Protected Species Mitigation and Monitoring Report

Gaherty Marine Geophysical Survey
in the
Central Pacific Ocean

26 November 2011- 29 December 2011

R/V Marcus G. Langseth

Prepared for

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1. EXECUTIVE SUMMARY

The National Science Foundation (NSF) owned research vessel (R/V), *Marcus G. Langseth*, operated by Lamont-Doherty Earth Observatory (L-DEO), a part of Columbia University, conducted a seismic survey in the central Pacific Ocean. The survey was conducted to study the properties of lithospheric plates. The *Langseth* left Honolulu Harbor on 26 November 2011 and began the survey on 30 November 2011. The survey was completed on 25 December 2011 and the *Langseth* returned to Honolulu on 29 December 2011.

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 23 November 2011 (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.

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

PSOs undertook a combination of visual and acoustic watches, conducting a total of 387 hours one minute of visual observations and 215 hours 53 minutes of acoustic monitoring over the course of the survey.

This visual monitoring effort produced a project total of seven protected species detection records: five cetacean records and two sea turtle records. Of the five cetacean records collected, two records were collected for odontocetes, while three records were of unidentified large cetaceans. Additionally, there was one acoustic detection made using the PAM system of a sperm whale.

Detections of protected species resulted in one mitigation action being implemented, a power-down of the acoustic source. A known six cetaceans 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 four sperm whale takes. Additionally, two unidentified whales were observed within the 160 dB safety radius.

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

2. INTRODUCTION

The following report details protected species monitoring and mitigation as well as seismic survey operations undertaken as part of the Gaherty two-dimensional (2D) marine seismic survey on board the *R/V Langseth* from 26 November to 29 December 2011 in the central Pacific Ocean.

This document serves to meet the reporting requirements dictated in the IHA issued to L-DEO by NMFS on 23 November 2011. 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 occurred in the central Pacific Ocean, between approximately 1,300 km south of Hawaii, in the area 5 to 10° North and 150 to 156° West (Figure 1). The seismic survey took place in water approximately 5,000 m deep. The *Langseth* deployed an array of 36 airguns as an energy source. The receiving system consisted of one 6 km hydrophone streamer and/or ocean bottom seismometers (OBSs). As the airgun array was towed along the survey lines, the hydrophone streamer received the returning acoustic signals and transferred the data to the onboard processing system. The OBSs recorded the returning acoustic signals internally for later analysis. A total of 34 short period (SP) OBSs, 28 broad band (BB) OBSs, and 8 magneto-telluric (MT) instruments (three test MTs) were deployed.

The total survey effort consisted of approximately 1695 km of transect lines. The 600 km long transect line was shot twice: once using the streamer as the receiver and once again using the OBSs. Subsequent seismic operations occurred along two semi-circular arcs (180°) centered at the mid-point of the 600 km long transect line with radii of 50 and 150 km, respectively (Figure 1).

The *Langseth*'s cruising speed was about 10 knots during transits and varied between 3.5 and 4.5 knots during the seismic survey. Seismic acquisition began on 07 December 2011 and continued until 18 December 2011. All of the planned transect lines were completed allowing the *Langseth* to acquire one additional OBS survey line.

The purpose of the seismic survey was to collect a suite of observations that would unambiguously characterize the detailed structure of oceanic lithosphere in an uncomplicated spreading segment far removed from the influence of asthenospheric melt. With these observations and associated analyses, L-DEO and scientists aimed to define the detailed structure of oceanic lithosphere and develop a comprehensive theory for its formation and evolution.

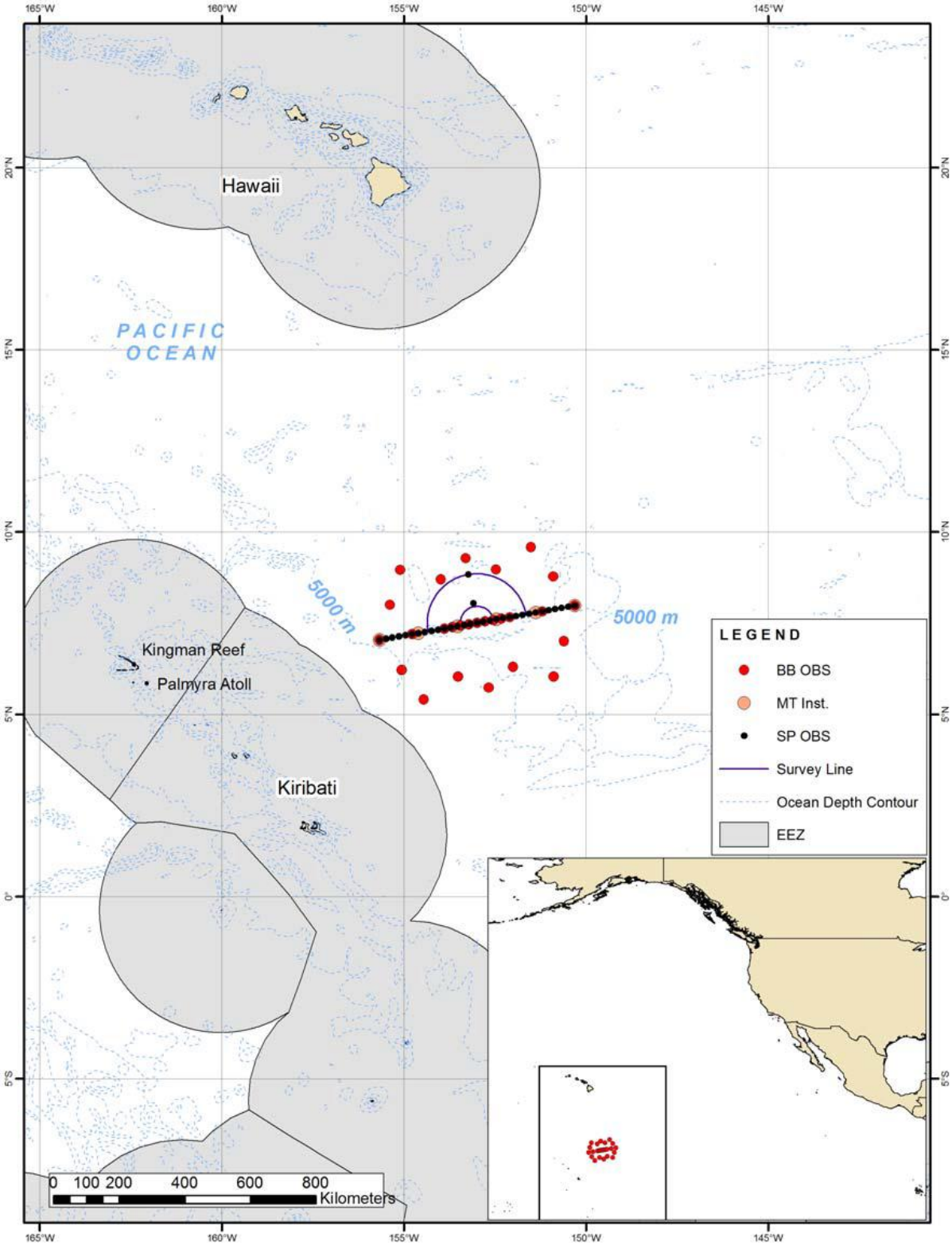


Figure 1. Location of the Gaherty marine geophysical survey in the central Pacific Ocean.

2.1.1. Energy Source

The acoustic source consisted of four towed airgun sub-arrays and one hydrophone streamer cable. The sub-arrays were deployed centrally astern as a single acoustic source with each array separated by eight meters. The airguns were towed at a depth of nine meters and were situated 181 meters astern of the vessel. This placed the source arrays 224.4 meters from the Navigational Reference Point (NRP), which was located on the PSO observation tower.

Each source array utilized a mixture of Bolt 1500LL and Bolt 1900LLX airguns ranging in volume from the smallest airgun of 40 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 and OBS lines was 600 meters, equating to approximately 250 seconds at typical survey speed. The sound signal receiving system during the acquisition of the MCS transect lines consisted of a single six kilometer long hydrophone streamer, which received the returning acoustic signals and transferred the data to the processing system located onboard 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.

Woods Hole Oceanographic Institute (WHOI) “D2” OBSs were used during the cruise. This type of OBS has a height of ~1 m and a maximum diameter of 50 cm. The anchor was made of hot-rolled steel and weighed 23 kg. The anchor dimensions are 2.5×30.5×38.1 cm. The MT instrument was used to passively record natural variations in the Earth’s magnetic and electric field and is approximately 1×1×1 m. The anchor was made of mild steel and is a tripod ~1.9 m in diameter at the base and ~37 cm high; in contact with the substrate are three feet ~23 cm in diameter.

Once an OBS or MT instrument was ready to be retrieved, an acoustic release transponder interrogates the instrument at a frequency of 9–11 kHz, and a response was received at a frequency of 9–13 kHz. The burn-wire release assembly was then activated, and the instrument was released from the anchor to float to the surface. Of the 34 SP OBSs deployed 30 were retrieved and of the three test MTs deployed two were retrieved. The remaining 28 BB OBS and 5 MTs remain deployed to retrieved after a year.

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. 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.

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 05:20 to 06:42 local time, while end of observation times ranged from 17:28 to18:12 local time.

A visual monitoring schedule was established by the PSOs where each person completed visual observations watches which varied in length between one to four hours, two to four times a day, for a total of four to seven 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 twice each day for breakfast and lunch.

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 was sitting nearby. Table 1 describes the various exclusion zone 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. Exclusion zone (EZ) radii for triggering mitigation.

Source and Volume	Array Tow Depth (m)	Water Depth (m)	Shut-down EZ for Cetaceans 180 dB (m)	Level-B Harassment Zone 160 dB (m)
Single bolt airgun (40 in³)	9	Deep (>1,000)	40	385
4 strings 36 airguns (6600 in³)	9	Deep (>1,000)	940	3,850

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 181m 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 and sea turtle identification manuals were consulted and photos were examined during visual watch breaks to confirm identifications.

During or immediately after each sighting event PSOs 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 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.

3.1.1. Forward Looking InfraRed (FLIR) Camera

A Forward Looking InfraRed (FLIR) Camera was utilized each day during the project in order to test its application and effectiveness in the detection of protected species. FLIR is a thermal imaging system that detects temperature differences between objects. The camera was mounted above the ship's wheelhouse at a height of 17.25 meters above the water (when the ship's draft is 4.5 meters). The monitor and joystick control unit of the system are located in the wheelhouse on the port side of the main steering console. The FLIR model used was the M-324XP model, designed specifically for marine use. The camera's operating temperatures range from -25˚ C to +55˚ C. The FLIR camera has a focal length of 19 mm and a zoom of 2x. It is capable of detecting objects 1.8 meters high from a distance of 450 meters, as well as a small vessel 4.0 m X 1.5 m from a distance of 1.3 kilometers. It is also designed to withstand a 100 knot wind and has a radial view of 360˚. Some of the ship's infrastructure impedes approximately 20% of the view of the water, (primarily in an aft direction toward the guns) as a result of the camera's location, which is forward of the exhaust stacks.

The PSOs monitored the FLIR camera daily, averaging four hours per day for a total effort of 124 hours and 51 minutes. This included two hours each morning and two hours each evening, timed to coincide with visual monitoring efforts. One sighting of protected species occurred with FLIR—a faint sperm whale blow, which was also detected visually (detection #4) on 15 December 2011. The PSO who detected the blow said that they probably would not have detected it without seeing exactly where the whales were visually. FLIR monitoring efforts also yielded a few seabird detections, as well as a few OBSs. While the OBSs and seabirds were observed visually from hundreds of meters away, they were only captured on FLIR at distances less than 100 meters. During periods of rain or high winds with sea spray the monitor would become hazy and difficult to observe with.

3.2. ACOUSTIC MONITORING SURVEY METHODOLOGY

PAM was used to augment visual monitoring efforts, by helping 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 half hour.

Acoustic monitoring for marine mammals was conducted aurally with *Sennheiser* headphones and visually with *Pamguard Beta 1.9.01*. 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 1.9.01* via USB connection. The amplitude of clicks detected at the front hydrophone was measured at 5th order Butterworth band-pass filters ranging from 35 kilohertz to 120 kilohertz with a high pass digital pre-filter set at 35 kilohertz (Butterworth 2nd order). *Pamguard* 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 below can be found in Appendix D.

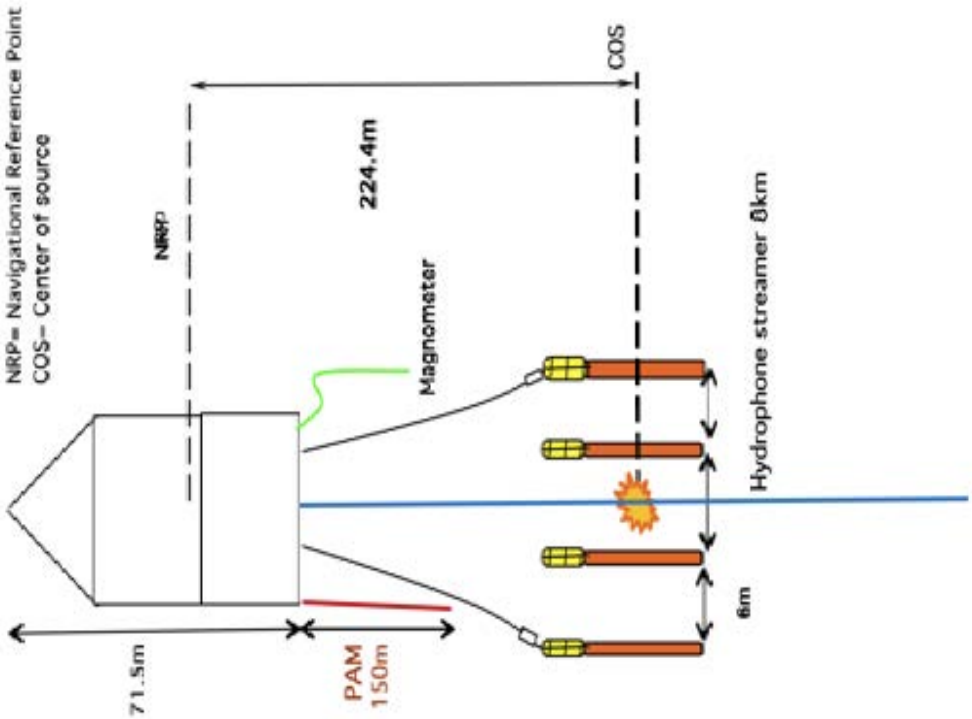


Figure 3. Location of the hydrophone deployment.

4. MONITORING EFFORT SUMMARY

4.1. SURVEY OPERATIONS SUMMARY

The *R/V Langseth* departed the port of Honolulu for the seismic survey site at 18:00 UTC on 26 November 2011. The deployment of OBSs began on 30 November 2011 as the *Langseth* reached the survey site. A total of 34 SP OBSs, 28 BB OBSs, and 8 MTs were deployed. The seismic gear was deployed and use of the acoustic source commenced at 02:52 UTC on 7 December 2011. Acquisition began on the first survey line began at 09:02 UTC on 7 December 2011. Table 2 outlines the dates and times of acquisition for each survey line.

Acquisition of survey lines was completed at 01:30 UTC on 18 December 2011. At this time the seismic gear was brought on board and OBS retrieval began. The OBS retrieval was finished on 25 December 2011 and the *Langseth* began the transit back to port arriving in Honolulu at 17:25 UTC on 29 December 2011.

Table 2. Gaherty marine geophysical survey multi-channel seismic and ocean-bottom seismometer survey lines acquired.

Survey Line	Date Acquisition Commenced	Time Acquisition Commenced	Date Acquisition Completed	Time Acquisition Completed
MGL1115test1 Seq001	07-Dec-2011	09:02	07-Dec-2011	09:16
MGL1115test2 Seq002	07-Dec-2011	09:16	07-Dec-2011	10:59
MGL1115-001 Seq003	07-Dec-2011	11:56	08-Dec-2011	17:15
MGL1115-002 Seq004	09-Dec-2011	14:01	09-Dec-2011	15:33
MGL1115-002A Seq005	09-Dec-2011	19:56	10-Dec-2011	23:09
MGL1115-02B Seq006	10-Dec-2011	23:11	13-Dec-2011	02:31
MGL1115-003 Seq007	13-Dec-2011	04:54	14-Dec-2011	02:47
MGL1115-003A Seq008	14-Dec-2011	05:37	14-Dec-2011	13:53
MGL1115-004 Seq009	14-Dec-2011	14:04	15-Dec-2011	02:19
MGL1115-004A Seq010	15-Dec-2011	05:19	15-Dec-2011	21:19
MGL1115-005 Seq011	15-Dec-2011	21:37	16-Dec-2011	06:22
MGL1115-006 Seq012	16-Dec-2011	06:27	17-Dec-2011	07:27
MGL1115-007 Seq13	17-Dec-2011	16:32	18-Dec-2011	01:30

The acoustic source was active throughout the survey, with a few periods of source silence, for a total of 244 hours and 23 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 active during mitigation power-downs initiated for protected species inside the safety radius as well as for mechanical/technical reasons for a total of 16 hours 26 minutes during the survey. Full power source operations accounted for 87% (211 hours 28 minutes) of airgun activity during the project. Line changes were often shot at full or partial power, totalling 12 hours 26 minutes of array activity. Additionally, the full volume of the acoustic source (36 airguns firing) ranged from 6420 in³ to 6600 in³, caused by various guns of different sizes being changed out on the arrays.

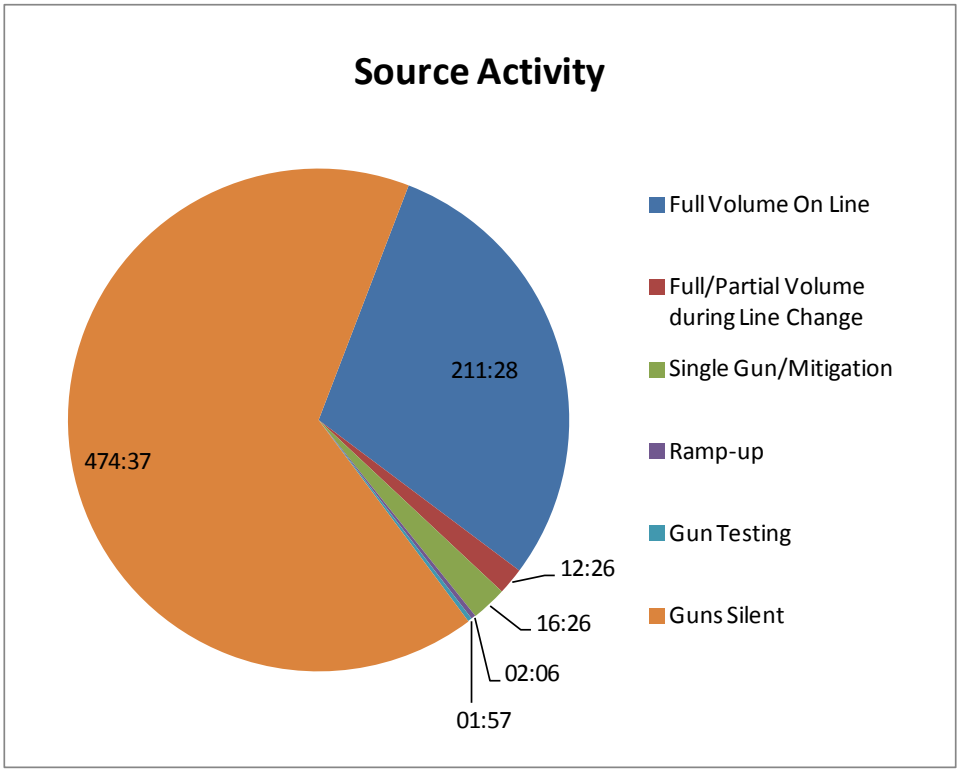


Figure 4. Total acoustic source operations.

The acoustic source was ramped up a total of four times over the course of the survey in order to commence full power survey operations in compliance with the IHA (Table 3). Each ramp-up was conducted over 30 to 33 minutes, where the NMFS approved automated gun controller program DigiShot added 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. Two ramp-ups were conducted during daylight hours during the Gaherty marine geophysical survey project and two ramp-ups were conducted at night. For the duration of both nighttime ramp ups the exclusion zone was monitored by one PSO in the bridge using FLIR and one PSO on the tower using a Night Quest NQ 2200 Night Vision Device. One daytime ramp-up was conducted from airgun silence during the survey. The remaining three ramp-ups were initiated with a mitigation source already active.

Table 3. Total acoustic source operations during Gaherty marine geophysical survey.

Acoustic Source Operations	Number	Duration (hh:mm)
Gun Tests		**1:57**
Ramp-up	**4**	**2:06**
Day time ramp-ups from silence	**1**	
Day time ramp-ups from mitigation	**3**	
Night time ramp-ups from mitigation	**2**	
Full power survey acquisition		**211:28**
Full/partial power line changes		**12:26**
Single airgun (40 in³)		**16:26**
Total time acoustic source was active		**244:23**

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 17:55 UTC on 26 November 2011 and continued until 04:12 UTC on 29 December 2011 when the vessel returned to Honolulu at the completion of the survey project. Visual monitoring was over a period of about 34 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 12 hours of visual observations per day. Visual observations were suspended from 18:30 UTC to 20:01 UTC on 27 November 2011 and from 00:00 UTC to 01:53 UTC on 28 November 2011 due to severe weather and several of the PSOs suffering from sea sickness.

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 not active during the majority of visual monitoring (29%) and was active for the majority of acoustic monitoring (99.8%), as shown in Figure 5. Once the survey began the acoustic source was only disabled twice while deploying and retrieving the hydrophone streamer.

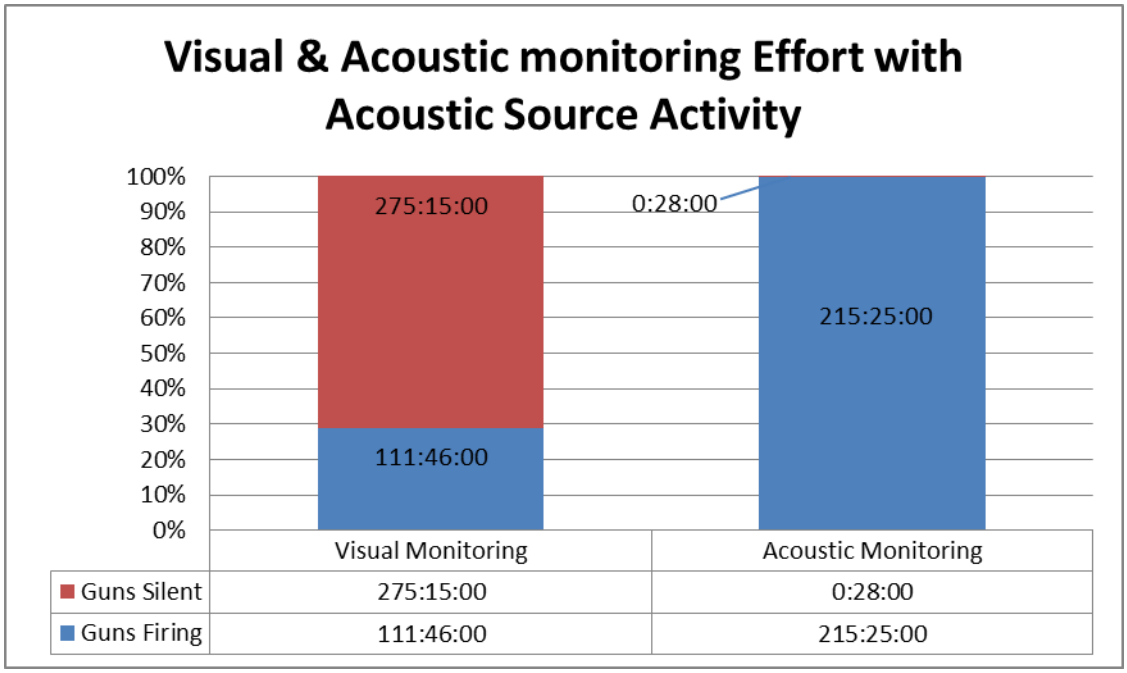


Figure 5. Duration of visual and acoustic monitoring effort while the acoustic source was active vs. silent.

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	**111:46**
Total monitoring while acoustic source silent	**275:15**
Total monitoring effort	**387:01**

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 71% of visual monitoring was conducted from the PSO tower during the Gaherty marine geophysical survey.

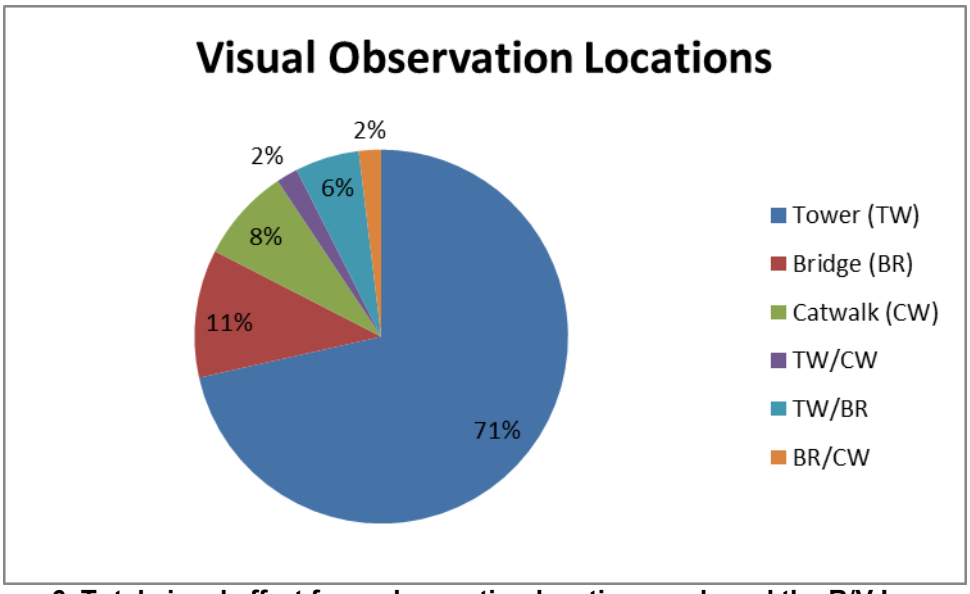


Figure 6. Total visual effort from observation locations on board the R/V Langseth.

4.3. ACOUSTIC MONITORING SURVEY SUMMARY

The hydrophone cable was deployed for the first time on 07 December 2011 after the vessel had completed deployment of the source arrays. Acoustic monitoring began immediately at 03:05 UTC and continued throughout the project with PSOs monitoring the hydrophones aurally and monitoring the *Pamguard* detection software visually both day and night. Acoustic monitoring for the project ended at 01:33 UTC on 18 December 2011 when acquisition of the final survey line was completed and the hydrophone cable was retrieved in preparation for the retrieval of the seismic equipment. Over the course of the project, PSOs conducted 215 hours and 53 minutes of acoustic monitoring, all but 28 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	**109:06**
Total day time monitoring	**106:47**
Total monitoring while acoustic source active	**215:25**
Total monitoring while acoustic source silent	**00:28**
Total acoustic monitoring	**215:53**

There were two periods of acoustic monitoring downtime (46 hours 35 minutes) throughout the project. The first acoustic monitoring downtime occurred when the cable was retrieved in order to deploy the seismic streamer once the acquisition of the first OBS line was completed. The second downtime occurred when the hydrophone cable was retrieved to prevent entanglement with the seismic equipment due to the current and direction of the swells, and remained on board while the seismic streamer was being retrieved. A description of all acoustic monitoring downtime is located in Appendix E.

Table 6. Passive acoustic monitoring (PAM) downtime.

Passive Acoustic Monitoring Downtime	Duration (hh:mm)
Seismic streamer deployment/retrieval	**27:38**
PAM cable entanglement	**18:57**
Total Passive Acoustic Monitoring Downtime	**46:35**

4.4. SIMULTANEOUS VISUAL AND ACOUSTIC MONITORING SUMMARY

While visual observations began on 26 November 2011 while acoustic observations began on 7 December 2011, 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 53% (387 hours 1 minute) while acoustic monitoring accounted for 30% (215 hours 53 minutes) and FLIR monitoring accounted for 17% (124 hours 51 minutes). As displayed in Figure 7 there were 106 hours 47 minutes of simultaneous visual and acoustic observations conducted during this survey. Simultaneous visual and acoustic monitoring accounted for 49% of total acoustic monitoring and 28% of the total visual observation.

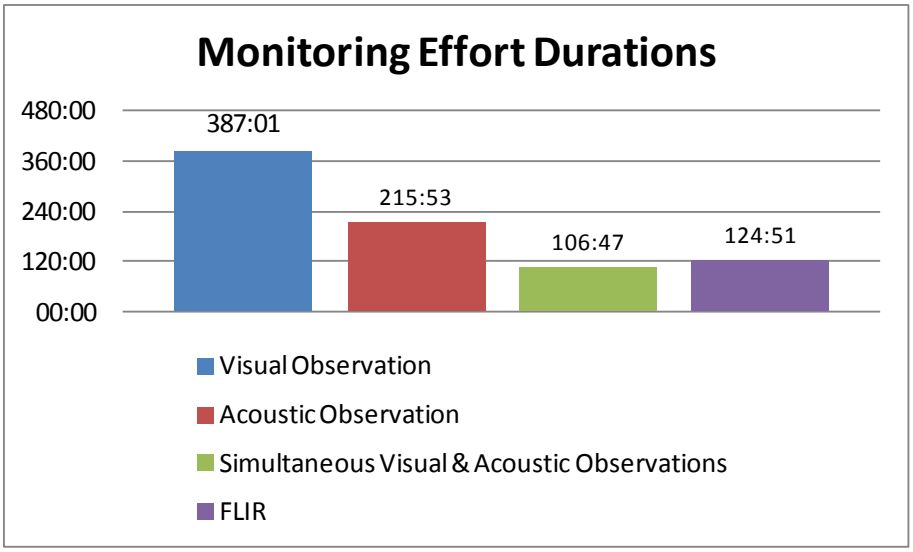
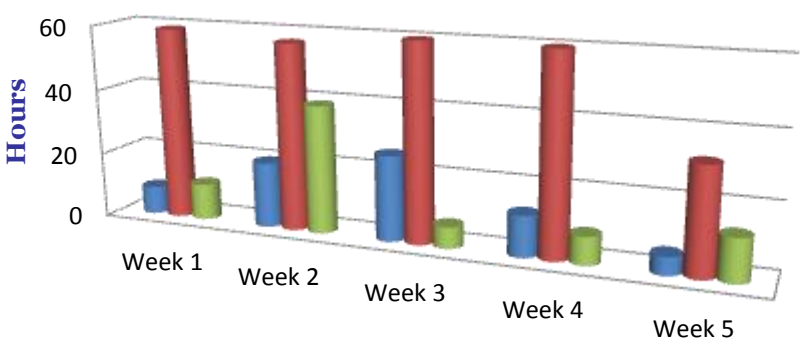


Figure 7. Total PAM, visual and FLIR monitoring effort.

4.5. ENVIRONMENTAL CONDITIONS

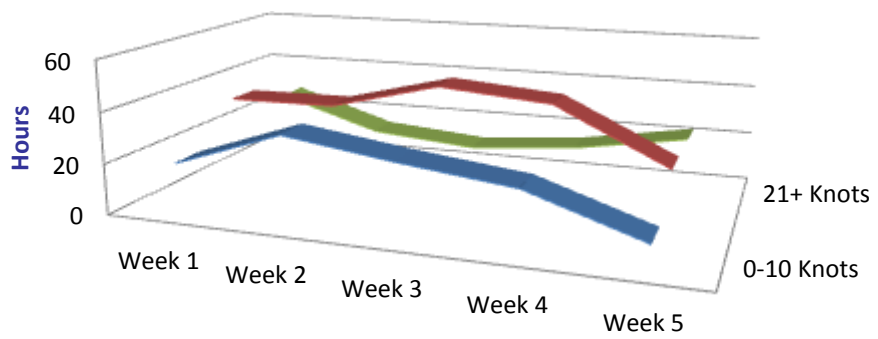
A majority of visual monitoring effort was conducted during average observations conditions with regular periods of high winds (greater than 21 knots) which often lasted hours or days at a time. There were no periods where visibility was obscured/hindered by precipitation and the safety radii were always visible. Visibility remained clear, 3 kilometers or more, for entirety of the cruise. The Beaufort Sea states ranged from levels 1 through 6 but generally remained between a level 3 and level 5. Calmer weather was present for the end of the cruise and ended with winds under 10 knots and a Beaufort Sea state level 2 (Figure 8).



	Week 1	Week 2	Week 3	Week 4	Week 5
Level 0-2	8.5	20	26	12.5	5.5
Level 3-5	59	57	60	60	32
Level 6+	11	39	6.5	8.5	13

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

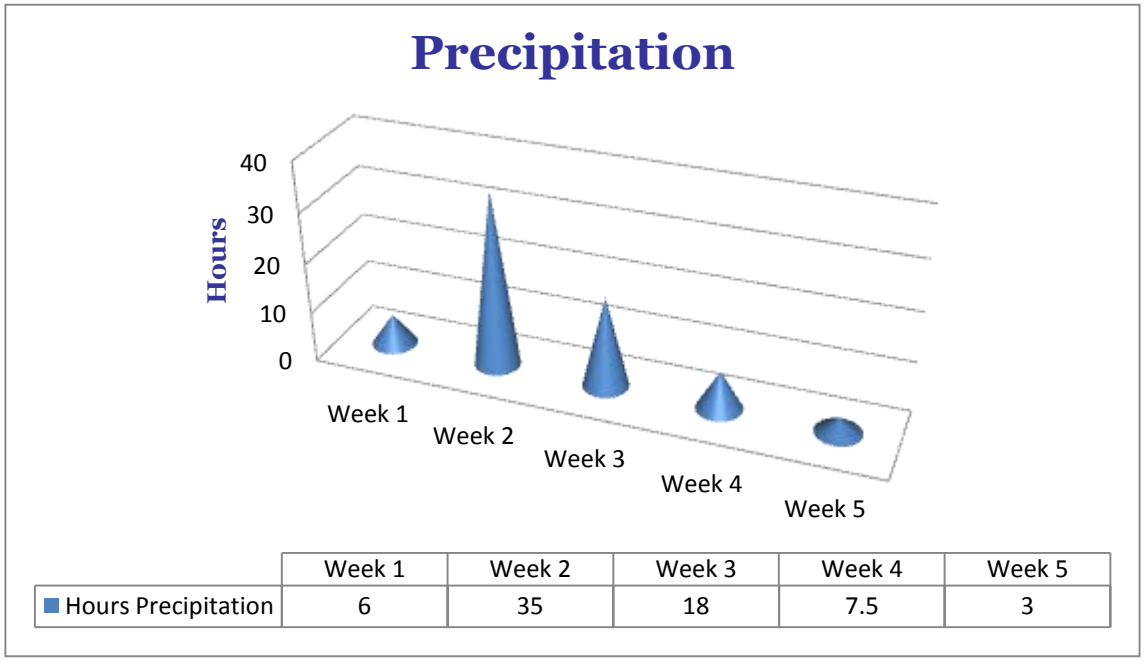
Wind forces remained relatively strong throughout the cruise with a minimum of less than 1 knot to a maximum of 41 knots during transit through the first week. Forces from 10-20 knots were the average during the cruise totaling 182 hours. Weeks 4 and 5 brought higher winds bringing the total hours of wind forces greater than 20 knots to 90.5 hours (Figure 9).



	Week 1	Week 2	Week 3	Week 4	Week 5
0-10 Knots	19	34	28	23	8.5
11-20 Knots	35	35.5	46.5	43	22
21+ Knots	27.5	14.5	11	15	22.5

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

Periods of light to heavy rain were intermittent throughout the cruise but did not often affect observations aside from a location change to the bridge. A total of 69.5 hours of precipitation was recorded (Figure 10).



	Week 1	Week 2	Week 3	Week 4	Week 5
Hours Precipitation	6	35	18	7.5	3

Figure 10. Duration of precipitation while visual monitoring was conducted.

5. MONITORING AND DETECTION RESULTS

5.1. VISUAL DETECTIONS

Visual monitoring conducted during the Gaherty marine geophysical survey resulted in the collection of seven records of detection for protected species (summarized in Appendix F and Appendix G). One species of marine mammal was positively identified, along with unidentified dolphins, three unidentified whales, and two unidentified shelled sea turtles. The total number of detection events and total number of animals recorded by species is described in Table 7.

A complete list of bird species 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 H.

Table 7. Number of visual detection records collected for each protected species.

	Total Number of Detection Records	Total Number of Animals Recorded
Cetaceans		
Unidentifiable whale	3	4
Odontocetes		
Sperm whale	1	4
Unidentifiable dolphin	1	3
Sea Turtles		
Unidentifiable shelled sea turtle	2	2
TOTAL	**7**	**13**

There were few sightings of protected species during the Gaherty survey and it was common to go multiple days with no detections of protected species (Figure 11).

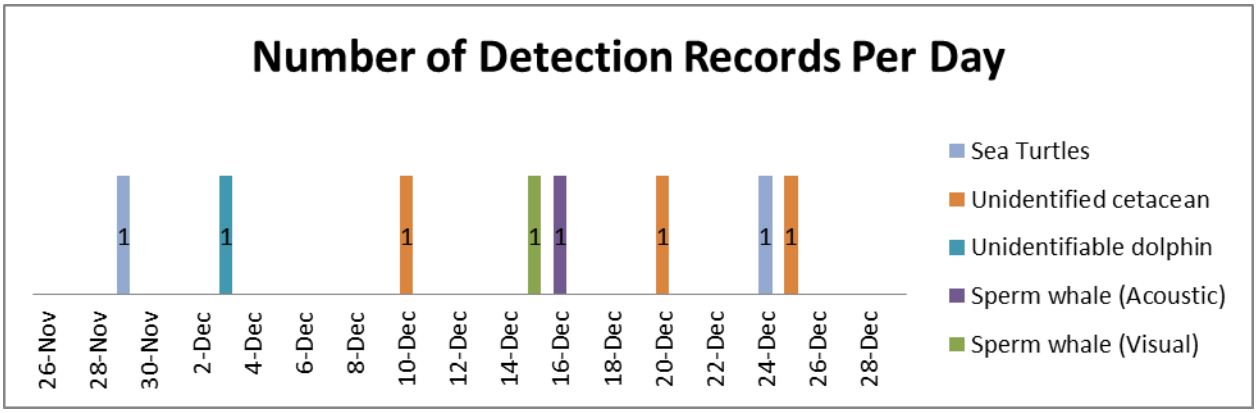


Figure 11. Number of protected species detections each day of the Gaherty marine geophysical survey.

Of the seven protected species detection events during the Gaherty marine geophysical survey, two detections (29%) occurred while the acoustic source was active and five detections (71%) occurred while the acoustic source was silent. Figure 12 demonstrates the species detected compared to airgun activity.

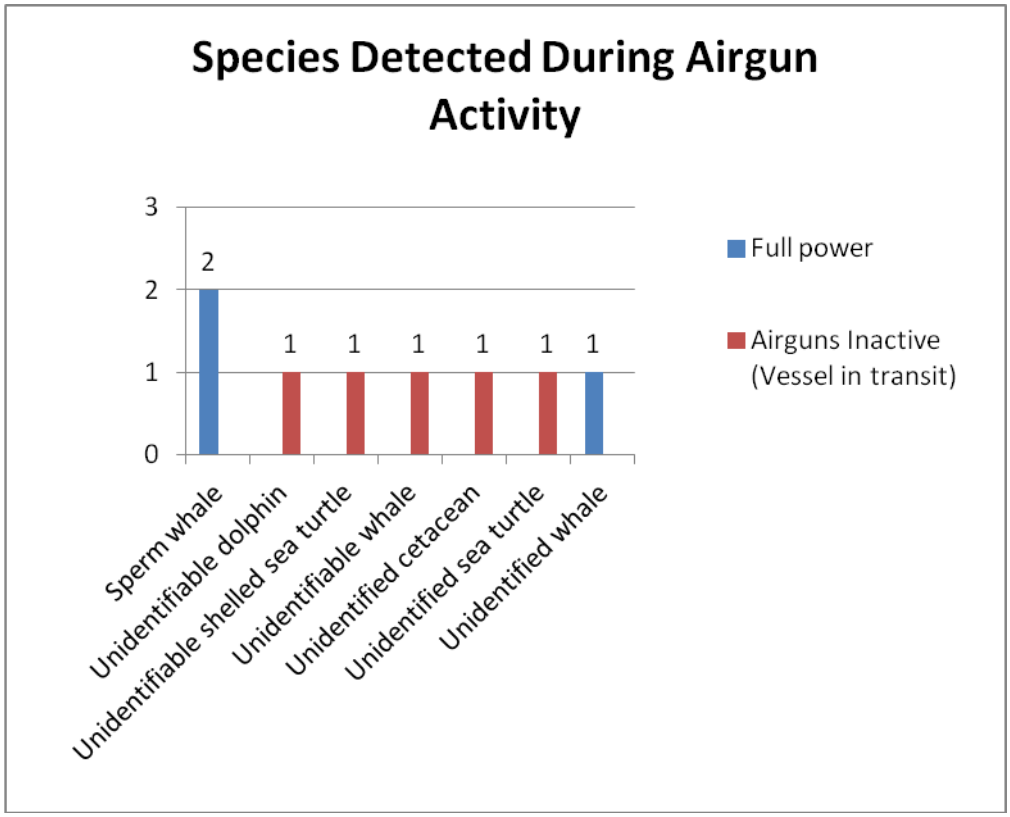


Figure 12. Species detected compared to airgun activity.

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 (6420-6600 in³)		Single Airgun 40 in³		Ramp-up / Other Reduced Volume		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)
Sperm whale	1	800	0	-	0	-	0	-
Unidentified whale	1	3031	0	-	0	-	2	1045
Unidentified dolphin	0	-	0	-	0	-	1	250
Unidentified sea turtle	0	-	0	-	0	-	2	100

Cetaceans were detected most frequently, consisting of 75% (6 detection records) of the total records. Figure 13 demonstrates the total number of animals observed, per species, during the detection events. Sperm whales were the most abundant positively identified protected species accounting for one visual detection of four animals and one acoustic detection of one animal.

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

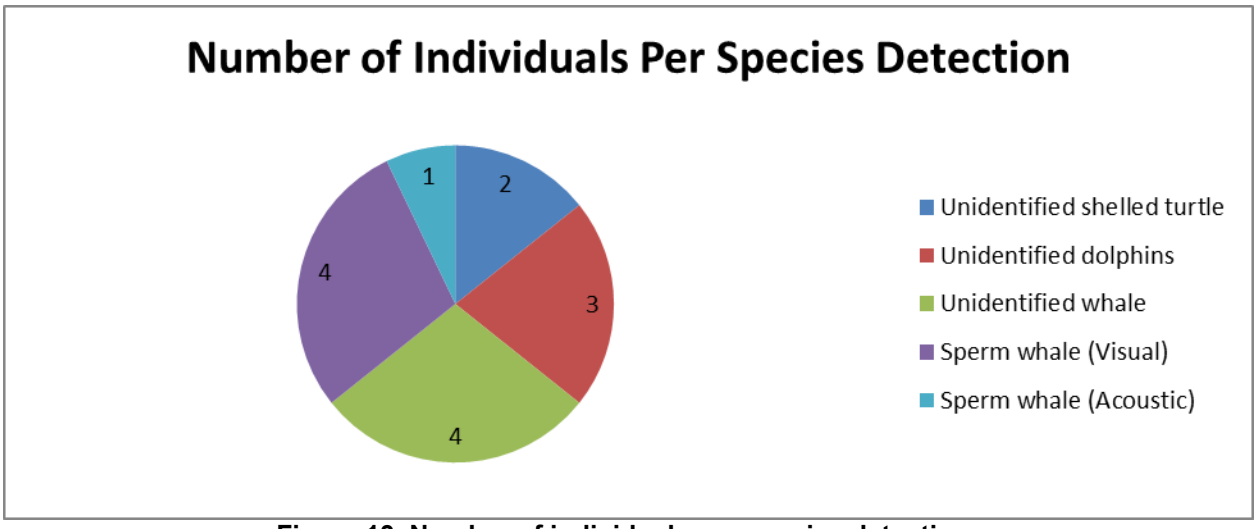


Figure 13. Number of individuals per species detection.

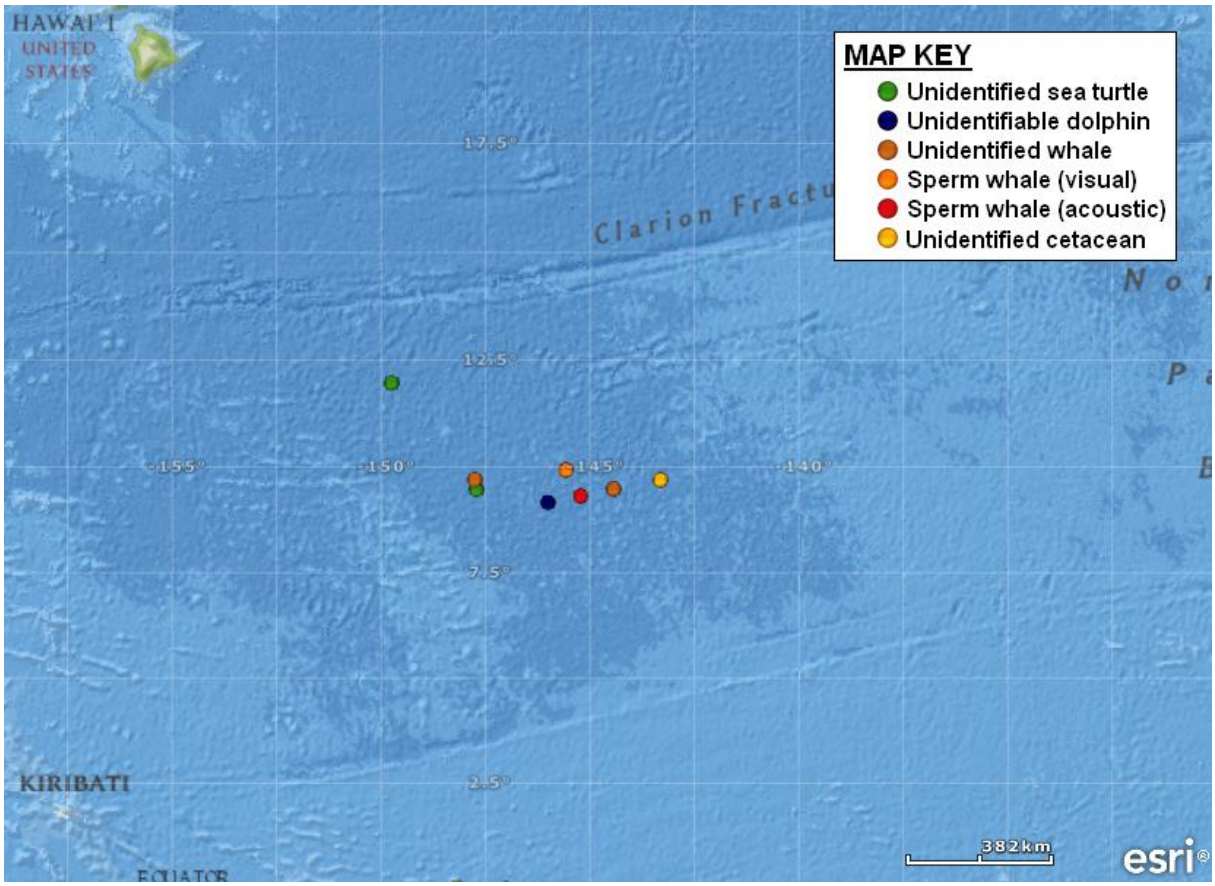


Figure 14. Marine mammal spatial distribution of detections from 26 November 2011- 29 December 2011 on board the *Langseth*.

5.1.1. Cetacean Detections

5.1.1.1. Sperm whale

On 15 December 2011 at 2:16 – 2:42 UTC, four whales were travelling in a southeasterly direction approximately 1600 meters ahead of the ship's bow moving perpendicular to the vessel. They were spread out across an area of approximately 3.5 km. The animal in the lead was very large, relative to the others and was approximately 20 meters in length. The two animals bringing up the rear were very close together and included one small juvenile. At 02:29, one of the animals fluked and dove while the others continued to move southeasterly. The juvenile was last seen blowing bubbles at the surface at 2:42 with a red-footed booby flying circles above it. The vessel had been at full power on a survey line and the mitigation action of a power down was implemented as the mammals entered the safety radii at 2:19. After the final sighting at 2:42 a period of 30 minutes was ensured of the safety radii being clear of the mammals before the implementation of a ramp up from the mitigation sound source; this resulted in a total mitigation period of 1 hour and 13 minutes before regaining full volume.

5.1.1.2. Unidentified dolphin

On 3 December 2011 at 12:08 UTC unidentified dolphins were seen during an OBS deployment by the crewmembers involved in the operation. The three dolphins were briefly porpoising before disappearing. The crewmembers that had the sighting did not notify the PSOs on duty while the mammals were present; therefore little information was noted about this sighting.

5.1.1.3. Unidentified whale

On 10 December 2011 two unidentifiable whales were detected ~3030 meters off the starboard side of the vessel. The low diffuse blows observed were ~2 meters high, at intervals of approximately 1 blow per minute. The whales made a shallow dive and were observed ~10 minutes later 4 km from the vessel, for a total of five blows observed over a period of 14 minutes. The whales moved at a moderate pace, in a parallel and opposite direction of travel of the vessel. A tall, non-falcate dorsal fin located 2/3 of the way down the body was observed while whales dived. The vessel was on a survey line at full power during this sighting, but due to the great distance of the whales' location no mitigation was required.

On 20 December 2011 at 18:34 UTC an unidentified whale was detected over 1 km off the starboard bow. A single, diffuse, conical shaped blow was seen momentarily with no direction of dispersal observed. The vessel was not in production during this sighting and therefore no mitigation action was necessary.

On 25 December 2011 at 2:04 UTC a short diffused blow was seen approximately 1000 meters off the starboard bow. Blows were then noted to be spaced out every 3-6 minutes observed from 2:04 to 2:22. The whale was sighted again from 3:00 to 3:26. The single blows seen were infrequent, sometimes faint, and continued at 3-7 minute intervals. The body of this animal was not seen. The seas during the sighting were choppy, with the wind is blowing at 20 knots, and these factors limited the sighting conditions. The vessel was operating in maneuvering turns and therefore the mammal's direction of travel was unknown and appeared quite varied. The sound source was not active for this sighting, resulting in no mitigation actions needed.

5.1.2. Sea Turtle Detections

5.1.2.1. Unidentified sea turtle

On 29 November 2011 at 18:31 UTC a brief sighting of an unidentified sea turtle occurred. The turtle was in sight for a minute at a distance of 100 meters off the vessel. During this time an olive green carapace of approximately 70 cm was the only part of the body seen, as the turtle did not lift its head above the surface. The turtle was swimming quickly just below the water's surface, parallel and in the opposite direction of travel of the vessel. The sound source was not active during this sighting and therefore no mitigation action was necessary.

On 24 December 2011 at 22:20 UTC an unidentified sea turtle was observed incidentally by a crewmember on the vessel quickly swimming away from the vessel. At a distance of 15 meters from the vessel the crewmember noted a brownish green carapace, flippers roughly the same color as the carapace, though the head was not observed. The sound source was not active during this sighting.

5.2. ACOUSTIC DETECTIONS

There was one acoustic detection on the PAM system during the Gaherty survey. On 16 December 2011 at 04:42 UTC a sperm whale was detected aurally and visually on the *Pamguard* low frequency spectrogram and click detector producing broadband echolocation clicks. The clicks could not be localized due to the brevity of the detection (See Figure 15 for a screenshot of the detection).

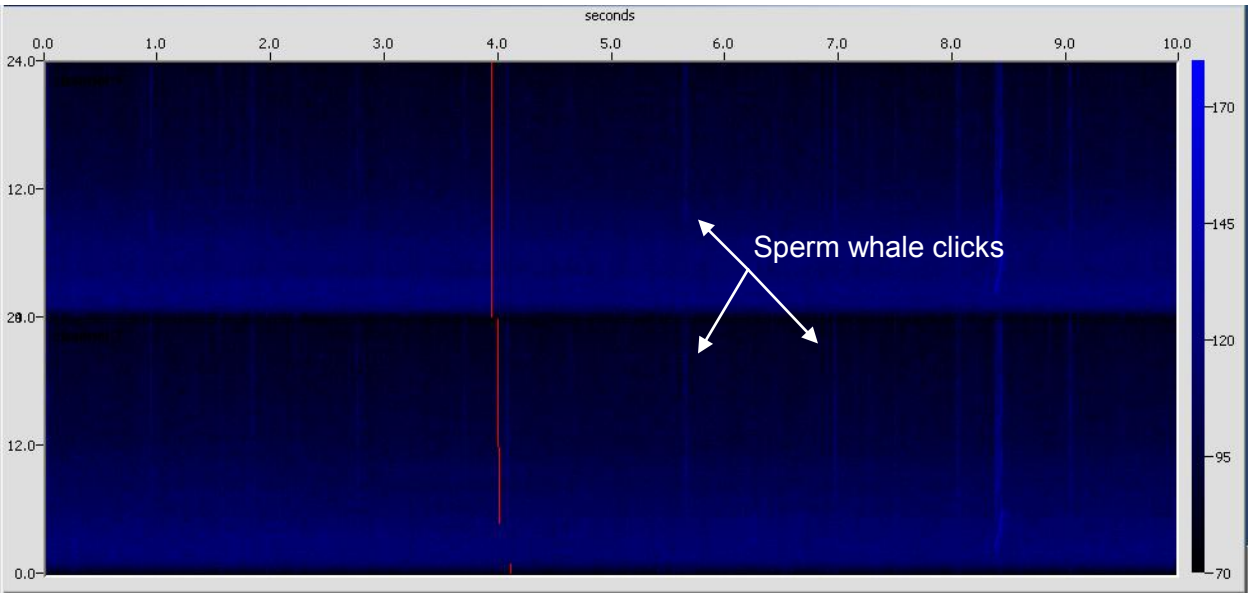


Figure 15. Spectrogram from LF *Pamguard* showing sperm whale clicks from acoustic detection #1 on 16 December.

6. MITIGATION ACTION SUMMARY

There was one mitigation action implemented during the Gaherty marine geophysical survey. It constituted of a power-down of the acoustic source for protected species inside the 180 dB safety radii. No shut-downs or delays to ramp-up were required or implemented. Mitigation actions caused a total duration of downtime of 1 hour 13 minutes during the survey. The number and duration of mitigation actions is summarized in Table 9.

Table 9. Number and duration of mitigation actions implemented during the Gaherty marine geophysical survey.

Mitigation Action	Cetaceans	
	Number	Duration
Delayed Ramp-up	0	0:00
Power-down	1	1:13
Shut-down	0	0:00
Total	**1**	**1:13**

On 15 December four sperm whales were observed traveling in front of the vessel. The animals were very spread out the first was a large adult followed by a mother-calf pair and ending with a smaller adult. The mother-calf pair entered the 180 dB safety radius resulting in a power down of the acoustic source. Just as they were observed leaving the safety radius the smaller adult whale entered the safety radius and fluked. Because this whale was last seen within the safety radius 30 minutes passed before a ramp up was conducted. This was the only mitigation action implemented during the Gaherty survey and accounts for 100% of mitigation downtime (Table 10).

Table 10. Power-downs and downtime duration by species.

Species	Number of Power-downs	Duration of Downtime	Percentage of Mitigation Downtime
Sperm whale	1	1:13	**100%**

Each mitigation action that was implemented during the survey is summarized in Table 11.

Table 11. Summary of each mitigation action implemented during the Gaherty marine geophysical survey.

Date	Visual Detection Number	Species	Group Size	Source Activity (initial detection)	Closest Approach to Firing Source/Power Level	Mitigation Action	Total Duration of Mitigation Event
15-Dec	4	Sperm whale	4	Firing full power	800m / 40 in³	Power down	1:13

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

NMFS granted an IHA to L-DEO for a marine seismic survey allowing Level B harassment takes (exposure to 160 dB received sound) for 18 marine mammal species: two mysticetes and 16 odontocete species. Direct visual observations recorded by PSOs of one 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 or 180 dB and 160 dB.

During the Gaherty marine geophysical survey four sperm whales and two unidentified whales were observed within the 160 dB predicted distances where Level B harassment is expected to occur while the acoustic source was active (Table 12).

Table 12. Level B Harassment Takes authorized by NMFS IHA for the Gaherty marine geophysical and number of known individuals exposed to 160 dB and 180 dB through visual observations.

Species	IHA Authorized Takes	Number of animals exposed to 180 dB	Number of animals exposed to 160 dB
Mysticetes			
Bryde's whale	8	0	0
Blue whale	2	0	0
Odontocetes			
Sperm whale	41	2	4
Dwarf sperm whale	105	0	0
Cuvier's beaked whale	91	0	0
Longman's beaked whale	14	0	0
Mesoplodon spp.	5	0	0
Rough-toothed dolphin	17	0	0
Bottlenose dolphin	68	0	0
Pantropical spotted dolphin	1,651	0	0
Spinner dolphin	2,516	0	0
Striped dolphin	226	0	0
Fraser's dolphin	182	0	0
Risso's dolphin	14	0	0
Melon-headed whale	101	0	0
False killer whale	9	0	0
Killer whale	5	0	0
Short-finned pilot whale	69	0	0
Cetaceans			
Unidentified whale	N/A	0	2

These numbers are likely to be an underestimate and provide the absolute minimum number of animals actually exposed. 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 13 describes the behavior of all animals, including unidentified species, which were exposed to 160 dB for the duration they were observed.

Table 13. Behavior of species exposed to 160 dB.

Species	Detection No.	No. of Animals	Initial behavior	Initial direction in relation to vessel	Final behavior	Final direction in relation to vessel
Unidentified whale	3	2	Blowing	Parallel, opposite direction	Diving	Parallel, opposite driection
Sperm whale	4	4	Blowing	Perpendicular, ahead of vessel	Blowing/ Diving	Away from vessel

6.1.1. Unidentified Whale

On 10 December 2011, two unidentifiable whales were observed 3031m off the starboard side of the vessel while the acoustic source was firing full power (6,600 in³). Both whales were exposed to noise levels greater than 160 dB and no mitigation actions were necessary. The whales did not change course over the duration of the detection and were last seen diving.

6.1.2. Sperm Whale

Sperm whales were the only positively identified protected species exposed to noise levels constituting Level-B harassment during the Gaherty marine geophysical survey. One detection event of sperm whales totalling a minimum of four animals was observed within the 160 dB safety radius while the acoustic source was active. Only two of these whales were also exposed to received sound levels of greater than 180 dB from the acoustic source, resulting in the implementation of a mitigation power-down.

On 15 December four sperm whales were observed passing off the vessel's starboard bow, the first passing outside of the 180 dB safety radius. Following were a mother/calf pair that entered within the 180 dB safety radius, approximately 900m from the acoustic source while it was firing full power (6,600 in³), resulting in a power down of the acoustic source. As the mother/calf pair was observed leaving the safety radius the last whale of the group entered the safety radius after the acoustic source had already been powered down. This whale fluked while inside the safety radius, necessitating a 30 minute waiting period before ramping up to resume production.

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

In order to minimize the Level-B incidental taking of marine mammals and sea turtles during the Gaherty marine geophysical survey, mitigation measures were implemented whenever these protected species were seen near or within the safety radii designated in the IHA. Very few mitigation acions were necessary during this survey with only one power down occurring that was implemented for sperm whales within the 180 dB safety radius.

7. ACKNOWLEDGEMENTS

The Protected Species Observers on board Langseth during the Gaherty marine geophysical survey in the central Pacific Ocean would like to thank the National Science Foundation, Lamont-Doherty Earth Observatory, and Woods Hole Oceanographic Institiute for the opportunity to work on this project. It was a pleasure to work with Drs. Jim Gaherty and Dan Lizzeralde, 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 and Olivia Lee 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 for reviewing this report.

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

8. LITERATURE CITED

LGL Ltd., Environmental Research Associates, 2011. “Environmental Assessment of a Marine Geophysical Survey by the R/V Marcus G. Langseth in the Central-Western Bering Sea, August 2011”.

APPENDIX A: **Incidental Harassment Authorization for the Gaherty marine geophysical survey**

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

NOV 23 2011

Meagan J. Cummings / Jeff Rupert
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 seismic survey in the central Pacific Ocean during November, 2011 through January, 2012.

You are required to comply with the conditions contained in the IHA. In addition, you must cooperate with any Federal, state, or local agency monitoring the impacts of your activity and 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 Jeannine Cody, Office of Protected Resources, NMFS, at 301-427-8415.

Sincerely,

for James H. Lecky
Director
Office of Protected Resources

Enclosures

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

DEPARTMENT OF COMMERCE

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

NATIONAL MARINE FISHERIES SERVICE

Incidental Harassment Authorization

The Lamont-Doherty Earth Observatory (L-DEO), Columbia University, P.O. Box 1000, 61 Route 9W, Palisades, New York 10964-8000, is hereby authorized under section 101(a)(5)(D) of the Marine Mammal Protection Act (MMPA) (16 U.S.C. 1371(a)(5)(D)) and 50 CFR 216.107, to harass small numbers of marine mammals incidental to a marine geophysical survey conducted by the R/V *Marcus G. Langseth* (*Langseth*) in the central Pacific Ocean, November, 2011 through January, 2012.

1. This Authorization is valid from November 26, 2011 through January 19, 2012.

2. This Authorization is valid only for specified activities associated with the R/V *Marcus G. Langseth*'s (*Langseth*) seismic operations as specified in L-DEO's Incidental Harassment Authorization (IHA) application and environmental analysis in the following specified geographic area:

   (a) In the central Pacific Ocean in international waters, bounded by 7-12°N and 148-142°W.

3. Species Authorized and Level of Takes

   (a) The incidental taking of marine mammals, by Level B harassment only, is limited to the following species in international waters in the central Pacific Ocean:

   (i) Mysticetes – see Table 2 (attached) for authorized species and take numbers.

   (ii) Odontocetes – see Table 2 (attached) for authorized species and take numbers.

   (iii) If any marine mammal species are encountered during seismic activities that are not listed in Table 2 (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.

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(c) The methods authorized for taking by Level B harassment is limited to the following acoustic sources without an amendment to this Authorization:

(i) an 36-airgun array that may range in size from 40 to 360 cubic inches (in^3) with a total volume of approximately 6,600 cubic inches (in^3) as an energy source;

(ii) a multi-beam echosounder;

(iii) a sub-bottom profiler; and

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

4. 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.

5. The Holder of this Authorization is required to cooperate with NMFS and any other Federal, state or local agency monitoring the impacts of the activity on marine mammals.

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 adverse 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 will be on watch) to visually watch for and monitor marine mammals near the seismic source vessel during daytime airgun operations (from civil twilight-dawn to civil twilight-dusk) and before and during start-ups of airguns day or night. The *Langseth*'s vessel crew will also assist in detecting marine mammals, when practicable. PSVOs will have access to reticle binoculars (7x50 Fujinon), big-eye binoculars (25x150), and night vision devices. PSVO shifts will last no longer than 4 hours at a time. PSVOs will also make observations during daytime periods when the seismic system is not operating for comparison of animal abundance and behavior, when feasible.

(b) PSVOs will conduct monitoring while the airgun array and streamers 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), sea state, visibility, and sun glare; and

(iii) the data listed under 6(c)(ii) will 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 PSVO and/or bioacoustician will monitor the PAM at all times in shifts no longer than 6 hours. A 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 PSVO immediately 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.

(f) Visually observe the entire extent of the exclusion zone (180 dB for cetaceans; see Table 1 [attached] for distances) using NMFS-qualified PSVOs, for at least 30 minutes prior to starting the airgun (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 observer 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 (min) (i.e., rough seas, fog, darkness), or if marine mammals are near, approaching, or in the exclusion zone, the airguns may not be started up. If one airgun is already running at a source level of at least 180 dB, L-DEO may start the second gun without

observing the entire exclusion zone for 30 min 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 exclusion zone for marine mammals before the 36-airgun array (6,600 in^3) is in operation; and a 180-dB exclusion zone before a single airgun (40 in^3) is in operation, respectively. See Table 1 (attached) for distances and safety radii.

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

(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 power-down or shut-down, will 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. 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 outside of 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 will 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 min for species with shorter dive durations (small odontocetes) or 30 min for species with longer dive durations (mysticetes and large odontocetes, including sperm, pygmy sperm, dwarf sperm, killer, and beaked whales).

(l) Following a power-down or shut-down and subsequent animal departure, airgun operations may resume following ramp-up procedures described in 6(h).

(m) Marine geophysical 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 PSVOs on duty.

(o) To the maximum extent practicable, schedule seismic operations (i.e., shooting airguns) during daylight hours.

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 central Pacific ocean cruise. 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) 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) and/or 180 dB re 1 μPa (rms) 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 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 will 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 will be considered to be the final report.

8. Reporting Prohibited Take

In the unanticipated event that the specified activity clearly causes the take of a marine mammal in a manner prohibited by the IHA (if issued), 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 Michael.Payne@noaa.gov and ITP.Cody@noaa.gov and the Pacific Islands Regional Stranding Coordinator at 808-944-2269 (David.Schofield@noaa.gov).

The report must include the following information:

- Time, date, and location (latitude/longitude) of the incident;
- Name and type of vessel involved;
- 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 all marine mammal observations in the 24 hours preceding the incident;
- Species identification or description of the animal(s) involved;
- Fate of the animal(s); and
- Photographs or video footage of the animal(s) (if equipment is available).

Activities will not resume until NMFS is able to review the circumstances of the prohibited take. NMFS will 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.

9. Reporting an Injured or Dead Marine Mammal with an Unknown Cause of Death

In the event that L-DEO discovers an injured or dead marine mammal, and the lead PSVO 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 Michael.Payne@noaa.gov and ITP.Cody@noaa.gov and the Pacific Islands Regional Stranding Coordinator at 808-944-2269 (David.Schofield@noaa.gov).

The report must include the same information identified in the paragraph 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.

10. Reporting an Injured or Dead Marine Mammal not Related to L-DEO Activities

In the event that L-DEO discovers an injured or dead marine mammal, and the lead PSVO determines that the injury or death is not associated with or related to the activities authorized in the IHA (e.g., previously wounded animal, carcass with moderate to advanced decomposition, or scavenger damage), L-DEO will 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 Michael.Payne@noaa.gov and ITP.Cody@noaa.gov and the Pacific Islands Regional Stranding Coordinator at 808-944-2269 (David.Schofield@noaa.gov), within 24 hours of the discovery. L-DEO will provide photographs or video footage (if available) or other documentation of the stranded animal sighting to NMFS.

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

12. A copy of this Authorization and the ITS must be in the possession of all contractors and protected species observers operating under the authority of this Incidental Harassment Authorization.

for _____ 11/23/11

James H. Lecky

Date

Director
Office of Protected Resources
National Marine Fisheries Service

Attachments

Attachment

Table 1. Exclusion Zone Radii for Triggering Mitigation.

Source and Volume	Water Depth	Predicted RMS Distances (m)	
		160 dB	180 dB
Single Bolt airgun (40 in^3)	Deep (> 1,000 m)	385	40
36-Airgun Array		3,850	940

Table 2. Authorized Take Numbers for Each Marine Mammal Species in the Central Pacific Ocean Survey Area.

Species	Authorized Take
Bryde's whale (*Balaenoptera brydei*)	8
Blue whale (*Balaenoptera musculus*)	2
Sperm whale (*Physeter macrocephalus*)	41
Dwarf sperm whale (*Kogia sima*)	105
Cuvier's beaked whale (*Ziphius cavirostris*)	91
Longman's beaked whale (*Indopacetus pacificus*)	14
Mesoplodon spp. Includes unidentified, ginkgo-toothed and Blainville's beaked whales.	5
Rough-toothed dolphin (*Steno bredanensis*)	17
Bottlenose dolphin (*Tursiops truncatus*)	68
Pantropical spotted dolphin (*Stenella attenuata*)	1,651
Spinner dolphin (*Stenella longirostris*)	2,516
Striped dolphin (*Stenella coeruleoalba*)	226
Fraser's dolphin (*Lagenodelphis hosei*)	182
Risso's dolphin (*Grampus griseus*)	14
Melon-headed whale (*Peponocephala electra*)	101
False killer whale (*Pseudorca crassidens*)	9
Killer whale (*Orcinus orca*)	5
Short-finned pilot whale (*Globicephala macrorhynchus*)	69

* The Incidental Take Statement does not authorize take for humpback, sei, or fin whales.

APPENDIX B: Basic Summary Data Form

BASIC DATA FORM		
LDEO Project Number		MGL1115
Seismic Contractor		Lamont-Doherty Earth Observatory of Columbia University
Area Surveyed During Reporting Period		Central Pacific Ocean
		Approximately between 7 to 12°N and 148 to 142°W
Survey Type		2D marine seismic
Vessel and/or Rig Name		*R/V Marcus G. Langseth*
Permit Number		IHA granted by NMFS on 23 November 2011
Location / Distance of Airgun Deployment		181m astern of vessel
Water Depth	**Min**	~4500m
	Max	~5500m
Dates of project		26 November 2011 THROUGH 29 December 2011
Total time airguns operating – all power levels:		244 hours 23 minutes
Time airguns operating at full power on survey lines:		211 hours 28 minutes
Time airguns operating at full/partial power on line changes:		12 hours 26 minutes
Amount of time mitigation gun (40 in³) operations:		16 hours 26 minutes
Amount of time in ramp-up:		2 hours 06 minutes
Number daytime ramp-ups:		2
Number of night time ramp-ups:		2
Number of ramp-ups from mitigation source:		3
Amount of time conducted in airgun testing:		1 hour 57 minutes
Duration of visual observations:		387 hours 1 minute
Duration of observations while airguns firing:		111 hours 46 minutes
Duration of observation during airgun silence:		275 hours 15 minutes
Duration of acoustic monitoring:		215 hours 53 minutes
Duration of acoustic monitoring while airguns firing:		215 hours 25 minutes
Duration of acoustic monitoring during airgun silence:		28 minutes
Duration of simultaneous acoustic and visual monitoring:		106 hours 47 minutes
Duration of FLIR monitoring:		124 hours 51 minutes
Lead Protected Species Observer:		Heidi Ingram
Protected Species Observers:		Dara Cameron
		Amanda Harrison
		Meghan Piercy
Acoustic Observer:		Emily Ellis
Number of Marine Mammals Visually Detected:		5
Number of Marine Mammals Acoustically Detected:		1
Number of Marine Mammals Detected by FLIR:		1
Number of acoustic detections confirmed by visual sighting:		0
Number of visual sighting confirmed by acoustic detection:		0
Number of Sea Turtles detected:		2
List Mitigation Actions (eg. Power-downs, shut-downs, ramp-up delays)		1 power down (15 Dec)
Duration of operational downtime due to mitigation:		1 hour 13 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.

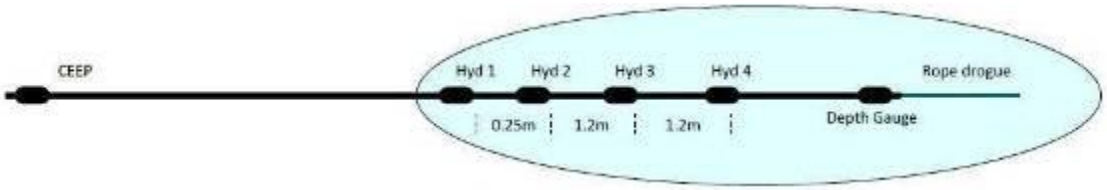

Figure D.16: Diagram of Linear Hydrophone Array.

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

Passive Acoustic Monitoring Downtime

Date	Monitoring Suspended	Date	Monitoring Resumed	Duration acoustic monitoring suspended	Comments
2011-12-08	16:26	2011-12-09	11:56	19:30	Hydrophone cable retrieved before gun arrays to deploy streamer.
2011-12-16	12:30	2011-12-17	15:35	27:05	Hydrophone cable retrieved to avoid entanglement with gun arrays 3 & 4 and for retrieval of streamer for acquisition of OBS line.

APPENDIX F: Summary of visual detections of protected species during the Gaherty marine geophysical survey.

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position	Source Activity Initial Detection	Movement/ Behaviour		CPA Source / Source Activity	Mitigation Action	Comments
1	29-Nov	18:31	Unidentified shelled sea turtle	1	11.97250°N 149.75068°W	Not Firing	PV/OD	SB	100m Not Firing	None	Observed while in transit to survey site.
2	3-Dec	22:08	Unidentified dolphin	3	09.16185°N 146.00463°W	Not Firing	UN	PO	Unknown Not Firing	None	Observed by OBS crew.
3	10-Dec	21:53	Unidentified whale	2	09.47800°N 144.42970°W	Firing full power	PV/OD	SB DV	3031m Full power	None	Whales exposed to 160 dB of received sound.
4	15-Dec	02:16	Sperm whale	4	09.92885°N 145.56913°W	Firing full power	PE/AH	SB DF	800m / Mitigation firing	Power down	All four whales exposed to 160 dB of received sound. Two whales exposed to 180 dB of received sound. One faint blow detected on FLIR.
5	20-Dec	18:34	Unidentified whale	1	09.69717°N 143.31742°W	Not Firing	UN	SB	1089m Not firing	None	Acoustic source on board.
6	24-Dec	22:20	Unidentified shelled sea turtle	1	09.47483°N 147.72148°W	Not Firing	PV/OD	NS	100m Not firing	None	Acoustic source on board.
7	25-Dec	2:04	Unidentified whale	1	09.70580°N 147.75683°W	Not Firing	UN	SB	1000m Not Firing	None	Acoustic source on board.

APPENDIX G: Summary of acoustic detections of protected species during the Gaherty 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-Dec	04:42	Sperm whale	1	09.32018°N 145.21990°W	Firing full power	Echolocation clicks	Unknown / Full power	None	

APPENDIX H: Species of birds observed during the Gaherty marine geophysical survey

Common Name	Family	Genus	Species	Approximate Number of Individuals Observed	Approximate Number of Days Species Was Observed
Masked booby	Pelecaniformidae	Sula	dactylatra	3	3
Red-footed booby	Pelecaniformidae	*Sula*	*sula*	3	3
Brown booby	Pelecaniformidae	*Sula*	*leucogaster*	11	9
Wedge-rumped storm petrel	Hydrobatidae	*Oceanodroma*	*tethys*	3	2
Leach's storm petrel	Hydrobatidae	*Oceanodroma*	*leucorhoa*	36	17
Cook's petrel	Procellariidae	*Pterodroma*	*cooki*	1	1
Herald Petrel	Procellariidae	*Pterodroma*	*arminjoniana*	1	1
Black-naped Tern	Laridae	*Sterna*	*sumatrana*	1	1
Grey-backed Tern	Laridae	*Sterna*	*lunata*	1	1
Pink-footed Shearwater	Procellariidae	*Puffinus*	*creatopus*	2	2
Hawaiian Petrel	Procellariidae	*Pterodroma*	*phaeopygia*	1	1
Juan Fernandez Petrel	Procellariidae	*Pterodroma*	*externa*	7	6
Red-tailed tropicbird	Phaethontidae	Phaethon	*rubricauda*	2	2
Laughing Gull	Laridae	Larus	*atricilla*	1	1
White-tailed tropicbird	Phaethontidae	Phaethon	*lepturus*	1	1
Unidentified petrel	Procellariidae			4	2
Unidentified Shearwaters	Procellariidae			21	1
Unidentified Tern	Laridae			4	2