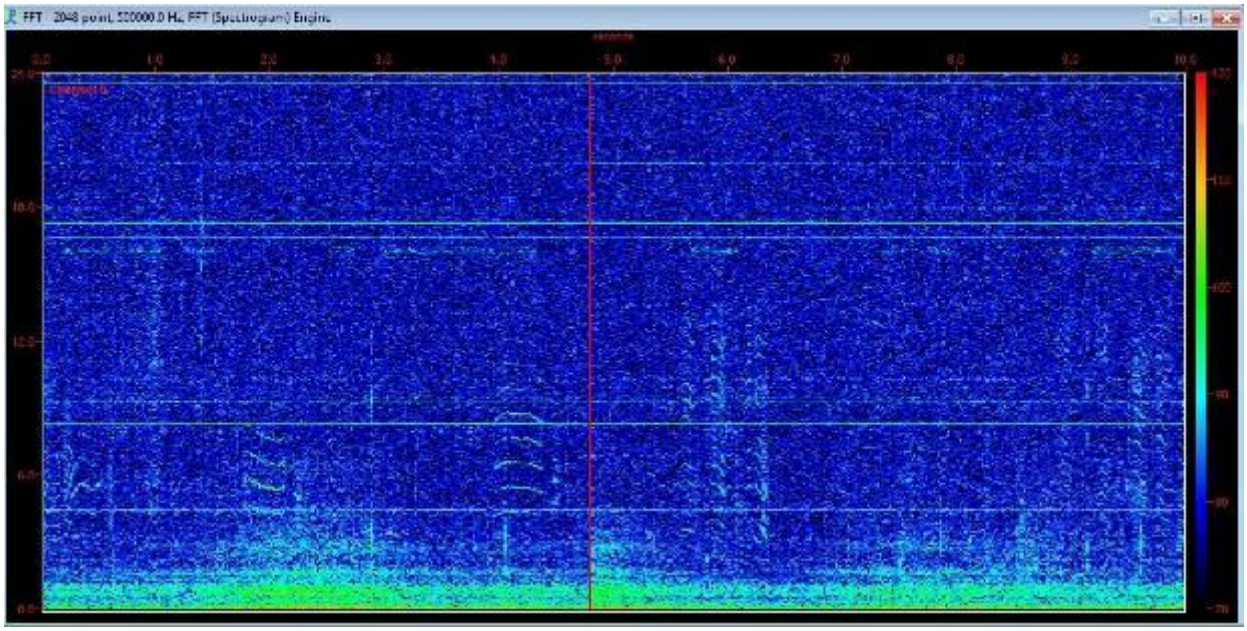

Figure 20. Multiple short whistles of an unidentified delphinid observed on the low frequency spectrogram on 19 July 2012 (acoustic detection 1).

7. MITIGATION ACTION SUMMARY

There were 28 mitigation actions implemented during the Cascadia subduction margin marine geophysical survey. There were 16 power-downs, nine shut-downs and three delayed ramp-ups of the acoustic source due to protected species being observed within the safety radii. The total duration of downtime caused by mitigation actions (including ramp-up, if required) was 19 hour 11 minutes during the survey. The number and duration of mitigation actions is summarized in Table 10. All mitigation actions were implemented for cetaceans; none were implemented for pinnipeds.

Table 10. Number and duration of mitigation actions implemented during the Cascadia subduction margin marine geophysical survey.

Mitigation Action	Cetaceans	
	Number	Duration
Delayed Ramp-up	3	5:20
Power-down	16	7:27
Shut-down	9	6:24
Total	**28**	**19:11**

All 28 mitigation actions were implemented for cetaceans (Table 11). The majority of mitigation downtime (55.6%) can be attributed to humpback whales. Due to originally being allotted 11 'takes' for humpback whales much of this downtime can be attributed to trying to avoid 'takes' of humpback whales. With many humpbacks observed in the area the acoustic source was powered-down during the shallower inshore turns of the survey to avoid exceeding allowable 'takes'. While powered-down if a humpback was observed to be likely to enter the 160 dB safety radius the acoustic source would be shut-down. On 20 July, NMFS issued more 'takes' for humpback whales and while the acoustic source was still powered-down during inshore turns the acoustic source was not shut-down to avoid 'takes'. The exceeded take report can be found in Appendix G.

A substantial amount of mitigation downtime (23.9%) can also be attributed to Pacific white-sided dolphins. During five of the nine Pacific white-sided dolphins they approached the airguns and attempted 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	-	1:37	**8.4%**
Humpback whale	3	1	4	10:40	**55.6%**
Unidentified baleen whale	-	1	-	1:05	**5.6%**
Northern right whale dolphin	-	1	-	0:02	**0.2%**
Pacific white-side dolphins	-	3	5	4:35	**23.9%**
Risso's dolphin	-	1	-	0:12	**1.0%**
Dall's porpoise	-	5	-	1:00	**5.2%**

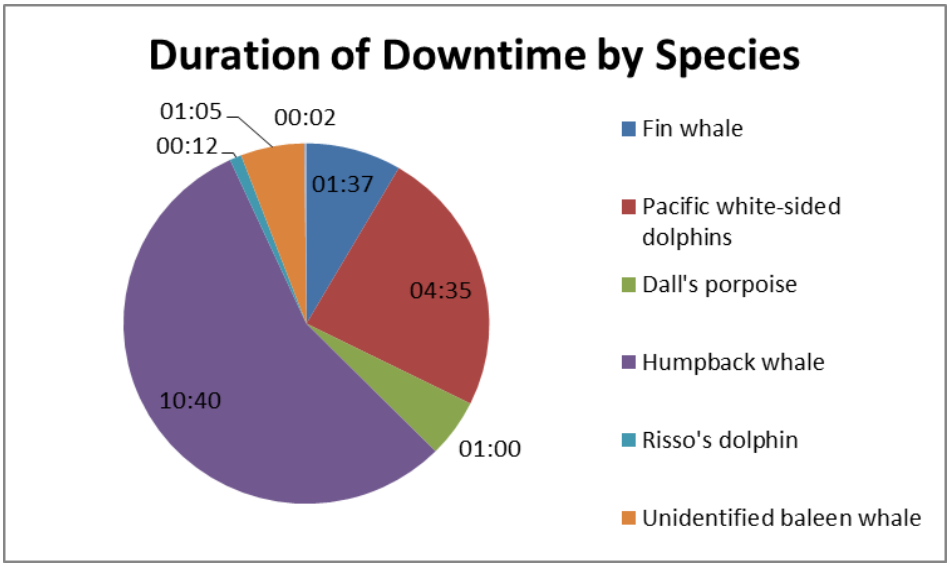

Figure 21. Duration of mitigation downtime per species.

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 Cascadia subduction margin 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
15-Jul	24	Pacific white-sided dolphin	14	Mitigation firing	5 m / Not firing	Shut-down	0:02
15-Jul	25	Humpback whale	2	Mitigation firing	60 m / Mitigation firing	Shut-down	0:05
15-Jul	26	Humpback whale	15	Not firing	50 m / Not firing	Delay soft start	2:35
15-Jul	27	Dall's porpoise	2	Full power	250 m / Full power	Power-down	0:15
16-Jul	28	Risso's dolphins	10	Full power	800 m / Full power	Power-down	0:12
16-Jul	29	Humpback whale	12	Mitigation firing	700 m / Mitigation firing	Shut-down	1:08
16-Jul	30	Humpback whale	1	Not firing	1600 m / Not firing	Delay soft start	1:30
16-Jul	31	Unidentified baleen whale	1	Ramp up	1300 m / Ramp up	Power-down	1:05
16-Jul	32	Pacific white-sided dolphin	65	Full power	1500 m / Full power	Power-down	0:09
16-Jul	34	Pacific white-sided dolphin	7	Full power	4 m / Not firing	Power-down / Shut-down	1:18

17-Jul	35	Pacific white-sided dolphin	75	Full power	1 m / Not firing	Shut-down	1:02
17-Jul	36	Northern right whale dolphin	80	Full power	450 m / Not firing	Power-down	0:02
18-Jul	38	Pacific white-sided dolphin	30	Mitigation firing	1 m / Not firing	Shut-down	0:34
19-Jul	44	Fin whale	2	Full power	640 m / Full power	Power-down	0:53
19-Jul	46	Pacific white-sided dolphin	6	Full power	200 m / Mitigation firing	Power-down	0:22
19-Jul	50	Humpback whale	1	Full power	845 m / Full power	Power-down	2:57
19-Jul	59	Humpback whale	1	Mitigation firing	800 m / Mitigation firing	Shut-down	0:54
20-Jul	63	Humpback whale	1	Mitigation firing	60 m / Mitigation firing	Shut-down	0:16
20-Jul	64	Humpback whale	1	Mitigation firing	4096 / Mitigation firing	Delay soft start	1:15
20-Jul	65	Dall's porpoise	5	Full power	600 m / Full power	Power-down	0:05
20-Jul	69	Fin whale	1	Full power	613 m / Mitigation firing	Power-down	0:16
20-Jul	70	Dall's porpoise	6	Mitigation firing	800 m / Mitigation firing	Power-down	0:09
20-Jul	72	Fin whale	1	Full power	730 m / Full power	Power-down	0:18
22-Jul	82	Dall's porpoise	3	Full power	200 m / Full power	Power-down	0:16
22-Jul	86	Pacific white-sided dolphin	3	Full power	5 m / Not firing	Shut-down	1:08
22-Jul	88	Fin whale	3	Full power	100 m / Mitigation firing	Power-down	0:10
23-Jul	90	Dall's porpoise	2	Partial power (3300 cu in.)	505 m / Partial power	Power-down	0:15

7.1. 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: seven mysticetes and 13 odontocete species, and four pinniped species. Direct visual observations recorded by PSOs of nine 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 Cascadia subduction margin marine geophysical survey humpback whales, fin whales, Pacific white sided-dolphins, Northern right whale dolphins, Risso's dolphins, and Dall's

porpoises were observed within both the 180/190 dB safety radius and 160 dB safety radius. While harbor porpoises, a Steller sea lion and a Northern fur seal 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). This includes protected species visually observed from the *Northern Light* that were determined to be within the 160 dB safety radius of the *R/V Langseth's* acoustic source while it was active.

Table 13. Level B Harassment Takes authorized by NMFS IHA for the Cascadia subduction margin 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
Mysticetes			
North Pacific right whale	0	0	0
Gray whale	12	0	0
Humpback whale	11	2	24
Minke whale	6	0	0
Sei whale	2	0	0
Fin whale	18	7	18
Blue whale	3	0	0
Unidentified baleen whale	-	1	5
Odontocetes			
Sperm whale	15	0	0
Unidentified *Kogia spp.*	10	0	0
Cuvier's beaked whale	6	0	0
Baird's beaked whale	17	0	0
Unidentified *Mesoplodon spp.*	25	0	0
Striped dolphin	2	0	0
Short-beaked common dolphin	238	0	0
Pacific white-sided dolphins	497	150	155
Northern right whale dolphin	183	190	190
Risso's dolphin	159	10	10
Killer whale	0	0	0
Harbor porpoise	2,580	0	9
Dall's porpoise	1,193	12	31
Pinnipeds			
Northern fur seal	1,190	0	1
California sea lion	0	0	0
Steller sea lion	187	0	1
Pacific harbor seal	1,192	0	0
Northern elephant seal	652	0	0

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 26.35 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. 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 observed from the *R/V Langseth* to be exposed to 160 dB.

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
Fin whale	21	4	Blowing	Variable	Roll / Dive	Parallel, same direction
Dall's porpoise	22	4	Fast swim	Parallel, opposite direction	Fast swim	Parallel, opposite direction
Fin whale	23	3	Blowing	Parallel, opposite direction	Blowing	Parallel, opposite direction
Pacific white-sided dolphin	24	14	Porpoising	Towards vessel	Bowride airguns	Away from vessel
Humpback whale	25	2	Blowing	Parallel, same direction	Breach	Towards vessel
Dall's porpoise	27	2	Porpoising	Away from vessel	Porpoising	Away from vessel
Risso's dolphin	28	10	Slow swim	Parallel, opposite direction	Slow swim	Perpendicular, behind vessel
Humpback whale	30	3	Blowing	Away from vessel	Fluke	Away from vessel
UNID baleen whale	31	1	Blowing	Perpendicular, ahead of vessel	Blowing	Away from vessel
Pacific white-sided dolphin	32	1	Porpoising	Parallel, opposite direction	Flipping	Parallel, opposite direction
Northern right whale dolphin	33	65	Porpoising	Parallel, opposite direction	Flipping / Lobtailing	Parallel, opposite direction
Pacific white-sided dolphin	34	75	Porpoising	Parallel, same direction	Bowride airguns	Towards vessel
Pacific white-sided dolphin	35	7	Porpoising	Parallel, opposite direction	Bowride airguns	Towards vessel
Northern right whale dolphin	36	30	Porpoising	Parallel, opposite direction	Porpoising	Perpendicular, behind vessel
Humpback whale	37	80	Blowing	Parallel, opposite direction	Fluke	Parallel, opposite direction
Pacific white-sided dolphin	38	1	Porpoising	Towards vessel	Bowride airguns	Away from vessel
Fin whale	44	30	Blowing	Perpendicular, ahead of vessel	Dive	Parallel, same direction
UNID baleen whale	45	2	Blowing	Parallel, opposite direction	Blowing	Parallel, same direction

Pacific white-sided dolphin	46	6	Fast swim	Towards vessel	Fast swim	Away from vessel
Humpback whale	47	3	Breach	Perpendicular, ahead of vessel	Roll / Flipper slap	Parallel, opposite direction
UNID baleen whale	48	1	Blowing	Parallel, opposite direction	Blowing	Parallel, opposite direction
Humpback whale	49	2	Blowing	Parallel, opposite direction	Fluke	Away from vessel
Humpback whale	50	3	Blowing	Away from vessel	Roll	Away from vessel
Humpback whale	59	1	Blowing	Perpendicular, ahead of vessel	Fluke	Perpendicular, ahead of vessel
Humpback whale	63	1	Blowing	Parallel, opposite direction	Breach	Parallel, opposite direction
Dall's porpoise	65	5	Fast swim	Towards vessel	Fast swim	Away from vessel
Dall's porpoise	67	5	Fast swim	Perpendicular, behind vessel	Fast swim	Variable / Perpendicular, behind vessel
Dall's porpoise	68	3	Fast swim	Parallel, opposite direction	Fast swim	Parallel, opposite direction
Fin whale	69	1	Blowing	Parallel, opposite direction	Roll / Fluke	Parallel, opposite direction
Fin whale	72	1	Blowing	Perpendicular, ahead of vessel	Dive	Perpendicular, ahead of vessel
Fin whale	74	1	Blowing	Perpendicular, ahead of vessel	Dive	Away from vessel
Fin whale	75	1	Blowing	Parallel, opposite direction	Dive	Away from vessel
Humpback whale	78	4	Breach	Perpendicular, ahead of vessel	Tail slap	Parallel, opposite direction
Humpback whale	79	1	Blowing	Perpendicular, ahead of vessel	Blowing	Parallel, opposite direction
Humpback whale	80	2	Blowing	Away from vessel	Breach	Away from vessel
Humpback whale	81	2	Breach	Unknown	Blowing	Unknown
Dall's porpoise	82	3	Fast swim	Parallel, opposite direction	Fast swim	Parallel, opposite direction

Fin whale	84	2	Blowing	Away from vessel	Blowing	Towards vessel
Northern right whale dolphin	85	35	Porpoising	Parallel, opposite direction	Flipping / Lobtailing	Parallel, opposite direction
Pacific white-sided dolphin	86	3	Fast swim	Towards vessel	Bowride airguns	Away from vessel
UNID baleen whale	87	1	Blowing	Unknown	Blowing	Unknown
Fin whale	88	3	Blowing	Parallel, opposite direction	Dive	Towards vessel / Parallel, opposite direction
Dall's porpoise	90	2	Fast swim	Away from vessel	Fast swim	Away from vessel

7.1.1. Cetaceans

7.1.1.1. Fin whale

There were nine sightings of fin whales (*Balaenoptera physalus*) totalling 18 animals that were observed within the 160 dB safety radius; seven of these animals were observed to be exposed to received sound pressure levels of 180 dB or greater. Of the 18 animals observed four were identified as juveniles. During five of the eight detections the whales were observed to change course multiple times over the duration of the sighting, with two whales approaching the vessel. During two sightings the whales were observed rolling showing their pectoral fins and during one sighting a whale showed its' fluke while diving.

7.1.1.2. Humpback whale

There were 13 sightings of humpback whales (*Megaptera novaeangliae*), totaling 24 animals that were observed within the 160 dB safety radius; two of these animals were observed within the 180 dB safety radius. One of the animals was identified as a juvenile. One sighting was made from the *Northern Light* of three whales ~12 km from the *Langseth*. During six of the 12 sightings made from the *Langseth* the whales were observed to exhibit active behavior such at breaching, flipper slapping, and rolling. On 21 July both the *Langseth* and *Northern Light* had multiple sightings of humpback whales while the *Northern Light* was ~3.5 to ~8.5 km from the *Langseth*. These sightings were counted as duplicate sightings although it is possible *Northern Light* observed animals that were not seen from the *Langseth*; making the total number of animals exposed to received sound levels of 160 dB higher.

7.1.1.3. Unidentified baleen whale

There were four sightings of unidentified baleen whales, totaling five animals that were observed within the 160 dB safety radius; one of these animals was observed within the 180 dB safety radius. None of these animals were identified as juveniles.

7.1.1.4. Northern right whale dolphin

There were three sightings of Northern right whale dolphins (*Lissodelphis borealis*), totaling 190 animals that were all observed within the 180 dB safety radius. These pods ranged from 35 to 80 animals making is very likely that there were quite a few juveniles in the pods, however

estimates were not possible due to the amount and distance of the dolphins. During each of these sightings the Northern right whale dolphins were observed with Pacific white-sided dolphins. During two of the sightings the dolphins were observed being breaching, belly-flopping, side-slapping, and lobtailing. During the third sighting the dolphins were observed porpoising, traveling quickly. While the Pacific white-sided dolphins observed in the missed pod would approach the vessel the Northern right whale dolphins would usually remain on course.

7.1.1.5. Pacific white-sided dolphin

There were seven detections of Pacific white-sided dolphins (*Lagenorhynchus obliquidens*), totaling 155 animals that were observed within the 160 dB safety radius; 150 of these animals were observed within the 180 dB safety radius. At least 11 of these animals were identified as juveniles. During five of the seven 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 2-34 minutes to 2.5 hours. During four of these sightings they were observed in mixed pods with Northern right whale dolphins. Three of these sightings also correlated with acoustic detections.

7.1.1.6. Risso's dolphin

There was one sighting of Risso's dolphins (*Grampus griseus*), totaling 10 animals; all observed within the 180 dB safety radius. During this sighting the dolphins were observed to swimming slowly at the surface of the water traveling parallel, in the opposite direction. As the vessel passed they turned perpendicular behind the vessel and continued to swim slowly at the surface.

7.1.1.7. Dall's porpoise

There were 10 sightings of Dall's porpoises (*Phocoenoides dalli*), totaling 32 animals observed within the 160 dB safety radius; 12 of these animals were observed within the 180 dB safety radius. Three sightings of Dall's porpoises were made from the *Northern Light* at distances ranging from ~0.5 to 10.5 km from the *Langseth*. During three of the seven sighting made from the *Langseth* the porpoises were observed to change course multiple times during the sighting. During the other four sightings the porpoises continued on their heading always traveling quickly at the surface of the water creating rooster-tail splashes.

7.1.1.8. Harbor porpoise

There were eight detections of harbor porpoises (*Phocoena phocoena*), totaling nine animals observed within the 160 dB safety radius; none of these animals were observed within the 180 dB safety radius. All sightings of harbor porpoises within the 160 dB safety radius were made from the *Northern Light* at distances ranging from ~3.5 to 8.5 km from the *Langseth*.

7.1.2. Pinnipeds

7.1.2.1. Northern fur seal

There was one sighting of a Northern fur seal (*Callorhinus ursinus*) within the 160 dB safety radius. This sighting was made from the *Northern Light* while it was ~10.8 km from the *Langseth*.

7.1.2.2. Steller sea lion

There was one sighting of a Steller sea lion (*Eumetopias jubatus*) within the 160 dB safety radius. This sighting was made from the *Northern Light* while it was ~3.6 km from the *Langseth*.

7.2. 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 Cascadia Subduction Margin Geohazards marine geophysical survey, mitigation measures were implemented whenever these protected species were seen near or within the safety radii designated in the IHA. Many mitigation actions were implemented during this survey with power-downs, shut-downs and delayed soft-starts being implemented for mysticetes and odontocetes.

Additional mitigation measures specific to the Cascadia Subduction Margin 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 Cascadia Subduction Margin survey, several large unidentified whales were observed.

A portion of the survey occurred in a humpback whale feeding area, with numerous humpbacks being observed during shoreward turns. While heading shoreward on transect lines the *Northern Light* would notify the *Langseth* when there were high densities of humpback whales ahead and the *Langseth* would power-down the acoustic source before entering shallower water to avoid having multiple 'takes' of humpback whales, often ending survey lines and turning early. Only one turn was made in shallow water during nighttime hours and on this occasion the acoustic source was powered-down to a single airgun when the vessel moved into water shallower than 100 meters.

8. ACKNOWLEDGEMENTS

The Protected Species Observers on board Langseth during the Cascadia subduction margin 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. Steve Holbrook, 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.

9. 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 for the Cascadia Subduction Margin Geohazards marine geophysical survey.**

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

JUL 10 2012

Meagan J. Cummings
Marine Environmental & Safety Coordinator
Department of Marine Operations
Lamont-Doherty Earth Observatory
P.O. Box 1000
Palisades, New York, 10964-8000

Dear Ms. Cummings:

Enclosed is an Incidental Harassment Authorization (IHA) issued to the Lamont-Doherty Earth Observatory, under the authority of section 101(a)(5)(D) of the Marine Mammal Protection Act (16 U.S.C. 1361 *et seq.*), to harass small numbers of marine mammals, by Level B harassment, incidental to the R/V *Marcus G. Langseth*'s marine geophysical survey in the northeastern Pacific Ocean during July, 2012.

You are required to comply with the conditions contained in the IHA which have also been included as Terms and Conditions for incidental take of endangered species in the Biological Opinion. In addition, you must submit a report to the National Marine Fisheries Service's (NMFS) Office of Protected Resources within 90 days of the completion of the cruise. The IHA requires monitoring of marine mammals by qualified individuals before, during, and after seismic activities and reporting of marine mammal observations, including species, numbers, and behavioral modifications potentially resulting from this activity.

If you have any questions concerning the IHA or its requirements, please contact Howard Goldstein, Jeannine Cody, or Jolie Harrison, Office of Protected Resources, NMFS, at 301-427-8401.

Sincerely,

Helen M. Golde
Acting Director
Office of Protected Resources

Enclosures

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

JUL 10 2012

Incidental Harassment Authorization

We hereby authorize Lamont-Doherty Earth Observatory (L-DEO), P.O. Box 1000, Palisades, New York 10964-8000, under section 101(a)(5)(D) of the Marine Mammal Protection Act (MMPA) (16 U.S.C. 1371(a)(5)(D)), to harass small numbers of marine mammals incidental to a marine geophysical (seismic) survey conducted by the R/V *Marcus G. Langseth* (*Langseth*) in the northeastern Pacific Ocean, July, 2012:

1. This Authorization is valid from July 12 through August 10, 2012.

2. This Authorization is valid only for the *Langseth*'s specified activities associated with seismic survey operations as specified in the Observatory's Incidental Harassment Authorization application and the National Science Foundation's (NSF) associated Environmental Assessment in the following specified geographic area:

(i) An area bounded by approximately 46° to 47.5° North by approximately 124° to 126.5° West.

3. Species Authorized and Level of Takes

(a) This authorization limits the incidental taking of marine mammals, by Level B harassment only, to the following species in the waters of the northeastern Pacific Ocean:

(i) Mysticetes – see Table 1 (attached) for authorized species and take numbers.

(ii) Odontocetes – see Table 1 (attached) for authorized species and take numbers.

(iii) Pinnipeds – see Table 1 (attached) for authorized species and take numbers.

(iii) During the seismic activities, if the Holder of this Authorization encounters any marine mammal species under NMFS jurisdiction during seismic activities that are not listed in Table 1 (attached) for authorized taking and are likely to be exposed to sound pressure levels (SPLs) greater than or equal to 160 dB re 1 μPa (rms), then the Holder of this Authorization must alter speed or course, power-down, or shut-down the airguns to avoid take.

(b) This Authorization prohibits the taking by injury (Level A harassment), serious injury, or death of any of the species listed in Condition 3(a) above or the taking of any kind of any other species of marine mammal thus, it may result in the modification, suspension or revocation of this Authorization.

4. This Authorization limits the methods authorized for taking by Level B harassment to the following acoustic sources without an amendment to this Authorization:

(i) A 36 Bolt airgun array with a total capacity of 6,600 in^3 (or smaller);

(ii) A multi-beam echosounder;

(iii) A sub-bottom profiler; and

(iv) An acoustic release transponder used to communicate with ocean bottom seismometers (OBS).

5. The taking of any marine mammal in a manner prohibited under this Authorization must be reported immediately to the Office of Protected Resources, National Marine Fisheries Service (NMFS), at 301-427-8401.

6. Mitigation and Monitoring Requirements

The Holder of this Authorization is required to implement the following mitigation and monitoring requirements when conducting the specified activities to achieve the least practicable impact on affected marine mammal species or stocks:

(a) Utilize two, NMFS-qualified, vessel-based Protected Species Visual Observers (PSVOs) (except during meal times and restroom breaks, when at least one PSVO shall be on watch) to visually watch for and monitor marine mammals near the seismic source vessel during daytime airgun operations (from nautical twilight-dawn to nautical twilight-dusk) and before and during start-ups of airguns day or night. The *Langseth*'s vessel crew shall also assist in detecting marine mammals, when practicable. PSVOs shall have access to reticle binoculars (7 x 50 Fujinon), big-eye binoculars (25 x 150), laser range-finding binoculars, and thermal imaging cameras. PSVO shifts shall last no longer than 4 hours at a time. PSVOs shall also make observations during daytime periods when the seismic system is not operating for comparison of animal abundance and behavior, when feasible.

(b) PSVOs shall conduct monitoring while the airgun array and streamer(s) are being deployed or recovered from the water.

(c) Record the following information when a marine mammal is sighted:

(i) Species, group size, age/size/sex categories (if determinable), behavior when first sighted and after initial sighting, heading (if consistent), bearing and distance from seismic vessel, sighting cue, apparent reaction to the airguns or vessel (e.g., none, avoidance, approach, paralleling, etc., and including responses to ramp-up), and behavioral pace; and

(ii) Time, location, heading, speed, activity of the vessel (including number of airguns operating and whether in state of ramp-up or power-down), Beaufort sea state and wind force, visibility, and sun glare; and

(iii) The data listed under Condition 6(c)(ii) shall also be recorded at the start and end of each observation watch and during a watch whenever there is a change in one or more of the variables.

(d) Utilize the passive acoustic monitoring (PAM) system, to the maximum extent practicable, to detect and allow some localization of marine mammals around the *Langseth* during all airgun operations and during most periods when airguns are not operating. One NMFS-qualified Protected Species Observer (PSO) and/or expert bioacoustician (i.e., Protected Species Acoustic Observer [PSAO]) shall monitor the PAM at all times in shifts no longer than 6 hours. An expert bioacoustician shall design and set up the PAM system and be present to operate or oversee PAM, and available when technical issues occur during the survey.

(e) Do and record the following when an animal is detected by the PAM:

(i) Notify the on-duty PSVO(s) immediately of the presence of a vocalizing marine mammal so a power-down or shut-down can be initiated, if required;

(ii) Enter the information regarding the vocalization into a database. The data to be entered include an acoustic encounter identification number, whether it was linked with a visual sighting, date, time when first and last heard and whenever any additional information was recorded, position, and water depth when first detected, bearing if determinable, species or species group (e.g., unidentified dolphin, sperm whale), types and nature of sounds heard (e.g., clicks, continuous, sporadic, whistles, creaks, burst pulses, strength of signal, etc.), and any other notable information. The acoustic detection can also be recorded for further analysis.

(f) Visually observe the entire extent of the exclusion zone (180 dB re 1 µPa [rms] for cetaceans and 190 dB re 1 µPa [rms] for pinnipeds; see Table 2 [attached] for distances) using NMFS-qualified PSVOs, for at least 30 minutes prior to starting the airgun array (day or night). If the PSVO finds a marine mammal within the exclusion zone, L-DEO must delay the seismic survey until the marine mammal(s) has left the area. If the PSVO sees a marine mammal that surfaces, then dives below the surface, the PSVO shall wait 30 minutes. If the PSVO sees no marine mammals during that time, they should assume that the animal has moved beyond the exclusion zone. If for any reason the entire radius cannot be seen for the entire 30 minutes (i.e., rough seas, fog, darkness), or if marine mammals are near, approaching, or in the exclusion zone, the airguns may not be ramped-up. If one airgun is already running at a source level of at least 180 dB re 1 µPa (rms), L-DEO may start the second airgun without observing the entire exclusion zone

for 30 minutes prior, provided no marine mammals are known to be near the exclusion zone (in accordance with Condition 6[h] below).

(g) Establish a 180 dB re 1 µPa (rms) and 190 dB re 1 µPa (rms) exclusion zone for marine mammals before the 4-string airgun array (6,600 in^3) is in operation; and a 180 dB re 1 µPa (rms) and 190 dB re 1 µPa (rms) exclusion zone before a single airgun (40 in^3) is in operation, respectively. See Table 2 (attached) for distances and exclusion zones.

(h) Ramp-up procedures at the start of seismic operations or after a shut-down - Implement a "ramp-up" procedure when starting up at the beginning of seismic operations or anytime after the entire array has been shut-down for more than 8 minutes, which means start the smallest gun first and add airguns in a sequence such that the source level of the array shall increase in steps not exceeding approximately 6 dB per 5-minute period. During ramp-up, the PSVOs shall monitor the 180 dB exclusion zone for cetaceans or the 190 dB exclusion zone for pinnipeds, and if marine mammals are sighted within or about to enter the relevant exclusion zone, a power-down, or shut-down shall be implemented as though the full array were operational. Therefore, initiation of ramp-up procedures from a shut-down or at the beginning of seismic operations requires that the PSVOs be able to view the full exclusion zone as described in Condition 6(f).

(i) Alter speed or course during seismic operations if a marine mammal, based on its position and relative motion, appears likely to enter the relevant exclusion zone. If speed or course alteration is not safe or practicable, or if after alteration the marine mammal still appears likely to enter the exclusion zone, further mitigation measures, such as a power-down or shut-down, shall be taken.

(j) Power-down or shut-down the airgun(s) if a marine mammal is detected within, approaches, or enters the relevant exclusion zone (as defined in Table 1, attached). A shut-down means all operating airguns are shut-down (i.e., turned off). A power-down means reducing the number of operating airguns to a single operating 40 in^3 airgun, which reduces the exclusion zone to the degree that the animal(s) is no longer in or about to enter it.

(k) Following a power-down, if the marine mammal approaches the smaller designated exclusion zone, the airguns must then be completely shut-down. Airgun activity shall not resume until the PSVO has visually observed the marine mammal(s) exiting the exclusion zone and is not likely to return, or has not been seen within the exclusion zone for 15 minutes for species with shorter dive durations (small odontocetes and pinnipeds) or 30 minutes for species with longer dive durations (mysticetes and large odontocetes, including sperm, pygmy sperm, dwarf sperm, killer, and beaked whales). Following a shut-down, the *Langseth* may resume airgun operations following ramp-up procedures described in Condition(h).

(l) Procedures after an extended power-down – Monitor the full 180 dB exclusion zone for cetaceans and the full 190 dB exclusion zone for pinnipeds. The *Langseth* may resume full power operations anytime after the entire array has been powered-down for more than 8 minutes. Resuming operations at full power after an extended power-down of more than 8 minutes requires that the PSVOs be able to view the full exclusion zone as described in Condition 6(f). If the PSVO sees a marine mammal within or about to enter the relevant exclusion zones, then the *Langseth* will implement a course/speed alteration or power-down.

(m) Marine seismic surveys may continue into night and low-light hours if such segment(s) of the survey is initiated when the entire relevant exclusion zones are visible and can be effectively monitored.

(n) No initiation of airgun array operations is permitted from a shut-down position at night or during low-light hours (such as in dense fog or heavy rain) when the entire relevant exclusion zone cannot be effectively monitored by the PSVO(s) on duty.

(o) If a North Pacific right whale (*Eubalaena japonica*) is visually sighted, the airgun array shall be shut-down regardless of the distance of the animal(s) to the sound source. The array shall not resume firing until 30 minutes after the last documented whale visual sighting.

(p) If killer whales (*Orcinus orca*) are visually sighted or detected acoustically, the airguns shall be shut-down regardless of the distance of the animal(s) to the sound source. The array shall not resume firing until 30 minutes after the last documented whale visual sighting or acoustic detection within the 160 dB buffer zone and/or 180 dB exclusion zone. If killer whales are sighted, the support vessel M/V *Northern Light* (*Northern Light*) will track them using the NMFS Northwest Region's Whale Watching Guidelines (see attached) for killer whales to ensure that they leave the buffer zone and not approach within at least 100 yards, as well as not herd, chase or separate the animals.

(q) Communicate with NMFS Northwest Fisheries Science Center (Brad.Hanson@noaa.gov, 206-300-0282), NMFS Northwest Regional Office (Lynne.Barre@noaa.gov, 206-718-3807 or Brent.Norberg@noaa.gov, 206-526-6550), The Whale Museum (hotline@whalemuseum.org, 1-800-562-8832), Orca Network (info@orcanetwork.org, 1-866-672-2638), and/or other source for near real-time reporting of the whereabouts of Southern Resident killer whales.

(r) To the maximum extent practicable, schedule seismic operations (i.e., shooting airguns) during daylight hours and OBS operations (i.e., deploy/retrieve) to nighttime hours.

(s) To the maximum extent practicable, plan to conduct seismic surveys (especially when near land) from the coast (inshore) and proceed towards the sea (offshore) in order to avoid trapping marine mammals in shallow water.

(t) Conduct a pre-survey beginning on July 11 (2 days before seismic operations commence) using the support vessel *Northern Light* or equivalent with three PSO's onboard for purposes of monitoring for the presence of marine mammals (particularly focusing attention to Southern Resident killer whales). The pre-survey will begin upon leaving port and during transit to the Northern Trehu line. The support vessel will then begin a zig-zag transect of the 160-dB buffer zone around the Trehu North line to either side of the Trehu North line from inshore to offshore remaining on the shelf looking for marine mammals. When the *Langseth* is ready to begin the seismic survey, the support vessel *Northern Light* will monitor north of the *Langseth* approximately 5 km away in the same zig-zag fashion as the pre-survey to monitor the 160 dB exclusion zone around the *Langseth* when the ship begins the survey on the continental shelf.

(u) To the maximum extent practicable, utilize a portable static hydrophone from the support vessel *Northern Light* to listen for and determine the presence of vocalizing marine mammals and assist with visual detections.

(v) Conduct seismic operations according to relevant sightings of marine mammals from the *Langseth* and the support vessel *Northern Light*. For example, if high densities of marine mammals, including Southern Resident killer whales, are sighted in the northern region of the seismic survey area then seismic operations will begin in the southern region of the study area.

7. Reporting Requirements

The Holder of this Authorization is required to:

(a) Submit a draft report on all activities and monitoring results to the Office of Protected Resources, NMFS, within 90 days of the completion of the *Langseth*'s three cruises. This report must contain and summarize the following information:

(i) Dates, times, locations, heading, speed, weather, sea conditions (including Beaufort sea state and wind force), and associated activities during all seismic operations and marine mammal sightings;

(ii) Species, number, location, distance from the vessel, and behavior of any marine mammals, as well as associated seismic activity (number of power-downs and shut-downs), observed throughout all monitoring activities.

(iii) An estimate of the number (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) and/or 180 dB re 1 µPa (rms) for cetaceans and 190 dB re 1 µPa (rms) for pinnipeds with a discussion of any specific behaviors those individuals exhibited; and (B) may have been exposed (based on reported and corrected empirical values for the 36

airgun array and modeling measurements for the single airgun) to the seismic activity at received levels greater than or equal to 160 dB re 1 µPa (rms) and/or 180 dB re 1 µPa (rms) for cetaceans and 190 dB re 1 µPa (rms) for pinnipeds with a discussion of the nature of the probable consequences of that exposure on the individuals that have been exposed.

(iv) A description of the number, location, distance from the vessel, and behavior of Southern Resident killer whales, if any, that have been exposed to seismic operations (based on visual and/or acoustic detection) at received levels greater than or equal to 160 dB re 1 Pa (rms) and followed by the support vessel. A discussion of the nature of the probable consequences of that exposure on the individuals that have been exposed should accompany this description.

(v) A description of the implementation and effectiveness of the: (A) terms and conditions of the Biological Opinion's Incidental Take Statement (ITS) (attached); and (B) mitigation measures of the Incidental Harassment Authorization. For the Biological Opinion, the report shall confirm the implementation of each Term and Condition, as well as any conservation recommendations, and describe their effectiveness, for minimizing the adverse effects of the action on Endangered Species Act-listed marine mammals.

(b) Submit a final report to the Chief, Permits and Conservation Division, Office of Protected Resources, NMFS, within 30 days after receiving comments from NMFS on the draft report. If NMFS decides that the draft report needs no comments, the draft report shall be considered to be the final report.

(c) In the unanticipated event that the specified activity clearly causes the take of a marine mammal in a manner prohibited by this Authorization, such as an injury (Level A harassment), serious injury or mortality (e.g., ship-strike, gear interaction, and/or entanglement), L-DEO shall immediately cease the specified activities and immediately report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401 and/or by email to Jolie.Harrison@noaa.gov, Jeannine.Cody@noaa.gov, and Howard.Goldstein@noaa.gov and the Northwest Regional Stranding Coordinator at 206-526-6550 (Brent.Norberg@noaa.gov). The report must include the following information:

(i) Time, date, and location (latitude/longitude) of the incident; the name and type of vessel involved; the vessel's speed during and leading up to the incident; description of the incident; status of all sound source use in the 24 hours preceding the incident; water depth; environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover, and visibility); description of marine mammal observations in the 24 hours preceding the incident; species identification or description of the animal(s) involved; the fate of the animal(s); and photographs or video footage of the animal (if equipment is available).

Activities shall not resume until NMFS is able to review the circumstances of the prohibited take. NMFS shall work with L-DEO to determine what is necessary to minimize the likelihood of further prohibited take and ensure MMPA compliance. L-DEO may not resume their activities until notified by NMFS via letter, email, or telephone.

In the event that L-DEO discovers an injured or dead marine mammal, and the lead PSO determines that the cause of the injury or death is unknown and the death is relatively recent (i.e., in less than a moderate state of decomposition as described in the next paragraph), L-DEO will immediately report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401, and/or by email to Jolie.Harrison@noaa.gov, Jeannine.Cody@noaa.gov, and Howard.Goldstein@noaa.gov, and the NMFS Northwest Regional Office (206-526-6550) and/or by email to the Northwest Regional Stranding Coordinator (Brent.Norberg@noaa.gov). The report must include the same information identified in Condition 7(c)(i) above. Activities may continue while NMFS reviews the circumstances of the incident. NMFS will work with L-DEO to determine whether modifications in the activities are appropriate.

In the event that L-DEO discovers an injured or dead marine mammal, and the lead PSO determines that the injury or death is not associated with or related to the activities authorized in Condition 2 of this Authorization (e.g., previously wounded animal, carcass with moderate to advanced decomposition, or scavenger damage), L-DEO shall report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401, and/or by email to Jolie.Harrison@noaa.gov, Jeannine.Cody@noaa.gov, and Howard.Goldstein@noaa.gov, and the NMFS Northwest Regional Office (206-526-6550) and/or by email to the Northwest Regional Stranding Coordinator (Brent.Norberg@noaa.gov) within 24 hours of the discovery. L-DEO shall provide photographs or video footage (if available) or other documentation of the stranded animal sighting to NMFS and the Marine Mammal Stranding Network. Activities may continue while NMFS reviews the circumstances of the incident.

9. L-DEO is required to comply with the Terms and Conditions of the ITS corresponding to NMFS's Biological Opinion issued to both NSF and NMFS's Office of Protected Resources (attached).

10. A copy of this Authorization and the ITS must be in the possession of all contractors and PSOs operating under the authority of this Incidental Harassment Authorization.

JUL 10 2012

Helen M. Golde
Acting Director
Office of Protected Resources
National Marine Fisheries Service

Date

Attachments

Attachment

Table 1. Authorized Take Numbers for Each Marine Mammal Species during the Cascadia Thrust Zone Northern Area and Cascadia Subduction Margin Seismic Survey in the northeastern Pacific Ocean.

Species	Authorized Take in the Cascadia Thrust Zone Northern Area and Cascadia Subduction Margin Study Area
Mysticetes	
North Pacific right whale (*Eubalaena japonica*)	0
Gray whale (*Eschrichtius robustus*)	12
Humpback whale (*Megaptera novaeangliae*)	11
Minke whale (*Balaenoptera acutorostrata*)	6
Sei whale (*Balaenoptera physalus*)	2
Fin whale (*Balaenoptera borealis*)	18
Blue whale (*Balaenoptera musculus*)	3
Sperm whale (*Physeter macrocephalus*)	15
Unidentified *Kogia* spp. Pygmy sperm whale (*Kogia breviceps*) and/or Dwarf sperm whale (*Kogia sima*)	10
Cuvier's beaked whale (*Ziphius cavirostris*)	6
Baird's beaked whale (*Berardius bairdii*)	17
Unidentified *Mesoplodon* beaked whale (*Mesoplodon* spp.)	25
Striped dolphin (*Stenella coeruleoalba*)	2
Short-beaked common dolphin (*Delphinus delphis*)	238

Pacific white-sided dolphin (*Lagenorhynchus obliquidens*)	497
Northern right whale dolphin (*Lissodelphis borealis*)	183
Risso's dolphin (*Grampus griseus*)	159
Killer whale (*Orcinus orca*)	0
Harbor porpoise (*Phocoena phocoena*)	2,580
Dall's porpoise (*Phocoenoides dalli*)	1,193
Pinnipeds	
Northern fur seal (*Callorhinus ursinus*)	1,190
California sea lion (*Zalophus californianus*)	0
Steller sea lion (*Eumetopias jubatus*)	187
Pacific harbor seal (*Phoca vitulina richardsi*)	1,192
Northern elephant seal (*Mirounga angustirostris*)	652

Table 2. Exclusion Zone Radii for Triggering Mitigation.

Source and Volume	Tow Depth (m)	Water Depth (m)	Predicted RMS Distances (m)		
			Shut-down Exclusion Zone for Pinnipeds 190 dB	Shut-down Exclusion Zone for Cetaceans 180 dB	Level-B Harassment Zone 160 dB
Single Bolt airgun 40 in^3	6 to 15	Shallow (<100)	150	296	1,050
		Intermediate (100 to 1,000)	18	60	578
		Deep (>1,000)	12	40	385

4 strings 36 airguns 6,600 in^3	9	Shallow (<100)	680	2,140	20,550
		Intermediate (100 to 1,000)	550	1,540	12,200
		Deep (>1,000)	400	940	3,850
4 strings 36 airguns 6,600 in^3	12	Shallow (<100)	770	2,250	23,470
		Intermediate (100 to 1,000)	615	1,810	13,935
		Deep (>1,000)	460	1,100	4,400
4 strings 36 airguns 6,600 in^3	15	Shallow (<100)	865	2,750	26,350
		Intermediate (100 to 1,000)	690	1,975	15,650
		Deep (>1,000)	520	1,200	4,490

National Marine Fisheries Service, Northwest Region

Whale Watching Guidelines

In order to protect and conserve marine mammals and promote public awareness of the need to avoid harassment of marine mammals, NMFS is providing the following information and guidelines for viewing marine mammals. These guidelines are directed towards those whose interests and enthusiasm for watching marine mammals may inadvertently disturb or harm the animals being viewed. Although these guidelines are generally directed at whale watching, they apply to viewing other marine mammal species such as killer whales, dolphins, and porpoise and include specific guidelines for seals and sea lions (pinnipeds) on land.

Marine mammals are protected under the Marine Mammal Protection Act of 1972 (MMPA). Large whales such as sperm whales and humpback whales are also protected under the Endangered Species Act. These laws prohibit the "take" of any marine mammal except by permit or exception. The term "take" means to harass, hunt, capture, or kill any marine mammal or attempt to engage in any such conduct. Thus, any actions by persons or vessels or aircraft that they are operating in the vicinity of marine mammals that substantially alter the behavior of marine mammals may be a violation of the law unless such persons have specific legal authority or a permit issued under the MMPA. Violators of the MMPA may be subject to a civil penalty of up to $10,000 for each violation, or criminal prosecution with a fine of up to $100,000 or imprisonment for up to one year, or both.

Human activities in the vicinity of marine mammals may harass these animals resulting in a range of impacts varying from no observable effect, to modifying their behavior, to causing physical harm to the animals. Activities that harass marine mammals can cause detrimental effects such as: separation of mother whales and their calves; disruption of migratory patterns; disruption of social groupings such as killer whale pods; interference in breeding and reproductive activities; and abandonment of nursing pups and/or rearing activities. These guidelines are intended to not only protect the animals, but also to benefit and protect the general public since an occurrence such as a vessel/whale collision could be detrimental to both the animal and the people involved.

Guidelines

People should not perform any action that substantially disrupts the normal behavior of a marine mammal. Such actions include the negligent or intentional operation of an aircraft or vessel, or individual acts that result in a substantial disruption of a marine mammal's normal behavior. These actions could be considered harassment and thus would be violations of the MMPA.

Substantial disruption of a marine mammal's normal behavior is actions by the marine mammal in response to vessel approach such as, but not limited to:

- a rapid change in direction or speed;
- escape tactics such as prolonged diving, underwater course changes, or underwater exhalation;
- evasive swimming patterns such as rapid swimming or "porpoising" at the surface;
- a rapid departure off land by seals or sea lions;
- attempts by a female whale to shield a calf from a vessel or a human observer by tail swishing or other protective movements.

Vessels

1. While underway, vessels should avoid intentionally approaching closer than 100 yards to a marine mammal. Activities within 100 yards of marine mammals require caution and approaching closer than 50 yards involve a high risk of harassing the animal.
2. Vessels should not be used to herd or chase marine mammals, nor to separate any groups of marine mammals.
3. Vessels should not be used to put people in the water in the vicinity of marine mammals.
4. When whale watching within 100 yards of a whale:
   - Do not take actions that may evoke a reaction from the whales or result in physical contact.
   - Maintain a constant speed while in the vicinity of a whale.
   - Avoid following behind a whale or approaching directly in front of a whale. Vessel movements should parallel the whale movements. When approaching whales, it should be from an oblique angle.
   - Avoid excessive speed. Vessels should not operate at speeds faster than a single whale or the slowest whale in a group.
   - Avoid radical speed or direction changes when approaching or leaving whales.
   - If possible, put the vessel in neutral and allow the whales to approach the vessel.
   - Avoid positioning the vessel such that it restricts or modifies the whale's normal movements.
   - Avoid going through or separating any groups or pairs of whales such as mother/calf pairs.

Aircraft

1. Aircraft should avoid flying lower than 1,000 feet over any marine mammal.
2. Aircraft should not hover or circle over marine mammals.

Individual Actions

1. Individuals should restrict their activities when within 100 yards of marine mammals to prevent an alteration of the animal's behavior due to the person's presence.
2. Swimmers or divers should not approach within 50 yards of marine mammals.

Seals and Sea Lions

Pinnipeds (seals and sea lions) are also protected under the MMPA and should not be disturbed by humans or by dogs accompanying them. Pinnipeds on land (haul-out areas) are especially sensitive to human and vessel disturbance. Intentional or negligent actions by persons, their pets, or the vessels/aircraft that they are operating in the vicinity of pinniped haul-outs that cause the pinnipeds to flee can be MMPA violations.

1. People/vessels should not intentionally approach pinnipeds hauled-out on land any closer than 100 yards.
2. The following reactions by the pinnipeds may indicate disturbance and should be avoided:
   - a number of animals raise their heads;
   - a few animals hurriedly enter the water;
   - a number of animals move closer to the water;
   - increased vocalizations by sea lions.

Summary

People should exert caution when in close proximity to marine mammals. Some activities may result in harassment of the animals even in instances when these guidelines are being adhered to. For example, in some circumstances, vessels operating outside the minimum approach distances may still result in disruption of the marine mammal's behavior, and therefore could be viewed as harassment. Failure to observe these guidelines may result in harassment of marine mammals which is a violation of the MMPA. Public cooperation in adherence to these guidelines is essential for the protection of these animals. Observations of marine mammal harassment should be reported to NMFS or State law enforcement offices.

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

SEP 0 4 2012

MEMORANDUM FOR: The Record

FROM: Howard Goldstein, Fisheries Biologist
Permits and Conservation Division
Office of Protected Resources

SUBJECT: Request for a Modified Incidental Harassment Authorization for Takes of Marine Mammals Incidental to a Marine Geophysical Survey in the Northeast Pacific Ocean, July, 2012

This memorandum addresses the request for a modified Incidental Harassment Authorization (IHA) for the last of three marine geophysical (seismic) surveys in the northeastern Pacific Ocean funded by the National Science Foundation (NSF) and conducted by the Lamont-Doherty Earth Observatory of Columbia University (L-DEO).

BACKGROUND

On January 27, 2012, the National Marine Fisheries Service (NMFS) received a complete application from the L-DEO, requesting that we issue an IHA for the take, by Level B harassment only, of small numbers of marine mammals incidental to conducting a marine geophysical (seismic) survey in the northeast Pacific Ocean in July, 2012. NMFS determined the application adequate and complete on March 27, 2012.

On May 2, 2012, NMFS published a notice of a proposed IHA in the *Federal Register* (77 FR 25966) disclosing the effects on marine mammals, making preliminary determinations and including a proposed IHA. NMFS considered and addressed all public comments as a component of the marine mammal impacts analysis required by the MMPA in order to reach a determination that only Level B harassment would occur as a result of the proposed L-DEO seismic survey conducted in accordance with the requirements of the IHA. NMFS also determined that the take of small numbers of marine mammals incidental to this activity would have a negligible impact on affected marine mammal species or stocks and would not have an unmitigable adverse impact on the availability of marine mammal species or stocks for taking for subsistence uses. The notice of the proposed IHA described a bundled IHA for L-DEO's plan to conduct three research studies on Juan de Fuca Plate, the Cascadia thrust zone, and the Cascadia subduction margin in waters off the Oregon and Washington coasts during June to July, 2012. The bundled IHA was separated into three individual IHAs for the three planned seismic surveys due to concerns regarding the potential occurrence of endangered Southern Resident killer whales (*Orcinus orca*) in the study area. On July 10, 2012, NMFS issued an IHA to L-DEO authorizing the take of small number of marine mammal incidental to conducting a marine seismic survey in the northeastern Pacific Ocean, from July 12 to August 10, 2012. On July 16, 2012, NMFS published a notice in the *Federal Register* (77 FR 41755) announcing the issuance of the three individual IHAs to L-DEO.

During seismic operations in the northeastern Pacific Ocean study area, there were many sightings of humpback whales (*Megaptera novaeangliae*), northern right whale dolphins (*Lissodelphis borealis*), and fin whales (*Balaenoptera physalus*) by Protected Species Observers (PSOs) on the R/V *Marcus G. Langseth* (*Langseth*) and support vessels M/V *Northern Light* (*Northern Light*) and R/V *Thomas G. Thompson* (*Thompson*). L-DEO was authorized for incidental take of 11 humpback whales, 183 northern right whale dolphins, and 18 fin whales. L-DEO promptly notified NMFS that they had many more sightings, including at least 15 documented sightings of humpback whales on July 16, 2012 alone. On July 17, 2012, NMFS received a request from L-DEO for additional authorized takes of humpback whales and northern right whale dolphins for the remainder of the seismic survey. On July 20, 2012, the July 10, 2012, IHA and Incidental Take Statement were exceeded when the 12th humpback whale was taken. On July 23, 2012, NMFS received notice from L-DEO that takes of fin whales were exceeded on July 22, 2012, but since the seismic survey was concluding the morning of July 23, 2012, they did not intend to request additional coverage for authorized takes.

In L-DEO and NSF's previous analysis, cetacean densities were derived from the pooled results of 1991 to 2008 surveys (abundances and survey area give for Oregon and Washington in Barlow, 2010). Based on the number of humpback whales and northern right whale dolphins seen so far, it is logical to estimate the potential take of humpback whales using the maximum density information available for that region during the summer instead of the mean density, such as identified in the Strategic Environmental Resources and Development Program (SERDP, http://seamap.env.duke.edu/serdp/serdp_map.php) for the region. There were multiple sightings of large groups of animals, on the order of 30 humpback whales and 75 to 80 northern right whale dolphins per sighting in some cases. With use of the support vessel, *Northern Light* and PSOs on the *Langseth* survey efforts were first able to proceed by revising the order of tracklines during the seismic survey to avoid additional takes of humpback whales and northern right whale dolphins. Proceeding in this manner was not sustainable; as the vessel neared the end of the survey some tracklines were no longer avoidable and data needed to be collected. Using SERDP data, L-DEO and NSF calculated the maximum density of humpback whales (i.e., 0.017335 animals per square kilometers [km^2] x 14,234 km^2 = 247 animals) and northern right whale dolphins (i.e., 0.12187animals per km^2 x 14234 km^2 = 1,735 animals) during the summer in the survey area and requested an additional 247 humpback whale and 1,735 northern right whale dolphin authorized takes.

ANALYSIS

The IHA application, Environmental Assessment, and *Federal Register* notice of a proposed IHA analyzed the potential impacts of the seismic survey on cetaceans and pinnipeds in general, including behavioral disturbance, masking, and hearing impairment. These documents further described the life history and density of humpback whales and northern right whale dolphins. Based on this information, these documents calculated and estimated that 11 humpback whales and 183 northern right whale dolphins would likely be exposed to sound levels greater than or equal to 160 dB re 1 µPam (rms) from these activities, which means that they would likely be taken by Level B harassment.

NMFS's original IHA for L-DEO's northeastern Pacific Ocean program was issued based on a determination that the activity would have a negligible impact on the affected species or stocks of marine mammals and would result in the take, by Level B harassment only, of small numbers of marine mammals. NMFS further determined that Level B harassment takes would be limited to temporary and short-term displacement of cetaceans and pinnipeds from areas where received sound levels from airgun operations were 160 dB re 1 µPa (rms) or greater. The maximum distance at

which received sound levels would equal or exceed 160 dB re 1 µPa (rms) was estimated to be 4,490 meters (m) (14,731 feet [ft]) in deep water depths (greater than 1,000 m [3,280.8 ft]), 15,650 m (51,345 ft) in intermediate water depths, and 26,350 m (86,450.1 ft) in shallow water depths for the 36 airgun array towed at a depth of 15 m (49.2 ft). Taking into account these potential effects on marine mammals from the sound source, the small numbers of each species or stock potentially affected, and the mitigation and monitoring measures that would be in effect to prevent hearing impairment, injury, serious injury, and mortality, NMFS concluded the activity would have a negligible impact on the affected species or stocks of marine mammals. NMFS also found no unmitigable adverse impacts on subsistence uses as there are no legal subsistence uses in this location.

CONCLUSIONS

In compliance with the IHA, NSF immediately notified NMFS as soon as it anticipated the authorized number of incidental takes might be exceeded. NMFS was not able to modify the IHA to include an additional 247 humpback whale and 1,735 northern right whale dolphin authorized takes, as requested by L-DEO and NSF, before the seismic survey concluded due to workload, staffing, and coordination issues.

ENDANGERED SPECIES ACT

Under section 7 of the ESA, the National Science Foundation (NSF) has initiated and engaged in formal consultation with the NMFS, Office of Protected Resources, Endangered Species Act Interagency Cooperation Division, on this seismic survey. NMFS (Permits and Conservation Division) also initiated and engaged in formal consultation with NMFS (Endangered Species Act Interagency Cooperation Division) on the issuance of an IHA under section 101(a)(5)(D) of the MMPA for this activity. These two consultations were consolidated and addressed in a single Biological Opinion addressing the direct and indirect effects of these interdependent actions. On June 8 and 11, 2012, new information was received and consultation was reinitiated on the three proposed seismic surveys and the associated issuance of the IHAs. The designs of the seismic surveys were modified and enhanced monitoring and mitigation measures were added to address concerns regarding endangered Southern Resident killer whales. On July 10, 2012, NMFS issued a Biological Opinion and concluded that the action and issuance of the IHA are not likely to jeopardize the continued existence of listed cetaceans, pinnipeds, and sea turtles and included an Incidental Take Statement incorporating the requirements of the IHA as Terms and Conditions. On July 13, 2012, after monitoring information was received, consultation was reinitiated on the third seismic survey and associated issuance of an IHA for additional authorized takes of humpback whales. On, July 22, 2012, the authorized take for fin whales was also exceeded. On July 26, 2012, NMFS, Endangered Species Act Interagency Cooperation Division, addressed the last of three seismic survey in the northeastern Pacific Ocean funded by the NSF and conducted by L-DEO as well as the NMFS, Permits and Conservation Division's issuance of an Incidental Harassment Authorization to L-DEO for take of marine mammals incidental to the conduct of the seismic surveys in a memorandum to the record.

NATIONAL ENVIRONMENTAL POLICY ACT

On June 8, 2012, NMFS adopted the NSF's *Environmental Assessment and Finding of No Significant Impact Determination Pursuant to the National Environmental Policy Act, 42 U.S.C. 4321 et seq. and Executive Order 12114, Marine Seismic Survey in the Northeastern Pacific Ocean, 2012*, which incorporates an *Environmental Assessment of a Marine Geophysical Survey by the R/V Marcus G. Langseth in the Northeastern Pacific Ocean, June-July 2012* prepared by LGL Ltd., Environmental Research Associates, and issued a Finding of No Significant Impact.

cc:
Lynne Barre, NMFS Northwest Regional Office
Holly Smith, NSF
Meagan Cummings, L-DEO

APPENDIX B: Basic Summary Data Form

BASIC DATA FORM				
LDEO Project Number		MGL1212		
Seismic Contractor		Lamont-Doherty Earth Observatory of Columbia University		
Area Surveyed During Reporting Period		Cascadia Subduction Margin Geohazards off Grays Harbor, Washington.		
		Approximately between 46 to 47.5°N and 124 to 126.5°W		
Survey Type		2D marine seismic		
Vessel and/or Rig Name		*R/V Marcus G. Langseth*		
Permit Number		IHA granted by NMFS on 10 July 2012		
Location / Distance of Airgun Deployment		232 meters aft of PSO tower		
Water Depth	**Min**	~50m		
	Max	~2650m		
Dates of project		12 July 2012	THROUGH	24 July 2012
Total time airguns operating – all power levels:		220 hours 13 minutes		
Time airguns operating at full power on survey lines:		145 hours 17 minutes		
Time airguns operating at partial power on survey lines:		14 hour 43 minutes		
Time airguns operating at full/partial power on line changes:		15 hours 10 minutes		
Amount of time mitigation gun (40 in³) operations:		38 hours 20 minutes		
Amount of time in ramp-up:		6 hour 43 minutes		
Number daytime ramp-ups:		9		
Number of night time ramp-ups:		1		
Number of ramp-ups from mitigation source:		6		
Amount of time conducted in airgun testing:		None		
Duration of visual observations:		196 hours 14 minute		
Duration of observations while airguns firing:		153 hours 15 minutes		
Duration of observation during airgun silence:		42 hours 59 minutes		
Duration of acoustic monitoring:		152 hours 03 minutes		
Duration of acoustic monitoring while airguns firing:		147 hours 56 minutes		
Duration of acoustic monitoring during airgun silence:		4 hours 07 minutes		
Duration of simultaneous acoustic and visual monitoring:		103 hours 48 minutes		
Lead Protected Species Observer:		Heidi Ingram		
Protected Species Observers:		Katie Douglas		
		Tatiana Moreno		
		Meagan Cummings		
Acoustic Observer:		Emily Ellis		
Number of Marine Mammals Visually Detected:		92		
Number of Marine Mammals Acoustically Detected:		3		
Number of acoustic detections confirmed by visual sighting:		0		
Number of visual sighting confirmed by acoustic detection:		3		
Number of Sea Turtles detected:		0		
List Mitigation Actions (eg. Power-downs, shut-downs, ramp-up delays)		16 power-downs, 9 shut-downs, 3 soft-start delays		
Duration of operational downtime due to mitigation:		19 hours 11 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 onboard connection
Connector Diameter 64mm

Inboard Deck Cable
Deck cable specification

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

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

PAM hydrophone deployment and retrieval procedure on the *R/V Marcus G. 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.14). 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.

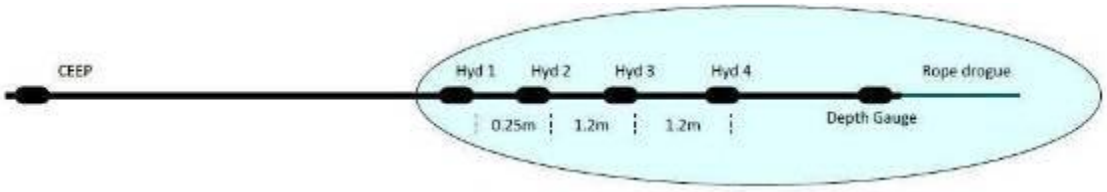

Figure D.16: Diagram of Linear Hydrophone Array.

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. 15). 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. 16). 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.17). 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.18). 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.19). 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.17: PAM Laptops and data processing unit setup.

Figure D.18: Hydrophone cable on winch.

Figure D.19: Hydrophone cable secured by a yale grip to the port sponson.

Figure D.20: Rope drogue and first chain weight secured near hydrophone elements.

Figure D.21: 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, 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

Date	Monitoring Suspended	Date	Monitoring Resumed	Duration acoustic monitoring suspended	Comments
7-13-2012	16:00	7-14-2012	03:10	11:10	PAM operator was unable to monitor PAM from 16:00 to 16:50 do to a conflict in obligations. PAM cable retrieved at 16:50 in order to untangle gun strings.
7-14-2012	06:00	7-14-2012	06:20	00:20	PAM system lost power due to ship's engines failing causing power and compressors to fail.
7-14-2012	07:46	7-16-2012	17:26	57:40	PAM operator heard knocking noise just before hydrophone depth jumped to 15m. Cable was noticeably entangled with gun string four; cable was retrieved, checked for damage, and remained on board until environmental conditions improved.
7-17-2012	11:25	7-17-2012	11:48	00:23	Operator heard a thumping noise every few minutes. Hydrophone cable was retrieved to check for possible fishing gear snag before redeploying.
7-18-2012	02:33	7-18-2012	22:56	20:23	Hydrophone cable retrieved in order to retrieve seismic gear for maintenance of the gun arrays and repair of the seismic streamer.
			Total	**89:56**	

APPENDIX F: Summary of visual detections of protected species from the R/V Langseth during the Cascadia subduction margin geohazards marine geophysical survey.

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

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

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position	Source Activity Initial Detection	Movement/ Behaviour		CPA Source / Source Activity	Mitigation Action	Comments
1	12-Jul	16:08	Harbour seal	2	46.19150°N 123.87567°W	Not firing	SA	BA NS	100 m / Not firing	None	Observed while in transit.
2	12-Jul	16:09	Harbour seal	1	46.19150°N 123.87567°W	Not firing	V	BA DI	75 m / Not firing	None	Observed while in transit.
3	12-Jul	16:17	Harbour seal	1	46.19040°N 123.89788°W	Not firing	V	BA DI	150 m / Not firing	None	Observed while in transit.
4	12-Jul	16:43	Harbour seal	1	46.23693°N 123.98912°W	Not firing	V	BA DI	200 m / Not firing	None	Observed while in transit.
5	12-Jul	16:53	Steller sea lion	1	46.25555°N 124.02530°W	Not firing	AV	BA DI	300 m / Not firing	None	Observed while in transit.
6	12-Jul	17:07	Steller sea lion	2	46.24903°N 124.08928°W	Not firing	AV	BA DI	150 m / Not firing	None	Observed while in transit.
7	12-Jul	17:33	Harbor porpoise	5	46.20625°N 124.15295°W	Not firing	AV	ST	300 m / Not firing	None	Observed while in transit.
8	12-Jul	17:42	Steller sea lion	3	46.22740°N 124.17708°W	Not firing	SA	BA	500 m / Not firing	None	Observed while in transit.

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position	Source Activity Initial Detection	Movement/ Behaviour		CPA Source / Source Activity	Mitigation Action	Comments
9	12-Jul	18:33	Risso's dolphin	11	46.35515°N 124.34002°W	Not firing	PV/OD	ST FF	600 m / Not firing	None	Observed while in transit.
10	12-Jul	19:34	Humpback whale	2	46.48325°N 124.52348°W	Not firing	PE/BH	SA BV	1300 m / Not firing	None	Observed while in transit.
11	12-Jul	20:13	Humpback whale	3	46.56704°N 124.64697°W	Not firing	TV	BV DF	500 m / Not firing	None	Observed while in transit.
12	12-Jul	20:36	Humpback whale	1	46.57978°N 124.67593°W	Not firing	UN	BV	1500 m / Not firing	None	Observed while in transit.
13	12-Jul	20:39	Northern fur seal	1	46.58157°N 124.68063°W	Not firing	PV/OD	BA ST	300 m / Not firing	None	Observed while in transit.
14	12-Jul	20:46	Humpback whale	3	46.58393°N 124.68641°W	Not firing	PV/OD	BV DF	1000 m / Not firing	None	Observed while deploying gear.
15	12-Jul	21:12	Humpback whale	1	46.59575°N 124.71525°W	Not firing	PE/BH	BV DF	2400 m / Not firing	None	Observed while deploying gear.
16	12-Jul	22:37	Humpback whale	5	46.64020°N 124.81163°W	Not firing	PV/OD	BV DF	845 m / Not firing	None	Observed while deploying gear.
17	12-Jul	23:08	Humpback whale	1	46.66335°N 124.83710°W	Not firing	AV	BV DF	700 m / Not firing	None	Observed while deploying gear.
18	12-Jul	23:18	Unidentified whale	1	46.67362°N 124.84863°W	Not firing	UN	BV	4150 m / Not firing	None	Observed while deploying gear.
19	12-Jul	23:29	Humpback whale	2	46.68148°N 124.85742°W	Not firing	PE/BH	BV DF	1400 m / Not firing	None	Observed while deploying gear.
20	13-Jul	22:47	Unidentified baleen whale	2	47.09210°N 125.71241°W	Mitigation firing	PE/AH	BV	800 m / Mitigation firing	None	Powered down for array maintenance.

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position	Source Activity Initial Detection	Movement/ Behaviour		CPA Source / Source Activity	Mitigation Action	Comments
21	14-Jul	19:20	Fin whale	4	47.02520°N 125.45415°W	Full power	V PV/SD	R DV	3900 m / Full power	None	
22	14-Jul	20:30	Dall's porpoise	4	47.03585°N 125.32839°W	Full power	PV/OD	SV	2500 m / Full power	None	
23	14-Jul	21:53	Fin whale	3	47.04853°N 125.17707°W	Full power	PV/OD	DV BV	4000 m / Full power	None	
24	15-Jul	1:44	Pacific white-sided dolphin	14	47.00490°N 124.83860°W	Mitigation firing	TV	PO FT	5 m / Not firing	Shut down	Observed leaving 180 dB safety radius, mitigation enabled.
25	15-Jul	2:21	Humpback whale	2	46.99453°N 124.78833°W	Mitigation firing	PV/SD	SA DF	60 m / Not firing	Shut down	Observed leaving 180 dB safety radius, mitigation enabled.
26	15-Jul	2:48	Humpback whale	15	46.99732°N 124.74077°W	Not firing	PV/OD	SA DF	50 m / Not firing	Delay soft start	Acoustic source disabled to avoid takes.
27	15-Jul	17:21	Dall's porpoise	2	46.82435°N 126.42128°W	Full power	AV	PO FT	250 m / Full power	Power down	Last observed within 180 dB safety radius. Waited 15 min. before resuming full power.
28	16-Jul	15:12	Risso's dolphin	10	46.78262°N 124.92327°W	Full power	PV/OD	ST	800 m / Full power	Power down	Observed leaving 180 dB safety radius, returned to full power.
29	16-Jul	18:29	Humpback whale	12	46.74262°N 124.61778°W	Mitigation firing	PE/AH	BV DF	150 m / Not firing	Shut down	Mitigation gun disabled to avoid takes.
30	16-Jul	20:37	Humpback whale	1	46.65417°N 124.69293°W	Not firing	AV	BV DI	1400 m / Not firing	Delay soft start	Ramp-up delayed to avoid takes.
31	16-Jul	22:06	Unidentifiable baleen whale	1	46.64327°N 124.82908°W	Ramp up	PE/AH	PO SA	1300 / Ramp up	Power down	Observed leaving 180 dB safety radius, began ramp-up.
32	16-Jul	23:30	Pacific white-sided dolphin	65	46.62243°N 124.96535°W	Full power	PV/OD	PO BR	1500 m / Full power	Power down	Observed leaving 180 dB safety radius, returned 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
33	16-Jul	23:30	Northern right whale dolphin	75	46.62243°N 124.96535°W	Full power	PV/OD	PO SA	1500 m / Full power	None	
34	16-Jul	23:56	Pacific white-sided dolphin	7	46.61013°N 125.01297°W	Full power	PV/SD	PO BR	4 m / Not firing	Power / Shut down	Correlates with acoustic det. 1. Last observed within 180 dB safety radius. Waited 15 min. before ramp-up.
35	17-Jul	14:31	Pacific white-sided dolphin	30	46.40942°N 125.85742°W	Full power	PV/OD	PO BR	1 m / Not firing	Shut down	Correlates with acoustic det. 2. Mixed pod. Last observed within 180 dB safety radius. Waited 15 min. before ramp-up.
36	17-Jul	14:31	Northern right whale dolphin	80	46.40942°N 125.85742°W	Full power	PV/OD	PO FT	450 m / Not firing	Power down	Mixed pod. Observed leaving 180 dB safety radius, array shut down for PWS dolphins.
37	17-Jul	23:47	Humpback whale	1	46.49618°N 124.85640°W	Full power	PV/OD	BV DF	2600 m / Full power	None	
38	18-Jul	2:40	Pacific white-sided dolphin	30	46.58663°N 124.90247°W	Mitigation firing	PV/OD	PO	1 m / Not firing	Shut down	Last observed within 180 dB safety radius. Airguns brought onboard for fishing line entanglement..
39	18-Jul	2:40	Northern right whale dolphin	2	46.58663°N 124.90247°W	Mitigation firing	PV/OD	PO	583 m / Mitigation	None	
40	18-Jul	3:34	Pacific white-sided dolphin	25	46.59213°N 124.99535°W	Not firing	PV/SD	PO	1089 m / Not firing	None	
41	18-Jul	3:34	Northern right whale dolphin	25	46.59213°N 124.99535°W	Not firing	PV/SD	PO	1089 m / Not firing	None	
42	18-Jul	4:11	Unidentified baleen whale	1	46.59537°N 125.06110°W	Not firing	PV/SD	BV	1535 m / Not firing	None	
43	18-Jul	20:13	Humpback whale	1	46.54835°N 125.13580°W	Not firing	PE/AH	BV DI	2400 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
44	19-Jul	16:25	Fin whale	2	46.68847°N 125.13530°W	Full power	PE/AH	BV DI	640 m / Mitigation	Power down	Last observed within 180 dB safety radius. Waited 30 min. before resuming full power.
45	19-Jul	17:43	Unidentified baleen whale	2	46.70008°N 125.00817°W	Full power	PE/AH	BV DI	2000 m / Full power	None	
46	19-Jul	17:47	Pacific white-sided dolphin	6	46.70167°N 124.99957°W	Full power	TV	FT	200 m / Mitigation	Power down	Last observed within 180 dB safety radius. Waited 15 min. before resuming full power.
47	19-Jul	20:00	Humpback whale	3	46.72118°N 124.75575°W	Full power	PE/AH	SA ST	3031 m / Full power	None	
48	19-Jul	20:23	Unidentified baleen whale	1	46.72520°N 124.70737°W	Full power	PV/OD	SA	2600 m / Full power	None	
49	19-Jul	20:49	Humpback whale	2	46.73008°N 124.64593°W	Full power	PV/OD	BV DF	2000 m / Full power	None	
50	19-Jul	20:59	Humpback whale	3	46.73052°N 124.63998°W	Full power	AV	RO BV	845 m / Full power	Power down	Exceeded current takes for humpbacks.
51	19-Jul	21:14	Humpback whale	1	46.73388°N 124.59833°W	Mitigation firing	AV	BV DI	2000 m / Mitigation	None	
52	19-Jul	21:25	Humpback whale	1	46.73410°N 124.59607°W	Mitigation firing	PV/OD	BV DI	2614 m / Mitigation	None	
53	19-Jul	21:20	Harbor porpoise	4	46.73388°N 124.59833°W	Mitigation firing	PV/OD	FT	600 m / Mitigation	None	
54	19-Jul	21:38	Humpback whale	2	46.73595°N 124.57305°W	Mitigation firing	AV	BV DV	600 m / Mitigation	None	

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position	Source Activity Initial Detection	Movement/ Behaviour		CPA Source / Source Activity	Mitigation Action	Comments
55	19-Jul	21:47	Humpback whale	1	46.73688°N 124.57650°W	Mitigation firing	PV/OD	BV SA	4096 m / Mitigation	None	
56	19-Jul	22:46	Humpback whale	1	46.79444°N 124.52418°W	Mitigation firing	PV/OD	BV	1089 m / Mitigation	None	
57	19-Jul	23:24	Humpback whale	1	46.83720°N 124.52997°W	Mitigation firing	UN	BV		None	
58	19-Jul	23:29	Humpback whale	1	46.85552°N 124.53308°W	Mitigation firing	UN	BV		None	
59	19-Jul	23:32	Humpback whale	1	46.84660°N 124.53315°W	Mitigation firing	PE/AH	BV DF	800 m / Mitigation	Shut down	Observed leaving 160 dB safety radius, mitigation gun enabled.
60	19-Jul	23:32	Humpback whale	1	46.84660°N 124.53315°W	Mitigation firing	UN	BV DV	4200 m / Mitigation	None	
61	20-Jul	00:42	Humpback whale	1	46.87650°N 124.62142°W	Mitigation firing	PV/OD	BV DV	1100 m / Mitigation	None	
62	20-Jul	00:46	Humpback whale	2	46.87615°N 124.62803°W	Mitigation firing	TV	BV DF	900 m / Mitigation	None	
63	20-Jul	00:49	Humpback whale	1	46.87547°N 124.63608°W	Mitigation firing	PV/OD	SA	60 m / Mitigation	Shut down	Observed leaving 160 dB safety radius, mitigation gun enabled.
64	20-Jul	01:05	Humpback whale	1	46.87310°N 124.66632°W	Mitigation firing	UN	SA	4096 m / Mitigation	Soft start delay	Waited 30 min. after last sighting to begin ramp-up.
65	20-Jul	16:16	Dall's porpoise	5	46.80972°N 126.31922°W	Full power	TV	FT	600 m / Full power	Power down	Observed leaving 180 dB safety radius, resume full power.
66	20-Jul	16:25	Unidentified whale	1	46.82072°N 126.32303°W	Full power	UN	BV	4096 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
67	20-Jul	18:19	Dall's porpoise	5	46.88882°N 126.18312°W	Full power	PE/BH	FT	1089 m / Full power	None	
68	20-Jul	18:50	Dall's porpoise	3	46.88635°N 126.12648°W	Full power	PV/OD	FT	3000 m / Full power	None	
69	20-Jul	19:16	Fin whale	1	46.89790°N 126.07625°W	Full power	PV/OD	DF RO	613 m / Mitigation	Power down	Observed leaving 180 dB safety radius.
70	20-Jul	19:42	Dall's porpoise	6	46.90237°N 126.02443°W	Mitigation firing	AV	FT	800 m / Mitigation	Power down	Entered safety radius while powered-down for det. 69. Last observed within 180 dB safety radius. Waited 15 mi. before resuming full power.
71	20-Jul	20:02	Unidentified baleen whale	1	46.90593°N 125.98552°W	Full power	PV/OD	BV DV	5000 m / Full power	None	
72	20-Jul	20:29	Fin whale	1	46.91093°N 125.92963°W	Full power	PE/AH	BV DV	730 m / Full power	Power down	Observed leaving 180 dB safety radius, resumed full power.
73	20-Jul	21:41	Fin whale	1	46.92320°N 125.79237°W	Full power	PV/OD	BV DV	4000 m / Full power	None	
74	20-Jul	23:55	Fin whale	1	46.94587°N 125.53530°W	Full power	PE/AH	BV DV	3417 m / Full power	None	
75	21-Jul	00:15	Fin whale	1	46.94895°N 125.49863°W	Full power	PV/OD	BV DV	1523 m / Full power	None	
76	21-Jul	00:54	Pacific white-sided dolphin	2	46.95540°N 125.42322°W	Full power	PV/OD	PO SA	4000 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
77	21-Jul	1:47	Unidentified whale	1	46.96393°N 125.32370°W	Full power	UN	BV	5664 m / Full power	None	
78	21-Jul	15:21	Humpback whale	4	47.11208°N 124.60578°W	Full power	PE/AH	SA DF	5664 m / Full power	None	
79	21-Jul	15:30	Humpback whale	1	47.11332°N 124.62623°W	Full power	PE/AH	BV	2164 m / Full power	None	
80	21-Jul	15:44	Humpback whale	2	47.11428°N 124.64392°W	Full power	AV	BV DF	2846 m / Full power	None	
81	21-Jul	17:00	Humpback whale	2	47.12122°N 124.75931°W	Full power	UN	SA BV	5859 m / Full power	None	
82	22-Jul	00:38	Dall's porpoise	3	47.08757°N 125.42202°W	Full power	PV/OD	SV	200 m / Full power	Power down	Last observed within 180 dB safety radius. Waited 15 min. before resuming full power.
83	22-Jul	1:11	Fin whale	3	47.04852°N 125.41722°W	Full power	PV/OD	BV DV	3922 m / Full power	None	
84	22-Jul	2:30	Fin whale	2	46.95108°N 125.40568°W	Full power	AV	BV DV	1735 m / Full power	None	
85	22-Jul	2:30	Northern right whale dolphin	35	46.95108°N 125.40568°W	Full power	AV	PO SA	1535 m / Full power	None	Exceeded 'takes' by seven animals.
86	22-Jul	3:19	Pacific white-sided dolphin	3	46.89192°N 125.39857°W	Full power	PV/OD	PO BR	5 m / Not firing	Shut down	Last observed within 180 dB safety radius. Waited 15 min. before ramp-up.
87	22-Jul	13:26	Unidentified whale	1	46.37317°N 125.51758°W	Full power	UN	BV	2846 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
88	22-Jul	23:13	Fin whale	3	46.45762°N 124.87430°W	Full power	PV/OD	BV DV	100 m / Mitigation firing	Power down	Observed leaving 180 dB safety radius, resumed full power.
89	22-Jul	23:30	Unidentified whale	2	46.47432°N 124.86670°W	Full power	UN	BV	4328 m / Full power	None	
90	23-Jul	14:29	Dall's porpoise	2	46.47167°N 125.14842°W	Partial power	AV	FT	505 m / Partial power	Power down	Last observed within 180 dB safety radius. Waited 15 min. before resuming partial power (3300 in^3).
91	23-Jul	23:24	Fin whale	3	46.51497°N 125.45048°W	Not firing	PV/OD	BV DV	2000 m / Not firing	None	Observed while in transit.
92	24-Jul	3:58	Dall's porpoise	4	46.69945°N 126.03570°W	Not firing	UN	FT	230 m / Not firing	None	Observed while in transit.

Summary of acoustic detections of protected species during the Cascadia subduction margin 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	16-Jul	23:59	Pacific white-sided dolphin	7	46.61013°N 125.01297°W	Full power	Multiple click trains of HF click detector	4 m / Not firing	Power / Shut down	Correlates with visual 34.
2	17-Jul	14:31	PWS & NRW dolphins	30	46.40942°N 125.85742°W	Full power	Multiple click trains of HF click detector. Faint whistle heard aurally.	1 m / Not firing	Shut down	Mixed pod, only PWS dolphins approached airguns.
3	22-Jul	3:20	Pacific white-sided dolphin	3	46.89192°N 125.39857°W	Full power	Multiple click trains on HF click detector.	5 m / Not firing	Shut down	Correlates with visual detection 86.

APPENDIX G: Summary of visual detections of protected species from the Northern Light during the Cascadia subduction margin geohazards marine geophysical survey.

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position		Source Activity Initial Detection	Distance from R/V Langseth if Source Active (km)	Comments
					GIS Latitude	GIS Longitude			
1	11-Jul	12:20	Grey Whale	2	48.39810°N	124.66812°W	Not firing	n/a	
2	11-Jul	13:16	Steller sea lion	1	48.31467°N	124.79563°W	Not firing	n/a	
3	11-Jul	13:50	Steller sea lion	1	48.21538°N	124.81110°W	Not firing	n/a	
4	11-Jul	14:43	Steller sea lion	1	48.04445°N	124.80470°W	Not firing	n/a	
5	11-Jul	14:45	Steller sea lion	1	48.04445°N	124.80470°W	Not firing	n/a	
6	11-Jul	14:47	Harbor Seal	1	48.03118°N	124.80333°W	Not firing	n/a	
7	11-Jul	15:16	Steller sea lion	1	47.93752°N	124.75773°W	Not firing	n/a	
8	11-Jul	15:22	Harbor Porpoise	1	47.92022°N	124.74932°W	Not firing	n/a	
9	11-Jul	15:51	Harbor Seal	1	47.85603°N	124.66905°W	Not firing	n/a	
10	11-Jul	15:59	Harbor Porpoise	1	47.84158°N	124.64308°W	Not firing	n/a	
11	11-Jul	16:50	Harbor Porpoise	1	47.71992°N	124.64308°W	Not firing	n/a	

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position		Source Activity Initial Detection	Distance from R/V Langseth if Source Active (km)	Comments
					GIS Latitude	GIS Longitude			
12	11-Jul	17:01	Harbor Porpoise	1	47.66992°N	124.52928°W	Not firing	n/a	
13	11-Jul	17:05	Harbor Porpoise	1	47.66992°N	124.51903°W	Not firing	n/a	
14	11-Jul	17:19	Humpback	1	47.65735°N	124.47780°W	Not firing	n/a	
15	11-Jul	17:24	Harbor Seal	1	47.61368°N	124.46700°W	Not firing	n/a	
16	11-Jul	17:39	Harbor Porpoise	6	47.56933°N	124.43392°W	Not firing	n/a	
17	11-Jul	17:54	Harbor Porpoise	1	47.52500°N	124.42117°W	Not firing	n/a	
18	11-Jul	18:08	Harbor Porpoise	1	47.50275°N	124.42933°W	Not firing	n/a	
19	11-Jul	18:22	Harbor Porpoise	1	47.48333°N	124.44823°W	Not firing	n/a	
20	11-Jul	18:31	Harbor Porpoise	2	47.47063°N	124.44823°W	Not firing	n/a	
21	11-Jul	19:13	Harbor Seal	1	47.39412°N	124.35487°W	Not firing	n/a	
22	11-Jul	19:53	Harbor Porpoise	1	47.28670°N	124.35487°W	Not firing	n/a	

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position		Source Activity Initial Detection	Distance from R/V Langseth if Source Active (km)	Comments
					GIS Latitude	GIS Longitude			
23	11-Jul	19:53	Harbor Porpoise	2	47.28405°N	124.35328°W	Not firing	n/a	
24	11-Jul	20:19	Harbor Porpoise	1	47.22655°N	124.32500°W	Not firing	n/a	
25	11-Jul	20:20	Harbor Porpoise	2	47.22248°N	124.32110°W	Not firing	n/a	
26	11-Jul	20:48	Harbor Porpoise	1	47.15357°N	124.27658°W	Not firing	n/a	
27	11-Jul	20:57	Harbor Porpoise	2	47.13167°N	124.27658°W	Not firing	n/a	
28	11-Jul	21:19	Harbor Porpoise	1	47.07223°N	124.27658°W	Not firing	n/a	
29	11-Jul	21:21	Harbor Porpoise	1	47.06627°N	124.27140°W	Not firing	n/a	
30	11-Jul	21:23	Harbor Porpoise	1	47.06330°N	124.26835°W	Not firing	n/a	
31	11-Jul	21:45	Harbor Porpoise	1	47.00317°N	124.25195°W	Not firing	n/a	
32	11-Jul	21:50	Harbor Porpoise	1	46.98938°N	124.25973°W	Not firing	n/a	
33	11-Jul	21:52	Harbor Porpoise	1	46.98103°N	124.26565°W	Not firing	n/a	

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position		Source Activity Initial Detection	Distance from R/V Langseth if Source Active (km)	Comments
					GIS Latitude	GIS Longitude			
34	11-Jul	21:58	Harbor Porpoise	1	46.96697°N	124.27467°W	Not firing	n/a	
35	11-Jul	22:15	Harbor Seal	1	46.92203°N	124.24400°W	Not firing	n/a	
36	11-Jul	22:24	Grey Whale	1	46.92203°N	124.20743°W	Not firing	n/a	
37	11-Jul	22:47	Harbor Seal	1	46.91282°N	124.10828°W	Not firing	n/a	
38	11-Jul	22:50	Harbor Seal	1	46.90925°N	124.10588°W	Not firing	n/a	
39	12-Jul	15:58	Harbor Porpoise	1	46.97403°N	124.22650°W	Not firing	n/a	
40	12-Jul	16:07	Harbor Seal	1	46.99722°N	124.23550°W	Not firing	n/a	
41	12-Jul	17:27	Harbor Porpoise	1	47.22680°N	124.31767°W	Not firing	n/a	
42	12-Jul	17:36	Harbor Porpoise	1	47.22680°N	124.31767°W	Not firing	n/a	
43	12-Jul	17:56	Harbor Porpoise	1	47.22987°N	124.36720°W	Not firing	n/a	
44	12-Jul	18:57	Steller sea lion	1	47.23502°N	124.49173°W	Not firing	n/a	

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position		Source Activity Initial Detection	Distance from R/V Langseth if Source Active (km)	Comments
					GIS Latitude	GIS Longitude			
45	12-Jul	19:08	Harbor Seal	1	47.24645°N	124.51987°W	Not firing	n/a	
46	12-Jul	19:47	Humpback	~15	47.17870°N	124.60010°W	Not firing	n/a	
47	12-Jul	19:57	Steller sea lion	4	47.17870°N	124.60010°W	Not firing	n/a	
48	12-Jul	22:21	Humpback	1	47.42428°N	124.71453°W	Not firing	n/a	
49	12-Jul	22:40	Humpback	1	47.22968°N	124.41537°W	Not firing	n/a	
50	12-Jul	22:47	Northern Fur Seal	1	47.22968°N	124.78518°W	Not firing	n/a	
51	12-Jul	23:39	Humpback	3	47.12742°N	124.82658°W	Not firing	n/a	
52	12-Jul	23:53	Humpback	1	47.11345°N	124.69000°W	Not firing	n/a	
53	13-Jul	00:58	Humpback	5	47.11345°N	124.69000°W	Not firing	n/a	
54	13-Jul	02:45	Humpback	1	47.05588°N	124.68782°W	Not firing	n/a	
55	13-Jul	03:08	Humpback	1	47.01723°N	124.65817°W	Not firing	n/a	

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position		Source Activity Initial Detection	Distance from *R/V Langseth* if Source Active (km)	Comments
					GIS Latitude	GIS Longitude			
56	13-Jul	18:16	Northern Right Whale Dolphin	1	46.99383°N	125.48592°W	Mitigation firing	82.11	
57	13-Jul	22:29	Humpback	1	47.08922°N	124.69788°W	Mitigation firing	75.12	
58	13-Jul	22:56	Humpback	1	47.10100°N	124.65470°W	Mitigation firing	81.92	
59	13-Jul	23:29	Humpback	2	47.09295°N	124.63242°W	Mitigation firing	86.17	
60	13-Jul	23:40	UID Fur Seal	1	47.08562°N	124.62872°W	Mitigation firing	86.42	
61	14-Jul	00:44	Harbor Porpoise	1	47.13560°N	124.51722°W	Mitigation firing	76.18	
62	14-Jul	2:18	Harbor Porpoise	1	47.17307°N	124.37225°W	Full power	126.37	
63	14-Jul	2:58	Harbor Porpoise	~10	47.11670°N	124.34013°W	Full power	132.83	
64	14-Jul	3:13	Harbor Porpoise	1	47.09142°N	124.32133°W	Full power	134.08	
65	14-Jul	3:23	Harbor Porpoise	1	47.07170°N	124.30622°W	Full power	139.15	
66	14-Jul	13:22	Pacific White Sided Dolphin	~50	47.06368°N	124.94032°W	Full power	86.52	

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position		Source Activity Initial Detection	Distance from R/V Langseth if Source Active (km)	Comments
					GIS Latitude	GIS Longitude			
67	14-Jul	13:32	Northern Right Whale Dolphin	~20	47.06368°N	124.94032°W	Full power	86.52	
68	14-Jul	13:32	Elephant Seal	1	47.04070°N	124.96613°W	Full power	84.32	
69	14-Jul	18:52	Pacific White Sided Dolphin	~200	46.95905°N	125.05747°W	Full power	33.60	
70	14-Jul	18:52	Northern Right Whale Dolphin	~40	46.95905°N	125.05747°W	Full power	33.60	
71	14-Jul	19:17	UNID Fur Seal	1	46.92825°N	125.00748°W	Full power	38.12	
72	14-Jul	20:53	Humpback	1	46.95910°N	124.77577°W	Full power	38.44	
73	14-Jul	21:32	UNID Fur Seal	1	46.94100°N	124.77007°W	Full power	35.86	
74	14-Jul	21:38	Humpback	1	46.94470°N	124.76338°W	Full power	36.12	
75	14-Jul	22:47	Humpback	1	47.00972°N	124.73812°W	Full power	25.07	
76	14-Jul	22:52	Humpback	1	47.02048°N	124.75725°W	Full power	23.40	
77	14-Jul	23:19	Harbor Seal	3	47.07773°N	124.75518°W	Full power	19.09	

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position		Source Activity Initial Detection	Distance from R/V Langseth if Source Active (km)	Comments
					GIS Latitude	GIS Longitude			
78	14-Jul	23:50	Humpback	1	47.07110°N	124.70493°W	Full power	18.62	
79	15-Jul	00:10	Harbor Porpoise	1	47.04107°N	124.60507°W	Full power	26.36	
80	15-Jul	00:17	Harbor Porpoise	2	47.03423°N	124.60507°W	Full power	22.65	
81	15-Jul	0:20	Harbor Porpoise	4	47.03183°N	124.57518°W	Full power	24.91	
82	15-Jul	00:22	Harbor Porpoise	2	47.02925°N	124.56632°W	Full power	25.63	
83	15-Jul	00:25	Harbor Porpoise	1	47.02708°N	124.55833°W	Full power	26.27	
84	15-Jul	00:38	Harbor Seal	1	47.01452°N	124.51260°W	Full power	27.25	
85	15-Jul	00:45	Harbor Porpoise	1	47.00847°N	124.49265°W	Full power	28.85	
86	15-Jul	00:45	Harbor Seal	1	47.00847°N	124.49265°W	Full power	28.85	
87	15-Jul	00:49	Harbor Porpoise	1	47.00463°N	124.48022°W	Mitigation firing	29.86	
88	15-Jul	00:54	Harbor Porpoise	1	47.00003°N	124.48243°W	Mitigation firing	29.05	

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position		Source Activity Initial Detection	Distance from R/V Langseth if Source Active (km)	Comments
					GIS Latitude	GIS Longitude			
89	16-Jul	13:31	Harbor Porpoise	2	46.84735°N	124.46847°W	Full power	47.11	
90	16-Jul	13:33	Harbor Porpoise	1	46.84643°N	124.47535°W	Full power	46.86	
91	16-Jul	14:40	Elephant Seal	1	46.82287°N	124.58922°W	Full power	29.49	
92	16-Jul	14:43	Northern Fur Seal	1	46.82183°N	124.59565°W	Full power	29.00	
93	16-Jul	14:49	Humpback	1	46.80722°N	124.59565°W	Full power	24.75	
94	16-Jul	17:12	Humpback	3	46.76182°N	124.54640°W	Full power	12.58	Animals exposed to received sound levels of 160 dB.
95	16-Jul	18:06	Humpback	2	46.70915°N	124.58152°W	Mitigation firing	7.98	
96	16-Jul	19:07	Humpback	7	46.68763°N	124.59867°W	Mitigation firing	1.21	
97	16-Jul	19:32	Dall's Porpoise	5	46.65567°N	124.66230°W	Not firing	6.27	
98	16-Jul	19:54	UNID Fur Seal	1	46.62577°N	124.91553°W	Not firing	21.85	
99	16-Jul	20:47	Elephant Seal	1	46.62577°N	124.91553°W	Not firing	15.23	

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position		Source Activity Initial Detection	Distance from R/V Langseth if Source Active (km)	Comments
					GIS Latitude	GIS Longitude			
100	16-Jul	21:33	Pacific White Sided Dolphin	8	46.63702°N	124.98760°W	Mitigation firing	15.35	
101	17-Jul	4:21	Pacific White Sided Dolphin	10	46.53108°N	124.84815°W	Full power	45.86	
102	17-Jul	13:46	Elephant Seal	1	46.48955°N	124.90455°W	Full power	78.15	
103	17-Jul	20:52	Elephant Seal	1	46.46978°N	124.98303°W	Full power	14.19	Possibly same animal as detection 102.
104	17-Jul	21:35	Dall's Porpoise	3	46.47548°N	124.89375°W	Full power	17.08	
105	18-Jul	0:22	Humpback	4	46.53015°N	124.60833°W	Full power	14.22	
106	18-Jul	1:02	Humpback	2	46.54053°N	124.60677°W	Mitigation firing	13.93	
107	18-Jul	2:02	Humpback	2	46.55723°N	124.57833°W	Mitigation firing	20.12	
108	18-Jul	2:30	Humpback	1	46.58488°N	124.64198°W	Mitigation firing	18.60	
109	18-Jul	02:47	Humpback	1	46.58223°N	124.70142°W	Mitigation firing	15.38	
110	18-Jul	13:50	Humpback	1	46.71933°N	124.52072°W	Not firing	58.77	

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position		Source Activity Initial Detection	Distance from R/V Langseth if Source Active (km)	Comments
					GIS Latitude	GIS Longitude			
111	18-Jul	14:47	Fur Seal	1	46.71997°N	124.59730°W	Full power	50.02	
112	18-Jul	16:47	UNID Large Whale	1	46.61820°N	124.74255°W	Full power	31.13	Likely fin whale
113	18-Jul	17:54	UNID Large Whale	1	46.88628°N	124.96925°W	Mitigation firing	30.24	Likely fin whale
114	18-Jul	22:58	Fin Whale	1	46.52087°N	124.97800°W	Mitigation firing	28.02	
115	18-Jul	23:23	Fin Whale	1	46.51498°N	124.97478°W	Mitigation firing	27.64	
116	19-Jul	06:17	Pacific White Sided Dolphin	4	46.51067°N	124.91303°W	Mitigation firing	78.20	
117	19-Jul	13:57	Dall's Porpoise	2	46.71948°N	124.82657°W	Full power	43.36	
118	19-Jul	17:38	Pacific White Sided Dolphin	8	46.71948°N	124.82657°W	Full power	14.00	
119	19-Jul	18:51	Humpback	1	46.71950°N	124.68038°W	Full power	15.00	
120	19-Jul	18:56	Humpback	1	46.71932°N	124.67035°W	Full power	15.76	
121	19-Jul	20:06	Dall's Porpoise	3	46.71882°N	124.61987°W	Full power	10.36	Animals exposed to received sound levels of 160 dB.

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position		Source Activity Initial Detection	Distance from R/V Langseth if Source Active (km)	Comments
					GIS Latitude	GIS Longitude			
122	19-Jul	20:08	Humpback	3	46.71883°N	124.61413°W	Full power	10.80	Animals exposed to received sound levels of 160 dB.
123	19-Jul	20:08	Northern Fur Seal	1	46.71883°N	124.61413°W	Full power	10.80	Animals exposed to received sound levels of 160 dB.
124	19-Jul	20:18	Humpback	1	46.73072°N	124.54077°W	Full power	16.42	
125	19-Jul	21:26	Humpback	3	46.81872°N	124.52898°W	Full power	9.71	
126	19-Jul	21:38	Humpback	2	46.83500°N	124.55517°W	Mitigation firing	11.06	
127	19-Jul	23:01	Humpback	1	46.82883°N	124.52832°W	Mitigation firing	0.53	
128	19-Jul	23:06	Dall's Porpoise	1	46.83785°N	124.52935°W	Mitigation firing	0.46	Animals exposed to received sound levels of 160 dB.
129	19-Jul	23:06	Humpback	1	46.84562°N	123.52952°W	Mitigation firing	1.33	
130	19-Jul	23:10	Humpback	4	46.84562°N	124.53062°W	Mitigation firing	4.53	
131	19-Jul	23:25	Humpback	2	46.87208°N	124.54813°W	Mitigation firing	4.53	
132	19-Jul	23:38	Humpback	1	46.87543°N	124.56637°W	Mitigation firing	1.74	

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position		Source Activity Initial Detection	Distance from R/V Langseth if Source Active (km)	Comments
					GIS Latitude	GIS Longitude			
133	19-Jul	23:50	Humpback	1	46.86468°N	124.58753°W	Mitigation firing	3.50	
134	19-Jul	23:56	Humpback	1	46.87677°N	124.59392°W	Not firing	3.83	
135	20-Jul	00:03	Humpback	2	46.88920°N	124.58373°W	Not firing	3.47	
136	20-Jul	00:07	Humpback	1	46.89275°N	124.57128°W	Not firing	2.96	
137	20-Jul	00:32	Humpback	3	46.89100°N	124.59717°W	Mitigation firing	1.50	
138	20-Jul	13:38	Humpback	1	47.02067°N	124.65325°W	Full power	113.94	
139	20-Jul	13:44	UNID Large Whale	1	47.01795°N	124.67563°W	Full power	112.24	
140	20-Jul	14:05	Harbor Porpoise	1	47.01425°N	124.71253°W	Full power	114.09	
141	20-Jul	14:40	Dall's Porpoise	4	47.00867°N	124.77603°W	Full power	112.90	
142	20-Jul	16:14	Risso's Dolphin	10	46.99970°N	124.93962°W	Mitigation firing	106.95	
143	20-Jul	17:03	Northern Fur Seal	1	46.98872°N	124.94768°W	Full power	105.51	

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position		Source Activity Initial Detection	Distance from R/V Langseth if Source Active (km)	Comments
					GIS Latitude	GIS Longitude			
144	20-Jul	17:41	Humpback	2	47.00860°N	124.99755°W	Full power	98.56	
145	20-Jul	18:35	Humpback	3	46.96068°N	125.04443°W	Full power	85.16	
146	20-Jul	20:09	Humpback	2	46.93598°N	124.81170°W	Full power	89.79	
147	20-Jul	20:12	Humpback	2	46.93675°N	124.80342°W	Full power	90.42	
148	20-Jul	20:50	Humpback	1	46.94510°N	124.73790°W	Full power	86.33	
149	20-Jul	20:59	Humpback	3	46.94142°N	124.76225°W	Mitigation firing	84.46	
150	20-Jul	21:25	Humpback	3	46.95553°N	124.69715°W	Full power	83.23	
151	20-Jul	21:31	Humpback	1	46.95423°N	124.67658°W	Full power	84.75	
152	20-Jul	21:36	Humpback	2	46.95425°N	124.66087°W	Full power	85.99	
153	20-Jul	21:42	Humpback	1	46.95513°N	124.64003°W	Full power	87.57	
154	20-Jul	21:48	Humpback	1	46.95497°N	124.61815°W	Full power	89.23	

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position		Source Activity Initial Detection	Distance from R/V Langseth if Source Active (km)	Comments
					GIS Latitude	GIS Longitude			
155	20-Jul	22:28	Humpback	1	46.98687°N	124.51270°W	Full power	90.21	
156	21-Jul	03:02	Humpback	2	47.09970°N	124.59615°W	Full power	46.81	
157	21-Jul	13:47	Harbor Porpoise	1	47.14693°N	124.49415°W	Full power	5.07	Animals exposed to received sound levels of 160 dB.
158	21-Jul	13:56	Steller sea lion	1	47.12207°N	124.51198°W	Full power	3.63	Animals exposed to received sound levels of 160 dB.
159	21-Jul	13:56	Harbor Porpoise	1	47.12207°N	124.51198°W	Full power	3.63	Animals exposed to received sound levels of 160 dB.
160	21-Jul	13:57	Harbor Porpoise	1	47.12083°N	124.51198°W	Full power	3.57	Animals exposed to received sound levels of 160 dB.
161	21-Jul	14:05	Humpback	1	47.12367°N	124.52590°W	Full power	4.63	Animals exposed to received sound levels of 160 dB.
162	21-Jul	15:10	Harbor Porpoise	1	47.16327°N	124.60180°W	Full power	6.40	Animals exposed to received sound levels of 160 dB.
163	21-Jul	15:16	Harbor Porpoise	2	47.16010°N	124.61295°W	Full power	5.28	Animals exposed to received sound levels of 160 dB.
164	21-Jul	15:39	Humpback	2	47.13477°N	124.66370°W	Full power	3.70	Animals exposed to received sound levels of 160 dB.
165	21-Jul	16:13	Humpback	1	47.15065°N	124.70092°W	Full power	3.62	Animals exposed to received sound levels of 160 dB.

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position		Source Activity Initial Detection	Distance from R/V Langseth if Source Active (km)	Comments
					GIS Latitude	GIS Longitude			
166	21-Jul	16:36	Humpback	7	47.18570°N	124.72355°W	Full power	7.67	Animals exposed to received sound levels of 160 dB.
167	21-Jul	16:44	Harbor Porpoise	1	47.18290°N	124.72875°W	Full power	7.13	Animals exposed to received sound levels of 160 dB.
168	21-Jul	16:55	Humpback	1	47.17737°N	124.72410°W	Full power	6.68	Animals exposed to received sound levels of 160 dB.
169	21-Jul	17:34	Dall's Porpoise	4	47.17030°N	124.74788°W	Full power	6.59	Animals exposed to received sound levels of 160 dB.
170	21-Jul	17:45	Humpback	3	47.17772°N	124.75405°W	Full power	8.43	Animals exposed to received sound levels of 160 dB.
171	21-Jul	17:45	Harbor Porpoise	1	47.17772°N	124.75405°W	Full power	8.43	Animals exposed to received sound levels of 160 dB.
172	21-Jul	17:57	Harbor Porpoise	1	47.18397°N	124.76048°W	Full power	8.53	Animals exposed to received sound levels of 160 dB.
173	21-Jul	18:01	Humpback	1	47.18210°N	124.77092°W	Full power	7.86	Animals exposed to received sound levels of 160 dB.
174	22-Jul	2:49	Minke whale	1	46.83838°N	125.18085°W	Full power	21.19	

Summary of acoustic detections of protected species on the *Northern Light* during the Cascadia subduction margin marine geophysical survey.

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position		Acoustic Detection Details
					GIS Latitude	GIS Longitude	
1	19-Jul	7:23	Unidentified dolphin	Unknown	46.62445°N	124.55492°W	Pulses, convex, up sweeping and down sweeping whistles, 3 – 24 kHz frequency range, amplitude of approximately 90 dB. No visual confirmation.
2	20-Jul	7:42	Unidentified dolphin	Unknown	47.00602°N	124.49120°W	At 07:42 UTC whistles from unidentifiable delphinids were heard acoustically. The whistles were last detected at 07:49 UTC. Spectrogram information unavailable. No visual confirmation.
3	21-Jul	9:38	Unidentified dolphin	Unknown	47.06048°N	124.51583°W	Briefly, at 09:38 UTC, whistles/clicks from unidentifiable delphinids were heard acoustically. Spectrogram information unavailable. No visual confirmation.
4	22-Jul	6:52	Unidentified dolphin	Unknown	46.75310°N	124.79130°W	At 06:52 UTC whistles from unidentifiable delphinids were heard acoustically. The whistles were last detected at 07:41 UTC. Spectrogram information unavailable. No visual confirmation.
5	22-Jul	9:22	Unidentified dolphin	Unknown	46.69340°N	124.50043°W	At 09:22 UTC whistles that were almost chirp-like from unidentifiable delphinids were heard acoustically. The whistles were last detected at 09:25. Spectrogram information unavailable. No visual confirmation.

APPENDIX H: Species of birds and other wildlife observed during the Cascadia subduction margin marine geophysical survey.

Common Name	Family	Genus	Species	Approximate Number of Individuals Observed	Approximate Number of Days Species Was Observed
Pelagic Cormorant	Phalacrocoracidae	*Phalacrocorax*	*pelagicus*	**5**	**1**
Pink-footed Shearwater	Procellariidae	*Puffinus*	*creatopus*	**2**	**1**
Sooty Shearwater	Procellariidae	*Puffinus*	*Griseus*	**60**	**2**
Brown Pelican	Pelecanidae	*Pelecanus*	*accidentalis*	**10**	**1**
Black-footed Albatross	Diomedeidae	*Diomedea*	*nigripes*	**132**	**9**
Herring Gull	Laridae	*Larus*	*argentatus*	**552**	**8**
Common Murre	Alcidae	*Uria*	*aalge*	**269**	**6**
Tufted Puffin	Alcidae	*Fratercula*	*cirrhata*	**4**	**3**
Northern Fulmar	Procellariidae	*Fulmarus*	*glacialis*	**94**	**8**
Fork-tailed Storm-petrel	Hydrobatidae	*Oceanodroma*	*furcata*	**2**	**1**
Leach's Storm-petrel	Hydrobatidae	*Oceanodroma*	*leucorhoa*	**26**	**6**
Unidentified Petrel	Procellariidae			**1**	**1**
Rufous Hummingbird	Trochilidae	*Selasphorous*	*rufus*	**1**	**1**
Caspian Tern	Sternidae	*Sterna*	*caspia*	**1**	**1**
Parasitic Jaeger	Stercorariidae	*Stercorarius*	*parasiticus*	**2**	**1**
Unidentified sandpiper	Scolopacidae			**1**	**1**
Unidentified shearwater	Procellariidae			**11**	**2**
Unidentified bird				**75**	**3**

Common Name	Family	Genus	Species	Approximate Number of Individuals Observed	Approximate Number of Days Species Was Observed
Blue shark	Carcharhinidae	*Prionace*	*Glauca*	3	2
Ocean sunfish	Molidea	*Mola*	*Mola*	3	2
Unidentified shark				1	1
Jellyfish				500+	1

APPENDIX I: Species of birds and other wildlife observed during the Cascadia subduction margin marine geophysical survey.

Exceeded Take Report

Time: 2:30 – 03:47 UTC, 22 July 2012
Location: 46.95108°N, 125.40568°W
Water depth: 1947 m
Vessel speed and heading: 4 kts, 181°

Wind speed and direction: 7 kts SW
Beaufort sea state: 2
Visibility: 9 km
Cloud cover/Glare: 100% / no glare

Vessel activity at initial sighting: Firing full power on survey line
Source activity in 24 hours preceding sighting: Firing full power with the exception of one power down for Dall's porpoises observed within the 180 dB safety radius.

Description of the incident: A pod of ~35 animals initially observed with detection 84 (two fin whales) at 02:30 - observed 3417m ahead of the vessel. At 03:13 observed 1535m directly in front of the vessel engaged in gregarious behavior - jumping and flipping. Observed at 03:23 1535m off the port side of the vessel; observed at 03:35 2614m off the stbd stern. Observed outside of the 160 dB safety radius at 4 km at 03:45. Acoustic source shut-down at 03:19 due to Pacific white-sided dolphins close the arrays. Ramp-up began at 03:47 UTC. Exceeded allotted takes by seven animals.

Description of all marine mammal observations in the 24 hours preceding the incident: Three fin whale sightings totaling 6 animals; one unidentified whale; four humpback whale sightings totaling nine animals; one Pacific white-sided dolphin sighting totaling two animals; and one Dall's porpoise sighting totaling three animals.

Photographs or video footage:n/a