NMFS 90-Day Report for Marine Mammal Monitoring and Mitigation during Apache's Cook Inlet 2014 Seismic Survey

2 April – 27 June 2014

Prepared for

Apache Alaska Corporation
510 L Street #310
Anchorage, AK 99501

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Prepared by Smultea Environmental Sciences (SES)
PO Box 256, Preston, WA 98050

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#ÏÖer PÈÏôÏ¢ Beluga whale (*Delphinapterus leucas*) in Cook Inlet, Alaska, taken April 2014 by Mark Cotter during an aerial survey.

Executive Summary

Apache Alaska Corporation (Apache) contracted Smultea Environmental Sciences (SES) to conduct a marine mammal monitoring and mitigation program for the 2014 Cook Inlet 2D Seismic Survey (*2014 Apache 2D Survey*) in Cook Inlet, Alaska, from 2 April - 27 June 2014. Seismic surveys were conducted in nearshore and offshore waters from one source vessel (the *M/V Arctic Wolf* (*Arctic Wolf*) or *M/V Peregrine* (*Peregrine*)) supported by one mitigation vessel and several nodal, transport, and housing vessels. Marine mammal monitoring was conducted by 7 - 10 Protected Species Observers (PSOs): two from the source vessel, two from the mitigation vessel, two to four from up to 6 different land platforms, and one to two from a small fixed-wing aircraft. PSO monitoring from vessels and land occurred during all daylight seismic operations and most daylight non-seismic periods. Aerial surveys were flown daily, weather permitting. The flight path and survey goals differed depending on the location and timing of the seismic operations relative to Zones 1 and 2, and the proximity of river mouths per the IHA as follows.

1. When survey operations occurred near (< 16 km) a river mouth, the aircraft surveyed and circled the river mouth to identify large congregations of beluga whales and harbor seal haul-outs.
2. When project operations occurred in Zone 1 (Figure 1), aerial survey observation effort paralleled the waterline 1.6 km offshore from Anchorage along the Susitna Delta coastline to the West Foreland, across the inlet to East Foreland, then north around the coastline of Chickaloon Bay to Burnt Island, and across to Anchorage (or in reverse order).
3. When project operations occurred in Zone 2 (Figure 1), aerial surveys were conducted, safety and weather permitting, a minimum distance of 30 km (18.6 mi) around the seismic operating area expected for that day. This typically consisted of flying parallel to the coastline ~1.6 km offshore from East Foreland south along the coastline, and/or flying up Kenai River about 1 km, then continuing south to Ninilchik and back along the coastline to East Foreland.

A total of 3,029.2 hours (hr) of PSO observations occurred 2 April–27 June 2014: 2,330.4 hr from vessels, followed by 659.4 hr from land stations and 39.4 hr during aerial surveys. PSOs were on watch during all daylight periods with seismic operations. Most on watch effort occurred while the 1,760 cubic inch (cui) airgun array operated (277.8 hr), followed by 91.6 hr with array volumes >440 (excluding the 1,760), 87.9 hr with volumes <440 cu in (excluding the 10 cui), 33.3 hr with volume 440 cui, and 16.0 hr with the 10 cui mitigation airgun.

Eight species of marine mammals were identified consisting of 3 mysticetes (the minke, gray and humpback whale), 3 odontocetes (the beluga whale, and Dall's and harbor porpoise) and 2 pinnipeds (the harbor seal and Steller sea lion). Unidentified marine mammals included unidentified large whale (1 individual) unidentified dolphin or porpoise (8 individuals) and unidentified pinniped (2 individuals).

A total of 716 groups consisting of ~1,364 individual marine mammals were observed during the *2014 Apache 2D Survey*. Most sightings (55%) were made from land (394 groups totaling 454 individuals), followed by 251 groups (totaling 468 individuals) seen from vessels, and 71 groups (totaling 442 individuals) seen from the airplane within 30 km of the source vessel. From vessels and land, harbor seals were the most frequently observed marine mammal species: 69% (*n* =492) of all groups and 45% (*n* =613) of all individuals. This was followed by harbor porpoise (77 groups totaling ~113 individuals) and beluga whales (57 groups totaling ~170 individuals). From the airplane, beluga whales were the most frequently observed species (62 groups totaling ~401 individuals).

Specific field monitoring and mitigation protocols were implemented as stipulated in the IHA. At the start of field observations, Apache contracted Seiche to conduct a sound source verification (SSV) study to estimate the mitigation distances from a 1,760 cui array and a 440 cui array to the 190 (for pinnipeds) and 180 (for cetaceans) dB re 1 µPa (rms) (dB [rms]) exclusion zones (EZ) and the 160 dB (rms) disturbance zone (DZ) to be monitored during the project. SSV results indicated that radial mitigation distances from the full 1,760 cui array were as follows: 880 m to the 190 dB (rms) EZ isopleth; 1,840 m to the 180 dB (rms) EZ isopleth; and 7,000 m to the 160 dB (rms) DZ isopleth.

Mitigation measures identified in the IHA were incorporated into the PSO field protocol and implemented during the survey. Prior to starting seismic operations from a shutdown lasting > 10 minutes (min), the full EZ was monitored for marine mammals for 30 minutes followed by gradual ramp-up of the airgun array. A shut down or power down was implemented if a marine mammal was observed within the EZ and on some occasions, if seen within the DZ.

As required by NMFS, weekly and monthly reports were submitted to NMFS during the survey. These reports summarized total sightings, number and type of mitigation measures implemented, and number of exposures by species (corresponding to the number of individuals seen within the EZ and DZ, per NMFS). A total of 13 shut downs and 7 ramp up delays were implemented for marine mammals during the survey. Observers recorded a total of 29 exposures (25 at ≥160 dB (rms) and 4 at ≥180 dB (rms), based on the DZ and EZ described above) as follows: 12 beluga whales, 6 harbor porpoise, 9 harbor seals, and 2 humpback whales.

Table of ContÅÎûÓ

Executive Summary ..... **i**
Acronyms and Abbreviations ..... **viii**
1. Introduction **1**
1.1. Objectives 1
2. Cook Inlet 2014 Seismic Survey Summary **2**
2.1. Survey Area 3
2.2. Survey Design 5
2.3. Seismic Recording System 5
2.4. Seismic Source 6
2.5. Vessel Support 7
3. Marine Mammal Mitigation and Monitoring Program **9**
3.1. Protected Species Observer Protocol 9
3.1.1. Vessel-based Observations *10*
3.1.2. Land-based Observations *10*
3.1.3. Aerial Observations *12*
3.2. Exclusion/Disturbance Zones and Monitoring Program 14
3.3. Seismic Survey Mitigation Measures 15
4. Marine Mammal Monitoring and Mitigation Methods and Analyses **16**
4.1. Analysis Methods 17
4.1.1. Effort and Sighting Summary Methods *17*
4.1.2. Methods for Calculating Sighting Rates for Vessel and Land Sightings *17*
4.1.3. Methods for Estimating Number of Exposures *18*
5. Results **19**
5.1. Effort from Vessels and Land 19
5.2. Marine Mammal Sighting Results 21
5.2.1. Sightings from Vessels and Land *21*
5.2.2. Sightings by Environmental Conditions *28*
5.2.3. Marine Mammal Behavior *30*
5.3. Closest Point of Approach (CPA) 34
5.4. Usable Data & Sighting Rates 38
5.5. Aerial Results 40
5.5.1. Aerial Effort *40*

5.5.2. Sightings from Aircraft 41
5.5.3. Behavior Observed from Aircraft 42
5.5.4. Sighting Rates from Aircraft 45
5.6. Mitigation Measures Implemented 46
5.7. Marine Mammal Exposures 47
5.8. Humpback Sightings Summary 48
6. Literature Cited 50
Appendix A. Incidental Harassment Authorization and Take Statement 52
Appendix B. Sound Source Verification Report 67
Appendix C. Land Observation Effort 96
Appendix D. Definitions of Five Standard Mitigation Measures Implemented during the Cook Inlet 2014 Seismic Survey per the NMFS-Issued IHA. 98
Appendix E. Summary and Description of Mitigation Measures during the Cook Inlet 2014 Seismic Survey. 100
Appendix F. Summary and Description of Marine Mammal Exposures during the Cook Inlet 2014 Seismic Survey. 103
Appendix G. Cook Inlet 2014 Seismic Survey Photo Log 108

List of Tables

Table 1. Summary of Seismic Survey Dates and Events* 2
Table 2. Details on the Vessels Operating for the Cook Inlet 2014 Seismic Survey 7
Table 3. Exclusion Zone (EZ) and Disturbance Zone (DZ) distances based on 2014 IHA and 2012 sound source verification (SSV) results implemented 2 April – 14 April. 14
Table 4. Exclusion Zones (EZ) and Disturbance Zones (DZ) based on 2014 sound source verification (SSV) results, implemented 15 April – 27 June 2014. 14
Table 5. Definitions of data collection and analysis terminology. 16
Table 6. Total On-Watch effort (hr) by month and vessel or land platform. 19
Table 7. Total On-Watch effort in distance traveled (km) by month and vessel. 19
Table 8. All vessel and land On-Watch effort (hr) during seismic and non-seismic periods. 19
Table 9. Sighting summary of all marine mammals observed from vessel and land platforms. 21
Table 10. Number of groups and estimated individuals observed from vessel and land platforms. 22
Table 11. Number of marine mammal groups observed during seismic and non-seismic periods, based on pooled vessel and land data. 30
Table 12. "Usable" effort by vessel and land platforms during seismic and non-seismic periods. 38
Table 13. Species group sighting rates during seismic and non-seismic periods. 39
Table 14. Total aerial effort by seismic and non-seismic effort in the survey area. 41
Table 15. Sighting summary of marine mammals observed from the aerial platform. 41
Table 16. Sighting summary of marine mammal groups observed from the aerial platform during seismic and non-seismic periods. 44
Table 17. Marine mammal sighting rates (number of groups per hr) from the aerial platform during seismic and non-seismic periods. 46
Table 18. Summary of all mitigation measures implemented for each marine mammal species. 47
Table 19. Authorized number of "takes" during the Cook Inlet 2014 Seismic Survey identified by NMFS in the IHA. 47
Table 20. Summary of the number of individual marine mammal observed within the DZ and EZs during the Cook Inlet 2014 Seismic Survey. 48
Table 21. Chronological schedule and list of land stations used by PSOs. 96
Table 22. Ramp-up time for the 440 cui and 1,760 cui arrays 98

List of Figures

Figure 1. Zone 1 and 2 of the Cook Inlet 2014 Seismic Survey 4
Figure 2.Land-based platform locations during the Cook Inlet 2014 Seismic Survey. 11
Figure 3. Aerial Tracklines Flown within Zone 2 during Apache Operations from 5 May to 27 June 2014 within Cook Inlet. 13
Figure 4. Total vessel and Land Effort (hr) during Seismic and Non-Seismic Periods.... 20
Figure 5. Total effort (hr) by seismic array or airgun volumes (cu in). 20
Figure 6. Map of all marine mammal groups observed from vessel and land platforms. 23
Figure 7. Map of all beluga whale groups observed from vessel and land platforms. 24
Figure 8. Map of all pinniped groups observed from vessel and land platforms..... 25
Figure 9. Map of all large whale (humpback, gray and minke whale) groups observed from vessel and land platforms. 26
Figure 10. Map of all dolphin and porpoise groups observed from vessel and land platforms. 27
Figure 11. Number of marine mammal groups observed from vessel and land platforms. 28
Figure 12. Number of marine mammal groups observed per effort hour from vessel and land platforms during Beaufort sea states (Bf) 0-6. 29
Figure 13. Number of marine mammal groups observed per effort hour from vessel and land platforms by visibility distance categories. 29
Figure 14. Sighting rates of initial behavior state of beluga whale groups during seismic and non-seismic periods, based on pooled vessel and land data..... 31
Figure 15. Sighting rates of initially observed behavior of harbor seal groups during seismic and non-seismic periods, based on pooled vessel and land data..... 32
Figure 16. Sighting rates of initially observed behavior of harbor porpoise groups during seismic and non-seismic periods, based on pooled vessel and land data..... 33
Figure 17. Sighting rates of initially observed behavior of large mysticete whale groups observed during seismic and non-seismic periods, based on pooled vessel and land data. 34
Figure 18. CPA sighting rates for all marine mammal groups observed from the source vessel (*Arctic Wolf* or *Peregrine*) during seismic and non-seismic periods, based on pooled vessel and land data..... 35
Figure 19. CPA sighting rates for beluga whale groups observed from the *source* vessel *(Arctic Wolf or Peregrine)* during seismic and non-seismic periods, based on pooled vessel and land data..... 36
Figure 20. CPA sighting rates for harbor porpoise groups observed from the source vessel (*Arctic Wolf* or *Peregrine*) during seismic and non-seismic periods, based on pooled vessel and land data..... 36
Figure 21. CPA sighting rates for harbor seal groups observed from the source vessel (*Arctic Wolf* or *Peregrine*) during seismic and non-seismic periods, based on pooled vessel and land data..... 37
Figure 22. CPA sighting rates for large mysticete whale groups observed from the source vessel (*Arctic Wolf* or *Peregrine*) during seismic and non-seismic periods, based on pooled vessel and land data..... 37

Figure 23. Sighting rates (number of groups per hr) for all marine mammals during seismic and non-seismic periods based on "usable" sightings and effort from vessel and land platforms. 39
Figure 24. Sighting rates (number of groups per hr) during seismic and non-seismic periods for all marine mammals observed from vessel and land platforms. 40
Figure 25. Map of species observed from aerial platform. 42
Figure 26. Beluga whale initial behaviors observed from the aerial platform. 43
Figure 27. Harbor seal initial behaviors observed from the aerial platform. 43
Figure 28. Beluga whale behavior state during seismic and non-seismic periods as observed from the aerial platform. Based on number of groups per hour of aerial effort (seismic and non-seismic). 44
Figure 29. Harbor seal behavior state during seismic and non-seismic periods as observed from the aerial platform. Based on number of groups per hour of aerial effort (seismic and non-seismic). 45
Figure 30. Sighting rates (number of groups per hr) during seismic and non-seismic periods for marine mammal species observed from the aerial platform. 46
Figure 31. Number of days PSOs observed from each land station. 97

Acronyms and Abbreviations

3D	three-dimensional
4MP	marine mammal monitoring and mitigation program
AKDT	Alaska Daylight Time
ASL	Above Sea Level
Bf	Beaufort sea state
BL	Body Lengths
CAA	Conflict Avoidance Agreement
CI	Cook Inlet
Com-Center	Communication and Call Center
CPA	closest point of approach
dB	decibel
DZ	disturbance zone
ESA	Endangered Species Act
EZ	exclusion zone
ft	feet
GPS	Global Positioning System
hr	hour
hr/d	hours per day
HSE	Health, Safety, and Environment
IC	Iñupiat Communicator
in^3	cubic inch(es)
IHA	Incidental Harassment Authorization
kHz	kilohertz
km	kilometer(s)
km^2	square kilometer(s)
km/hr	kilometers per hour
kt	knot(s)
LOA	Letter of Authorization
m	meter(s)
mi	mile(s)
mi^2	square mile(s)

min	minute(s)
MMPA	Marine Mammal Protection Act
µPa	MicroPascal
M/V	motor vessel
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NVD	night vision device
OBN	ocean bottom node
PSO	protected species observer
QA/QC	quality assessment / quality check
rms	root mean square
SAE	SAExploration
SPL	sound pressure level(s)
SSV	sound source verification
Unid	unidentified
U.S.	United States
USB	Universal Serial Bus
USBL	Ultra-Short Baseline
USFWS	U.S. Fish and Wildlife Service

1. Introduction

In fall 2013, Apache applied to the National Marine Fisheries Service (NMFS) for an Incidental Harassment Authorization (IHA) 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 a seismic survey in Cook Inlet, Alaska (NMFS 2014). NMFS issued this IHA on 4 March 2014. The IHA covered the period from March 1 through December 31, 2014.

Apache contracted SAExploration (SAE) to conduct the 2014 seismic survey in Cook Inlet (hereafter Cook Inlet 2014 Seismic Survey) and Smultea Environmental Sciences (SES) to conduct the marine mammal monitoring and mitigation program (4MP). Seismic operations commenced on 2 April 2014 and continued through 27 June 2014 in Cook Inlet. This 90-day report summarizes results of the 4MP based on report stipulations identified in the project IHA. Results describe Protected Species Observer (PSO) monitoring efforts, environmental conditions, marine mammal sightings, and associated mitigation measures implemented for marine mammals under NMFS jurisdiction.

Other marine mammals (sea otters) were observed during the Cook Inlet 2014 Seismic Survey. However, sea otter sighting and mitigation data are not included in this report as this species is under U.S. Fish and Wildlife Service (USFWS) jurisdiction.

1.1. Objectives

4MP objectives were described in detail in the Apache IHA Application and in the IHA issued by NMFS to Apache (Appendix A, "Incidental Harassment Authorization and ") and consisted of the following:

1. Provide real–time sighting data needed to implement the mitigation requirements;
2. Document the numbers of marine mammals exposed to seismic pulses; and
3. Determine the reactions (if any) of marine mammals exposed to seismic sound impulses.

2. Cook Inlet 2014 Seismic Survey Summary

The Cook Inlet 2014 Seismic Survey occurred from 2 April to 27 June 2014 within upper and central Cook Inlet, within areas designated as Zone 1 and Zone 2 (Figure 1). The total project area (Zone 1 and Zone 2) encompassed approximately 4,238 square kilometers (km^2) of intertidal and offshore areas (Apache 2013). Zone 1 was located in eastern upper Cook Inlet with Zone 2 located further south in the inlet (Figure 1).

Events and dates associated with the Cook Inlet 2014 Seismic Survey are summarized in Table 1. Survey mobilization began in late March and seismic operations were initiated on 2 April for the sound source verification study (SSV) stipulated by NMFS in the IHA (NMFS 2014). Apache contracted Seiche Measurements LTD to conduct the SSV. The preliminary SSV report was sent by Apache to NMFS on 10 April 2014 and the final SSV report was sent by Apache to NMFS in June 2014 (see Appendix B, "Source Sound Verification Report"). Seismic operations in Zone 1 started 6 April and ended on 5 May, followed by transition to Zone 2. Seismic operations began in Zone 2 on 5 May. In order to not interfere or have conflict with the commercial driftnet fishing season, seismic operations ceased 27 June 2014 (Table 1). Apache considered continuing operations in Zone 2 following the end of the fishing season in order to complete a shallow hazard survey. Due to a variety of reasons the decision was made to conclude marine seismic operations with Apache notifying NMFS on 20 November 2014 that no further operations were to occur during 2014.

Table 1. Summary of Seismic Survey Dates and Events*

2014 $ÁôÅjóq	**3ÕÒÖÅy EÖÅÎôjóq**
28 March– 2 April	Project vessel mobilization in Homer, Alaska.
2 April	Vessels transit to project location near Kenai and Kasilof rivers.
3 – 6 April	Sound Source Verification (SSV) conducted in Zone 2 in Kenai and Kasilof regions (Figure 1).
6 April	Seismic operations commence in Zone 1 in Susitna and Moose Point regions (Figure 1).
6 – 14 April	Seismic operations occur in Zone 1 on western side of central Cook Inlet near Susitna River Delta (Figure 1).
14 April	End of seismic operations in NMFS-restricted 10-mile (16-km) radius area of the Susitna River Delta identified in Section 7(p) of the 2014 IHA within Cook Inlet Beluga Critical Habitat area.
14 April – 5 May	April seismic operations move to Zone 1 eastern Cook Inlet and operate in Moose Point region.

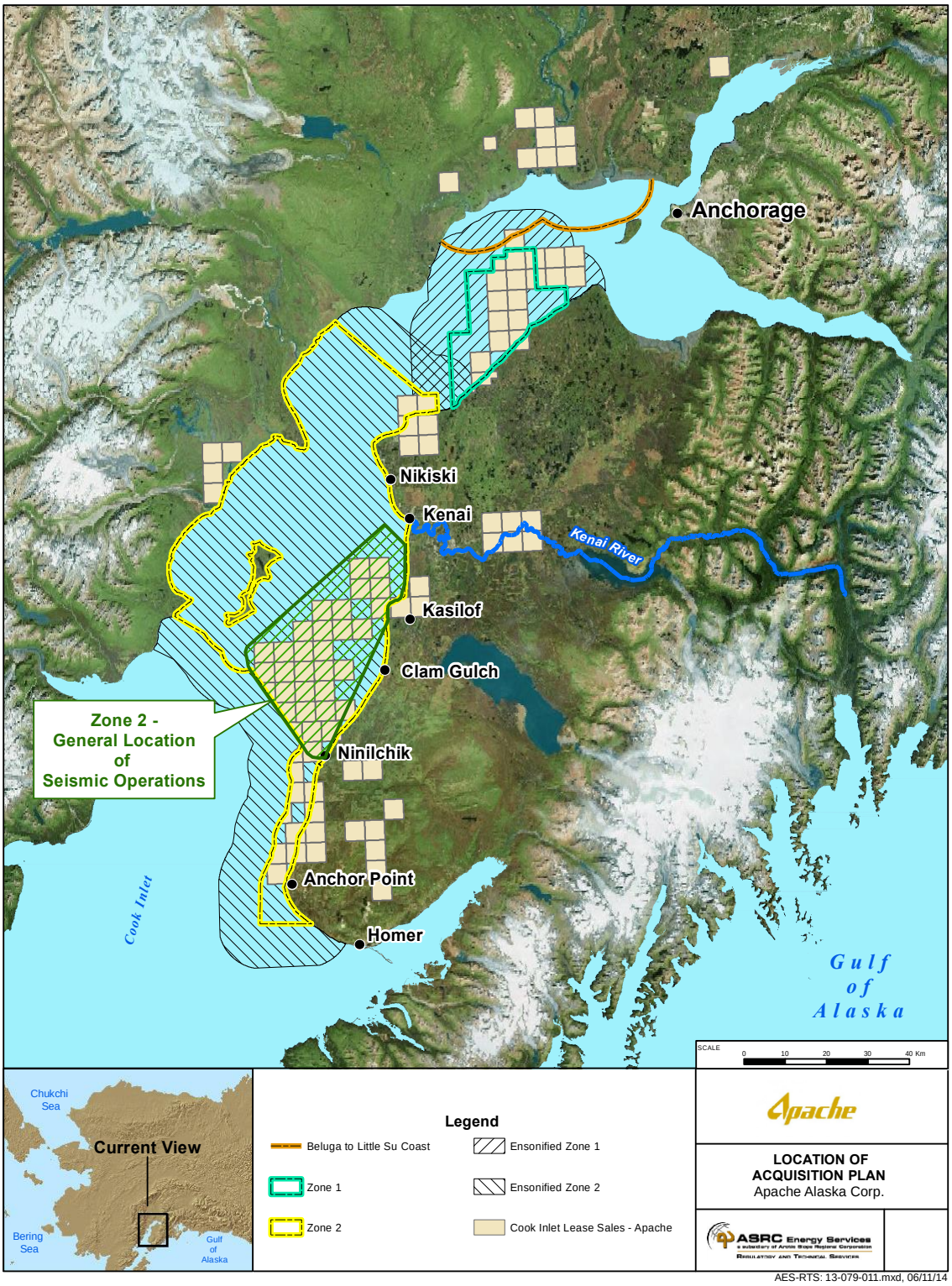
2014 $ÁôÅjóq	**3ÕÒÖÅy EÖÅÎôjóq**
5 May	Operations in Zone 1 completed. Vessels move to Zone 2 - South Kenai region.
5 May – 27 June	Zone 2 operations continue in nearshore and offshore regions between Kenai and Ninilchik.
27 June	In order to not interfere or have conflict with the commercial driftnet fishing season, seismic operations ended and survey demobilized.

* See Figure 1 for locations mentioned in this table.

2.1. Survey Area

A map of the survey area depicting survey line locations within Zones 1 and 2 as identified in the IHA, and the estimated associated 160-dB (rms) ensonification zones for the full 1,760 cui array are depicted in Figure 1.

Figure 1. Zone 1 and 2 of the Cook Inlet 2014 Seismic Survey



2.2. Survey Design

Zones 1 and 2 both encompassed land, inter-tidal transition zone, and marine environments. 4MP activities occurred only in the transition zone and marine environments, as the land-based portion of the program did not result in underwater sound levels exceeding NMFS-regulated marine mammal exposure thresholds. Transition zone and offshore acquisition included areas below the mean high tide line. Although the survey was active 24-hours per day, airgun operations only occurred during slack tides (low and high) to avoid adverse effects of the swift tidal currents associated with tide changes. Strong ebb and flood tide currents limited operations and safety of vessels deploying the airguns, and decreased the signal-to-noise ratio of the seismic signal to below background levels

Four slack tides generally occur within a 24-hour (hr) period in Cook Inlet. Thus, seismic operations occurred for approximately 2-3 hours around each of the four slack tide periods every 24 hr, totaling about 8-12 hours per 24-hr period. Vessels laid and retrieved the nodal sensors on the sea floor bottom in periods of low current or, in the case of the intertidal area, during high tide. Offshore and transition zone seismic operations involved input/output sleeve airguns in two different array configurations of 440 and 1,760 cui.

2.3. Seismic Recording System

The seismic recording system consisted of an autonomous or "nodal" system (i.e., no cables) comprised of two node types, one for the land and one for the intertidal and marine environment. The land environment involved a single-component sensor land node. The inter-tidal and marine zone involved a submersible multi-component system comprised of three velocity sensors and a hydrophone. These systems allow recording of continuous data. In-line receiver node systems were spaced 50 m apart, with nodes deployed in patches for up to 15 days for the seismic source.

Apache employed a geometric method known as *patch shooting* to gather seismic data. This type of seismic surveying requires using multiple vessels for cable layout/pickup, recording, and sourcing. Operations began by laying nodes off the back of the layout vessels along the seafloor parallel to each other along node lines spaced 402 or 503 m apart. Apache's patch consisted of 6-8 node lines (receivers) generally running perpendicular to the shoreline for transition zones and parallel to the shoreline for offshore areas (Figure 1). Overall, most lines ran perpendicular to the shoreline. The entire patch was laid on the seafloor by node vessels prior to airgun activity. Individual vessels were capable of carrying up to 400 nodes. With three node vessels operating simultaneously, a patch was laid down in a single 24-hr period, weather permitting.

After nodes were placed on the seafloor, the exact position of each node was required for proper data processing. Several techniques were used to locate the node positions on the seafloor, depending on water depth. In very shallow water,

the node's position was determined either by a land surveyor during low tide, or accepted the position where the navigator laid the unit.

In deeper water, two recognized techniques were used. The first involved a hull- or pole-mounted pinger to send a signal to the transponder attached to each node. Transponders were coded and crew tracked which transponder corresponded to which node prior to/ layout. The transponder's response (once pinged or "interrogated") was added to several other responses to create a suite of ranges and bearings between the pinger boat and node. Those data were then used to determine a precise node position. In good conditions, nodes were interrogated as they were laid out. Nodes were also commonly pinged after being laid out. The Sonardyne Shallow Water Cable Positioning system was the pinger used for this method. Additional instruments used included: (1) a Scout Ultra-Short Baseline (USBL) Transceiver (operational frequency 33-55 kilohertz (kHz) at maximum source level of 188 dB re 1 µPa at 1 m); and (2) an Ultra-short Baseline (USBL) Transponder (operational frequency 35-50 kHz at source level of 185 dB re 1 µPa at 1 m).

The Ocean Bottom Receiver Location (OBRL) was the second technique used in deeper water. This technique used a small volume (10 cui) airgun firing parallel to the node line. The airgun was fired along each side of the line. Resulting data were gathered from the node and combined with the known position of the airgun to provide a precise location of each node during data processing. Seismic source activity began after the full node patch had been positioned on the seafloor.

2.4. Seismic Source

Apache's transition zone and offshore methods used two source vessels synchronized in time. The *Arctic Wolf* and *Peregrine* were equipped with air compressors and 1,760 cui airgun arrays. The *Peregrine* was also equipped with a 440 cui shallow water array to deploy at high tide in intertidal areas with water < 1.8 m deep. Source transit lines were orientated perpendicular to the node lines and parallel to the beach. Vessels tried to maintain a speed of 2-4 knots (kt) to cover approximately 50 m between airgun pops. The objective was to generate source positions for each of the two arrays close to a 50 m interval along each of the source lines in a patch.

Each source line was approximately 12.9 km long. A single vessel could acquire a source line in approximately 1 hr. With two source vessels operating simultaneously, a patch of approximately 3,900 source points could be acquired in a single day averaging 8-12 total hr of seismic operations.

After patch node data were acquired, the node vessels picked up the patch and rolled it to the next location. This pickup effort took 3/4 of a day to complete.

2.5. Vessel Support

The 11 vessels involved with the Cook Inlet 2014 Seismic Survey and their purposes during the survey are listed in Table 2. The *Peregrine* was the only seismic source vessel used from 6 April through 5 June, and was replaced by the *Arctic Wolf* seismic source vessel from 7 June-27 June 2014 (Table 2). The primary mitigation vessel was the *Dreamcatcher*. All other boats acted as support vessels, and at times were used as additional mitigation vessels.

Table 2. Details on the Vessels Operating for the Cook Inlet 2014 Seismic Survey

6ÅÓÓÅÌ	$ÁÔes Ï Î 0ÒÏÊÅÃÔ	6ÅÓÓel 0ÕÒÐÏÓÅ	3ÉÚÅ	$ÏÃÕ Í ÅÎÔÁÔÉÏ Î . Ï8	#ÁÌÌ SÉÇ Î	'ÒÏÓÓ 4Ï Î ÎÁÇÅ
M/V Peregrine Falcon	06 April – 05 June	Source vessel	26 m x 6 m (85 ft x 24 ft)	950245	WCZ6285	131
M/V Arctic Wolf	07-27 June	Source vessel	41 m x 9 m (135 ft x 30 ft)	687450	-	251
M/V Westward Wind	01 – 27 June	Node vessel	47 m x 10 m (155 ft x 34 ft)	774367	WCX9055	289
M/V Miss Diane	06 April – 27 June	Node vessel	26 m x 6 m (85 ft x 20 ft)	1210779	WAV0779	53
M/V Mark Stevens	06 April – 27 June	Node vessel	26 m x 6.7 m (85 ft x 22 ft)	1238385	WCZ-7941	81
M/V Enterprise	01 – 27 June	Support vessel				
M/V Dreamcatcher	06 April – 27 June	Mitigation vessel	26 m x 7.1 m (85 ft x 23 ft)	963070	WBN5411	100
M/V Wingham	06 April – 27 June	Support vessel				
M/V Aubree Tara	06 April – 27 June	Crew/Equipment Transport				
M/V Sleeprobber	06 April – 27 June	Support vessel	-	-	-	-
M/V Storm Warning	01 – 27 June	Support vessel	-	-	-	-

6ÅÓÓÅÌ	**$ÁÔes Ï Î 0ÒÏÊÅÃÔ**	**6ÅÓÓel 0ÕÒÐÏÓÅ**	**3ÉÚÅ**	**$ ÏÃÕ Í ÅÎÔÁÔÉÏ Î . Ï8**	**#ÁÌÌ SÉÇÎ**	**' ÒÏÓÓ 4Ï Î ÎÁÇÅ**
M/V Redeemer	28 April – 06 May	2nd Mitigation vessel (specific to tidal zone operations)				

3. Marine Mammal Mitigation and Monitoring Program

This section describes the mitigation and monitoring measures implemented to address report requirements specified in the NMFS-issued IHA. Data analyses, methods, and results for vessel-based visual monitoring are provided in Section 4.

The Cook Inlet 2014 Seismic Survey deployed Trained PSOs on vessels, aircraft, and land that had two primary areas of responsibility:

1. - Ï Î É Ô Ï Ò É Î Ç¸ Record numbers, behavior, and locations of marine mammals both during, and in absence of, seismic survey activity. Document animal reactions (where applicable). Document selected environmental variables that may affect the ability to sight marine mammals.

2. - É Ô É Ç Á Ô É Ï Î ¸ Detect marine mammals within, or about to enter, the applicable EZ and initiate immediate shutdown or power down of the airguns. Use visual monitoring to estimate the number of marine mammals potentially exposed to airgun sounds at specified levels.

Under the MMPA, NMFS has defined two levels of harassment for marine mammals:

- Level A harassment is defined as "…any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal stock in the wild."
- Level B harassment is defined as "…any act of pursuit, torment, or annoyance which has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering."

Since 1997, NMFS has been using standard sound exposure thresholds to determine when an activity that produces sound underwater might result in impacts to a marine mammal such that a take by harassment might occur (70 FR 1871). The current Level A (injury) threshold for impulse noise is 180 dB re 1 µPa rms (dB rms) for cetaceans (whales, dolphins, and porpoises) and 190 dB (rms) for pinnipeds (seals, sea lions). The current Level B (disturbance) threshold for impulse noise is 160 dB (rms) for cetaceans and pinnipeds.

3.1. Protected Species Observer Protocol

SES employed a large team of trained and experienced PSOs for the 4MP program. All PSOs had experience in marine mammal research and/or monitoring and were approved by NMFS prior to the start of the program or their rotation into the project. PSOs were trained on specific project details and requirements, and sighting

information for marine mammals occurring in the project area prior to going to the project site. At any given time, there were 7 to 10 PSOs simultaneously on the project site: two on the seismic source vessel (the *Peregrine* or *Arctic Wolf*), two on the *Dreamcatcher* mitigation vessel, and one to four at the land-based station(s), occasionally with PSOs at two land sites (more PSOs were needed at the land station during summer when daylight was longer).

Two PSOs were generally based at each observation station to watch for marine mammals prior to, during, and after seismic activity to monitor the 160-dB (rms) DZ. Observations also occurred as possible from land, source and mitigation vessels, and the aircraft on days when seismic activity did not occur. One PSO was designated as the Lead PSO at each observation platform to communicate with the Operations Team, conduct daily data quality checking, data back up, submit summaries, and back up and send daily data to the client and SES Project Manager.

3.1.1. Vessel-based Observations

PSOs on the vessels rotated observation shifts every 2-4 hours to more effectively monitor the project area, implement mitigation measures, and avoid observer fatigue. Observations occurred during all daylight hours prior to, during, and after seismic operations, unless precluded by weather conditions (e.g., fog, ice, high sea states). Vessel-based observers watched for marine mammals from the best available vantage point on the bridge of the *Peregrine, Arctic Wolf,* and *Dreamcatcher*. While on watch, PSOs systematically scanned the area around the vessel during all vessel activities in a sweeping pattern: usually alternating scan sweeps between reticle binoculars (Fujinon 7 × 50) and the unaided eye. Observations focused forward and to the sides of the vessel in an arc of ~180º; however, PSOs also regularly checked for marine mammal presence astern of the vessel. Behind the observer, visibility was obscured for approximately 90 degrees due to vessel superstructure.

3.1.2. Land-based Observations

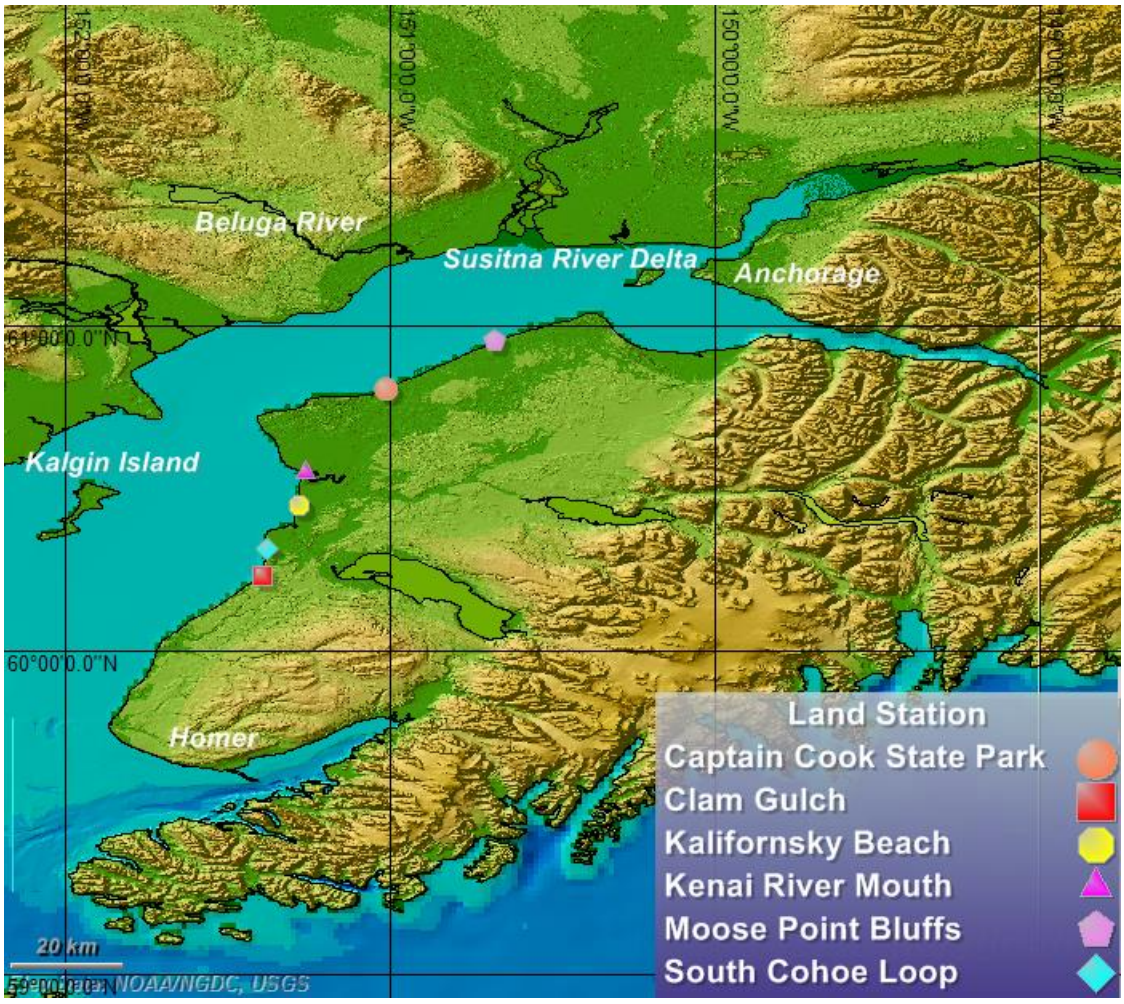
PSOs observed daily for marine mammals from a land-based station, weather permitting. Due to the remoteness of the area, selection of safe and accessible shore stations was limited. Land stations were selected based on the following parameters, as feasible: (1) closest to seismic operations area with a view of the seismic source vessel(s); 2) accessibility (i.e., public and/or permitted land use with road access, and (3) sufficient elevation to observe marine mammals.

Land-based equipment typically included a truck for transportation and safety, handheld 7 x 50 reticle binoculars, tripod-mounted "Big Eye" binoculars (20 x 100), a VHF radio and cell phone(s) for communications with the vessels and others, and a Sokkia DT510 land surveyor's theodolite (note that although the theodolite was not a requirement in the IHA, it was used to increase precision of sightings). Land stations were simultaneously staffed with two to three observers, with at least two

additional observers rotating shifts during the long daylight periods of late spring/early summer. One PSO scanned with the "Big Eye" binoculars, one alternated scans with the naked eye and 7 x 50 reticle binoculars, and/or one recorded data and operated the theodolite. Land-based PSOs observed the survey area at least 30 min prior to, during, and after airgun operations, including sunrise/set clears.

Land-based platforms on the East side of Cook Inlet included Clam Gulch, Kenai River Mouth, South Cohoe Loop Road, Captain Cook State Park, Kalifornsky Beach Road, and Moose Point Bluffs (Figure 2). Platform use was coordinated with the positioning of the *Dreamcatcher* to ensure that both up- and down-inlet sides of the then-current survey area were monitored. The Lead PSO coordinated transportation to and from land platforms through the Seismic Crew Project Manager on land. A chronological schedule and list of land stations used by PSOs during the project is provided in Appendix C, "Land Observation Effort."

Figure 2.Land-based platform locations during the Cook Inlet 2014 Seismic Survey.



3.1.3. Aerial Observations

As stipulated in the IHA (NMFS 2014), aerial surveys were flown daily, weather permitting. The flight path and survey goals differed depending on the location and timing of the seismic operations relative to Zones 1 and 2, and the proximity of river mouths per the IHA as follows.

1. When survey operations occurred near (< 1.6 km) a river mouth, the aircraft surveyed and circled the river mouth to identify large congregations of beluga whales and harbor seal haul-outs.
2. When project operations occurred in Zone 1 (Figure 1), aerial survey observation effort paralleled the waterline 1.6 km offshore from Anchorage along the Susitna Delta coastline to the West Foreland, across the inlet to East Foreland, then north around the coastline of Chickaloon Bay to Burnt Island, and across to Anchorage (or in reverse order).
3. When project operations occurred in Zone 2 (Figure 1), aerial surveys were conducted, safety and weather permitting, a minimum distance of 30 km (18.6 mi) around the seismic operating area expected for that day. This typically consisted of flying parallel to the coastline ~1.6 km offshore from East Foreland south along the coastline, and/or flying up Kenai River about 1 km, then continuing south to Ninilchik and back along the coastline to East Foreland.

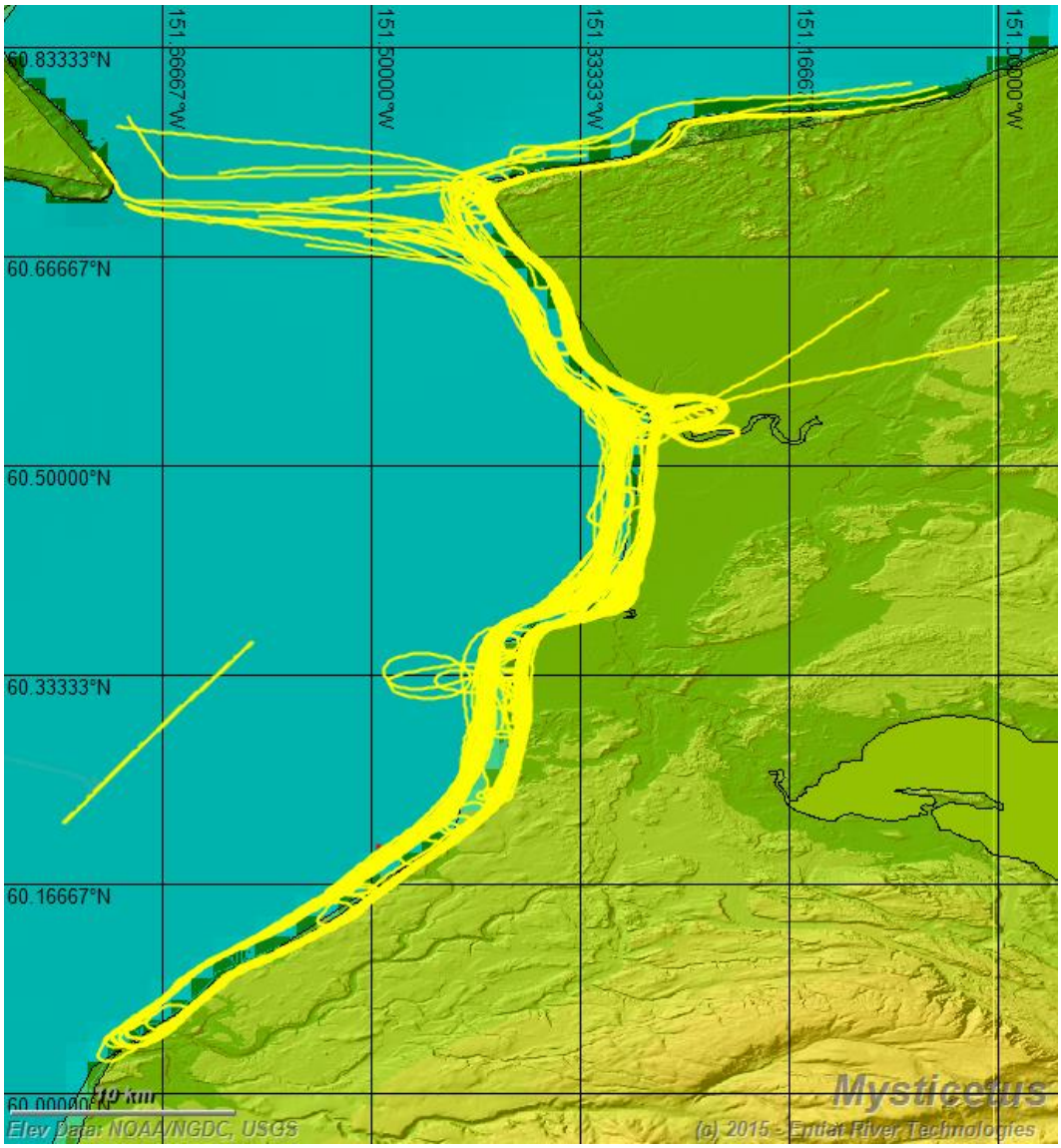
Aerial surveys generally began at noon each day from a fixed high-wing, single-engine Cessna 172 with flat windows flying at an altitude of 305 m and speed of 100 kt. One dedicated experienced "primary" marine mammal observer watched out the right window and one pilot watched opportunistically out the left and front window for marine mammal sightings. The primary observer ran a PC laptop loaded with *Mysticetus* System software (*Mysticetus*™) (http://www.mysticetus.com) connected to a global positioning system (GPS) (either a GlobalSat BU-353-S4 Universal Serial Bus (USB) or a GlobalSat BT368i Bluetooth). Occasionally, a second researcher sat in the rear right seat to opportunistically take photographs and assist with note taking on the laptop (a second observer was present during 43 of the total 76 flights).

Upon sighting a beluga whale, aggregation of harbor seals, an unidentified sighting, an unusual species, or after crossing a river mouth, the aircraft was directed to circle the sighting or river mouth to confirm species and group size/composition and/or expend extra search effort to identify other potential marine mammals. A minimum, maximum, and best group size were recorded along with the number of calves and non-calf white and gray belugas whales, as possible. A calf was defined as an animal no more than one-half the size of the large animal it was closely accompanying. The first-observed behavior state, magnetic direction of travel, estimated travel speed, and minimum and maximum dispersal distance were recorded. The minimum and the maximum distance between individuals within a group was estimated in adult body lengths (BL) ([Smultea and Bacon 2012). Sightings were kept at a minimum radial distance of 500 m and 305 m altitude from the aircraft. A shortcut key was selected when a marine mammal sighting was made and the declination angle was

entered into the PC using a Suunto clinometer. Species, group size/composition, first observed behavior state, and group heading were entered into a custom *Mysticetus* data entry form.

Throughout the flight, *Mysticetus* displayed a map of the plane's track in real-time as well as the calculated positions of any recorded sightings, bathymetry, and the shoreline. Two backup handheld Garmin Etrex 10 GPS units were used during all flights. *Mysticetus* automatically backed up data to a USB thumb drive every 3 min during the flight. Swarovski 10x42 WB and/or Fujinon 7x50 WPC-XL binoculars were used to confirm sightings as needed. A Sony mini audio recorder, model *IC Recorder*, with a mini external microphone taped inside the earpiece of the BOSE headset, was used to record all audio during the survey as a backup data source.

Figure 3. Aerial Tracklines Flown within Zone 2 during Apache Operations from 5 May to 27 June 2014 within Cook Inlet.



3.2. Exclusion/Disturbance Zones and Monitoring Program

At the start of the project, exclusion zones (EZ) (i.e., "safety radii") identified in the NMFS-issued IHA for the Cook Inlet 2014 Seismic Survey were applied under the project 4MP, as proposed in the project IHA application (Apache 2013). These zones were based on current NMFS guidelines (e.g., 65 FR 16374) indicating that the "safety radii" for marine mammals around airgun arrays are customarily defined as the distances within which received seismic impulse levels are ≥ 180 dB (rms) for cetaceans and ≥ 190 dB (rms) for pinnipeds. These safety criteria assume that seismic pulses at lower received levels will not injure these animals or impair their hearing ability, but that higher received levels could potentially have such effects. In addition, NMFS assumes that marine mammals exposed to ≥ 160 dB (rms) are potentially subject to behavioral disturbance.

Per the 2014 IHA, from 2 April–14 April, PSOs established and monitored the respective 180 and 190 dB (rms) EZs and the 160 dB (rms) DZ that had been used during the 2012 Cook Inlet 3D Seismic Program (based on the 2012 SSV results) (Table 3). On 15 April 2014, the EZ and DZ were updated and approved by NMFS based on the 2014 SSV results, at which time PSOs began to implement these new mitigation zones (Table 4).

Table 3. Exclusion Zone (EZ) and Disturbance Zone (DZ) distances based on 2014 IHA and 2012 sound source verification (SSV) results implemented 2 April – 14 April.

3ÏÕÒÅÅ	ρω0 Ä" %: ,evel A j0ÉÎ ÎÉÐÅÄÓQ	ρψ0 Ä" %: ,evel A j#ÅÔÁÃÅÁÎÓQ	ρφ0 Ä" $: ,evel B j!ÌÌ - ÁÒÉÎÅ - Á Í ÍÀs)
10 cui airgun – mitigation gun	10 m	10 m	280 m
440 cui airgun array	100 m	310 m	2,500 m
1,200 cui airgun array	250 m	910 m	5,300 m
2,400 cui airgun array	380 m	1,400 m	9,500 m

Table 4. Exclusion Zones (EZ) and Disturbance Zones (DZ) based on 2014 sound source verification (SSV) results, implemented 15 April – 27 June 2014.

3ÏÕÒÅÅ	ρω0 Ä" %: ,evel A j0ÉÎ ÎÉÐÅÄÓQ	ρψ0 Ä" %: ,evel A j#ÅÔÁÃÅÁÎÓQ	ρφ0 Ä" $: ,evel B j!ÌÌ Í ÁÒÉne Í Á Í ÍÀs)
10 cui airgun – mitigation gun	10 m	10 m	280 m
440 cui airgun array	50 m	500 m	3,050 m

3ÏÕÒÅÅ	ρω0 Ä" %: ,evel A j0ÉÎÎÉÐÅÄÓǫ	ρψ0 Ä" %: ,evel A j#ÅÔÁÂÅÁÎÓǫ	ρφ0 Ä" $: ,evel B j!ÌÌ ÍÁÒÉne ÍÁÍ ÍÁÌs)
1,760 cui airgun array	880 m	1840 m	7000 m

3.3. Seismic Survey Mitigation Measures

Five standard seismic-related mitigation measures were implemented for marine mammal sightings during the Cook Inlet 2014 Seismic Survey, as applicable. These five measures are considered standard measures implemented during seismic operations relative to marine mammals: ramp ups, power downs, shutdowns, poor visibility conditions, and operation of a single source (10 in^3) airgun (i.e., mitigation airgun). The monitoring and mitigation protocol associated with these five standard measures are summarized and defined in Appendix D, "Definitions of Five Standard Mitigation Measures Implemented during the Cook Inlet 2014 Seismic Survey per the NMFS-Issued IHA." EZs and the 160 dB (rms) DZ for cetaceans and pinnipeds were monitored by PSOs on the source vessel, mitigation vessel and land platforms, and when feasible from the aircraft, during all daytime seismic activities.

4. Marine Mammal Monitoring and Mitigation Methods and Analyses

This section describes data analysis methods and 4MP results, and estimates the number of marine mammals exposed to seismic survey operations during the Cook Inlet 2014 Seismic Survey. Terminology and definitions used in this section are defined in Table 5.

Table 5. Definitions of data collection and analysis terminology.

/ ÆÆZ × atch %ÆÆÏÒÔ	Periods when Protected Species Observers (PSOs) were not on active watch duty and thus were not consistently looking for marine mammals. Any sightings made during these periods were considered opportunistic. For example, when PSOs were sitting in the bridge and occasionally looking for marine mammals, or were taking a break on or off the bridge but made a sighting.
/ ÎZ × ÁÔÃh %ÆÆÏÒÔ	Periods when at least one PSO was on active watch duty and dedicated to looking for marine mammals.
Seismic %ÆÆÏÒÔ	Periods when at least one PSO was on watch while airguns were operating from the source vessel. This included ramp ups, power downs, and when the single mitigation airgun was operating. PSOs were on watch during all daylight airgun operations.
. Ï ÎZSeismic %ÆÆÏÒÔ	Periods when no airguns were operating.
6ÉÓÉÂÉÌÉÔÙ	Visibility refers to the clarity of the atmosphere between the observer's position and the horizon and is adversely affected by such environmental conditions as fog, rain, snow, haze, and the degree of light.
' ÒÏup (É8Åøh **3**ÉÇÈÔÉÎÇ	One or more individuals seen close together and coordinated in a similar manner (e.g., coordinated surfacings, orientation, etc.).
3ÉÇÈÔÉ**Î g 2**ÁÔÅ	The number of marine mammal groups (or individuals) seen per hour of "usable" PSO effort
5ÓÁÂÌÅ %ÆÆÏÒÔ	PSO effort limited to specific viewing conditions to facilitate comparison of sighting rates under standardized sighting conditions. Usable effort was limited to periods when PSOs were on watch under the following conditions: visibility > 1 km; daylight; Beaufort sea state (Bf) < 5.

4.1. Analysis Methods

4.1.1. Effort and Sighting Summary Methods

General summaries of PSO effort and data included all sightings and effort. In other words, effort totals were not filtered or restricted by environmental conditions in the general summaries presented in graphs and figures. However, effort data were filtered to certain "usable" conditions for sighting rates to standardize comparisons (Table 6).

Data on the number of marine mammal sightings are presented to the species level whenever possible in species summary tables. However, some sightings were not identified to species or genus if the PSO did not feel confident in their identification, as instructed to do during the PSO training conducted prior to the project start. Environmental factors including high Bf, poor visibility, ice coverage, distance from the observer, observer eye height above sea level, and glare can limit the ability to identify marine mammals to species. PSOs labeled animals as "unidentified" if unsure of species identification.

Distribution of sightings around the source vessel was assessed relative to several variables. These included bearing from the PSO to the sighting, initial and subsequent resight distances of the sighting from the PSO, and Closest (observed) Point of Approach (CPA) of the animal(s) to the source vessel in operation.

Marine mammal movement relative to the vessel and initial and secondary behavior states and events were recorded for each marine mammal sighting based on pre-defined protocol and ethograms provided to the PSOs during training and made available on the project vessels. Marine mammal initial behaviors included swim, look, dive, sink, rest, surface active, mill, and unknown/other. These parameters followed those presented in numerous other 90-day reports associated with seismic operations (e.g., Aerts et al. 2008; Blees et al. 2010; Lomac-MacNair et al. 2013).

4.1.2. Methods for Calculating Sighting Rates for Vessel and Land Sightings

Sighting rates of marine mammals observed from vessel and land platforms were calculated as the number of groups seen per hour of "usable" effort as defined in Table 6. Sighting rates were based on hours of effort because distance (i.e., km) was not considered appropriate for the survey conditions where survey lines were spaced closely together in the same small region.

4.1.3. Methods for Estimating Number of Exposures

NMFS considers exposures of cetaceans and pinnipeds to anthropogenic received sound levels ≥ 160 dB (rms) to be a "take by harassment" (Level B harassment) that could potentially result in disturbance of these animals (NMFS 2005, 71 FR 50027).

The number of exposures was based on direct observations/counts of cetaceans and pinnipeds during seismic activities. As requested by NMFS in section 8(v) of the IHA, estimates of take by Level B harassment were based on presence in the 160 dB harassment zone. During the Cook Inlet 2014 Seismic Survey "presence" was interpreted as visual observation.

5. Results

5.1. Effort from Vessels and Land

A total of 2,989.8 hr of on-watch PSO effort occurred from vessels or land during the Cook Inlet 2014 Seismic Survey. Most (78 %) such effort occurred from vessels (2,330.4 hr) with the remaining 659.4 hr from land stations. PSOs were on watch during all daylight periods with active seismic operations (i.e., seismic periods) as required by the IHA, and during most non-seismic periods. The majority (76 %) of on-watch PSO effort occurred during non-seismic periods (2,273.0 hr), with the remaining 24 % during seismic periods (716.8 hr) (Table 8). PSO seismic effort occurred primarily while the full 1,760 cubic inch (cui) airgun array operated (277.8 hr), followed by 91.6 hr with array volumes > 440 cui (excluding the 1,760 cui), 87.9 hr with volumes < 440 cu in (excluding the 10 cui), 33.3 hr with array volume 440 cui, and 16.0 hr with the 10 cui mitigation airgun (Table 8, Figure 5).

Table 6. Total On-Watch effort (hr) by month and vessel or land platform.

	Vessel				Land	Total
Month	***Arctic Wolf***	***Dreamcatcher***	***Peregrine***	**All Vessels**		
April	0.0	355.0	327.4	682.4	194.3	876.7
May	0.0	422.3	423.9	846.2	158.6	1004.8
June	352.3	385.8	63.6	801.8	306.6	1108.3
Total	**352.3**	**1163.1**	**814.9**	**2330.4**	**659.5**	**2989.8**

Table 7. Total On-Watch effort in distance traveled (km) by month and vessel.

Month	*Arctic Wolf*	*Dreamcatcher*	*Peregrine*	Total All Vessels
April	0.0	418.2	875.0	1,293.2
May	0.0	647.7	1,172.2	1,819.9
June	810.8	398.6	225.7	1,435.2
Total	**810.8**	**1,464.5**	**2,272.9**	**4,548.2**

Table 8. All vessel and land On-Watch effort (hr) during seismic and non-seismic periods.

Platform	Seismic Effort (hr)	Non-Seismic Effort (hr)	Totals (hr)
Vessel	526.3	1,804.1	2,330.4
Land	190.5	468.9	659.4
Total	**716. 8**	**2,273.0**	**2,989.8**

Figure 4. Total vessel and Land Effort (hr) during Seismic and Non-Seismic Periods.

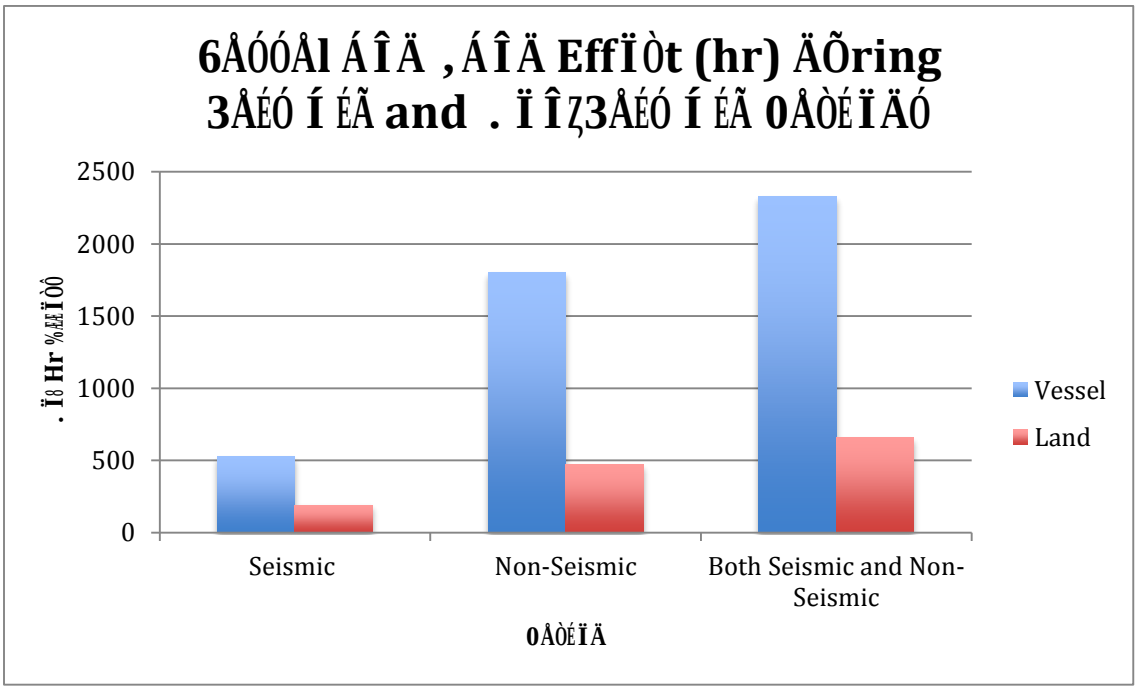
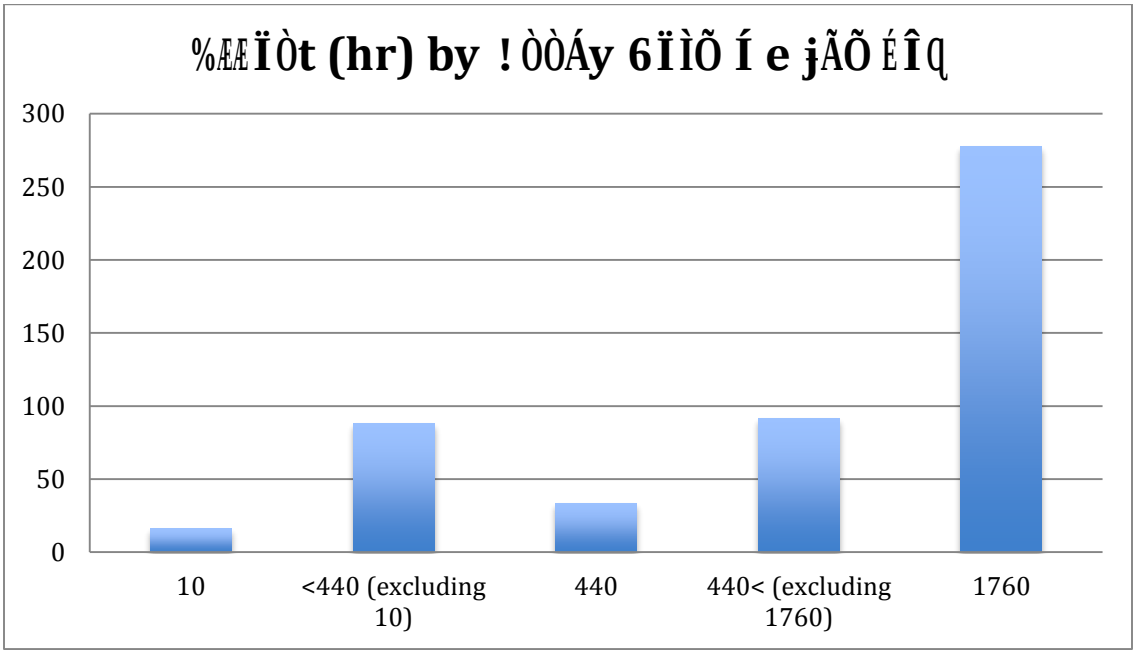


Figure 5. Total effort (hr) by seismic array or airgun volumes (cu in).



5.2. Marine Mammal Sighting Results

5.2.1. Sightings from Vessels and Land

Eight species of marine mammals were confirmed as observed from vessels and land as follows: 3 mysticetes (the minke, gray and humpback whale), 3 odontocetes (the beluga whale, Dall's and harbor porpoise) and 2 pinnipeds (the harbor seal and Steller sea lion). Unidentified marine mammals included unidentified large whale, unidentified dolphin or porpoise and unidentified pinniped.

A total of 645 marine mammal groups (922 individuals) were observed from vessel and land platforms during the Cook Inlet 2014 Seismic Survey (Table 9). The harbor seal was the most frequently observed species with 492 groups (613 individuals), followed by the harbor porpoise (77 groups of 113 individuals), and beluga whale (57 groups of 170 individuals). Large whale sightings consisted of 5 humpback groups (6 individuals), 1 gray whale and 2 minke whale groups (3 individuals). Other observations included 2 groups (3 individuals) of Dall's porpoise, 2 Steller sea lions, 1 unidentified baleen whale, 4 unidentified dolphin or porpoise groups (8 individuals) and 2 unidentified pinnipeds (Table 9). The majority (61%, 394 groups) of sightings were made from land platforms, followed by 139 (22 %) from the *Dreamcatcher*, 60 (9 %) from the *Peregrine* and 52 (8 %) from the *Arctic Wolf* (Table 10; Figure 6).

Table 9. Sighting summary of all marine mammals observed from vessel and land platforms.

Species	No. Groups	No. Estimated Individuals
Beluga Whale	57	170
Dall's Porpoise	2	3
Gray Whale	1	1
Harbor Porpoise	77	113
Harbor Seal	492	613
Humpback Whale	5	6
Minke Whale	2	3
Steller Sea Lion	2	2
Unid Baleen Whale	1	1
Unid Dolphin or Porpoise	4	8
Unid Pinniped	2	2
Total	**645**	**922**

Most (87 %) of the total 645 marine mammal groups observed from vessel and land platforms were seen during non-seismic periods, when most (76%) PSO effort occurred. The remaining groups (13 %) were seen during seismic periods (n = 85). To account for differences in effort during seismic and non-seismic periods and to

facilitate comparisons using normalized data, sighting rates (i.e., the number of groups seen per hr of effort) are applied and presented in Section 5.2.2, "Sightings by Environmental Conditions" and Section 5.2.3, "Marine Mammal Behavior."

Table 10. Number of groups and estimated individuals observed from vessel and land platforms.

Species	*Arctic Wolf*		*Dreamcatcher*		*Peregrine*		Land	
	No. Groups	No. Ind.	No. Groups	No. Ind.	No. Groups	No. Ind.	No. Groups	No. Ind.
Beluga Whale			25	96	13	33	19	41
Dall's Porpoise			2	3				
Gray Whale	1	1						
Harbor Porpoise	16	20	20	38	15	24	26	31
Harbor Seal	31	33	89	126	25	74	347	380
Humpback Whale	1	2	2	2	2	2		
Minke Whale	2	3						
Steller Sea Lion			1	1	1	1		
Unid. Baleen Whale	1	1						
Unid. Dolphin or Porpoise					3	7	1	1
Unid. Pinniped					1	1	1	1
Totals	**52**	**60**	**139**	**266**	**60**	**142**	**394**	**454**

Figure 6. Map of all marine mammal groups observed from vessel and land platforms.

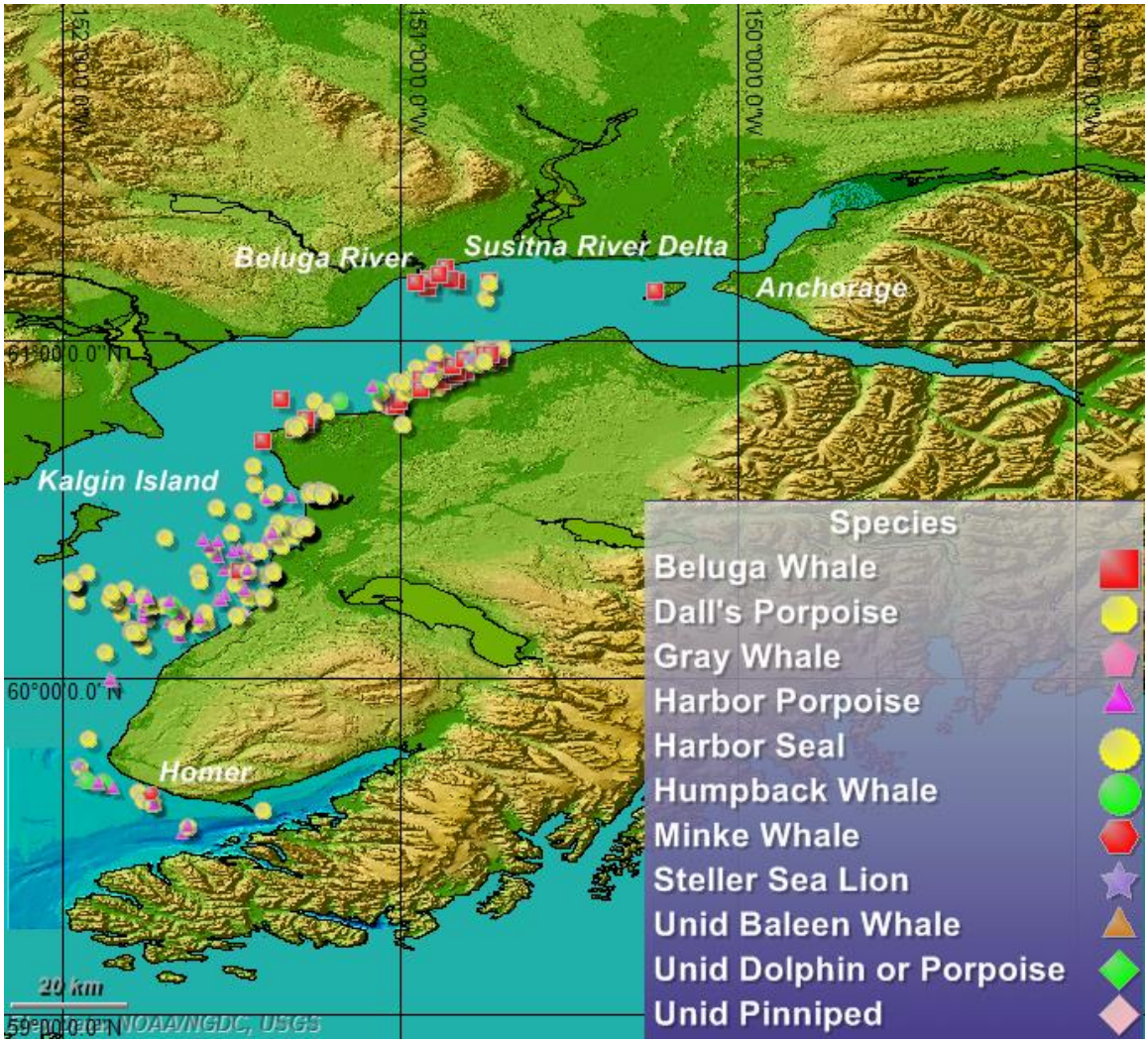


Figure 7. Map of all beluga whale groups observed from vessel and land platforms.

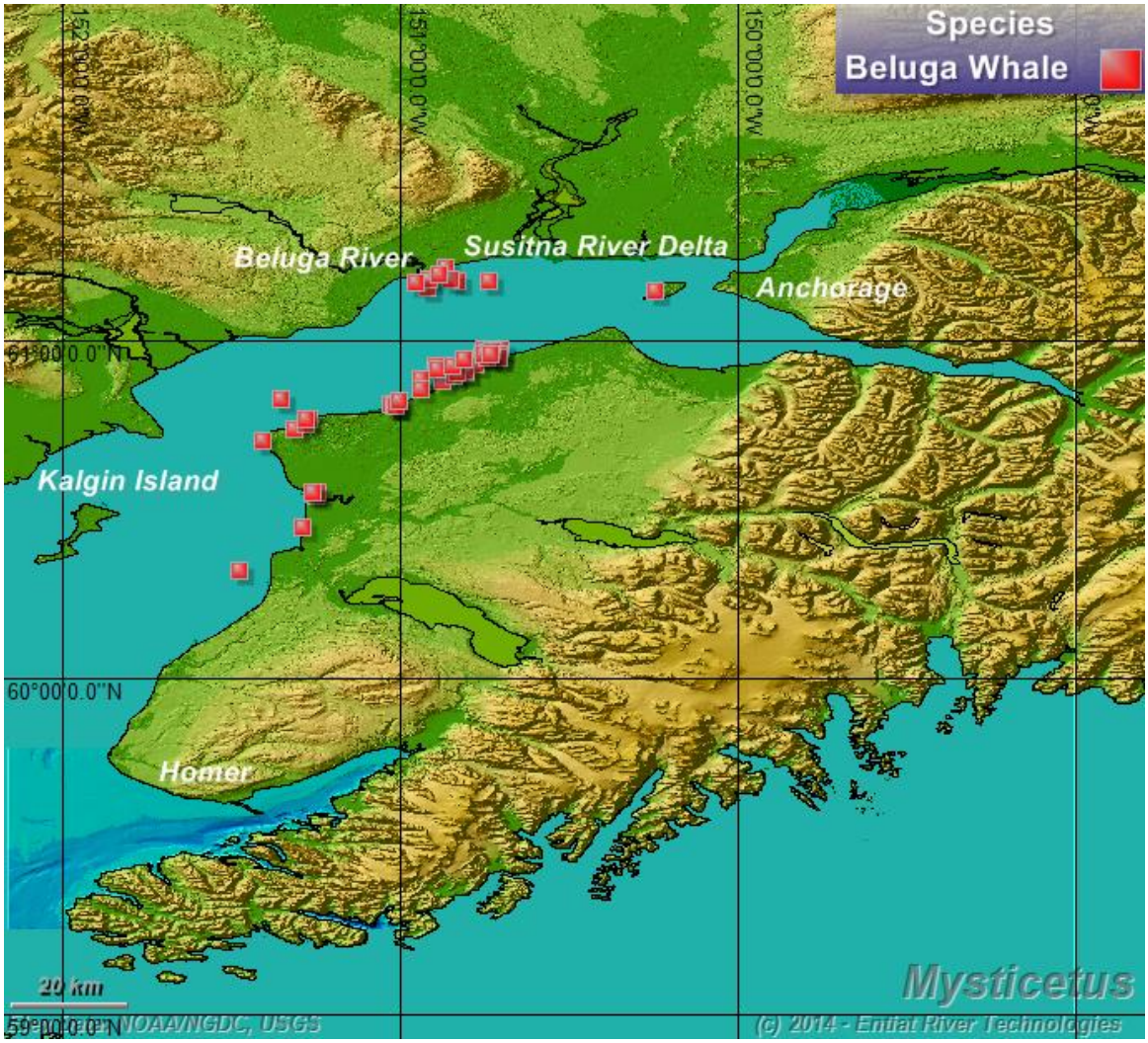


Figure 8. Map of all pinniped groups observed from vessel and land platforms.

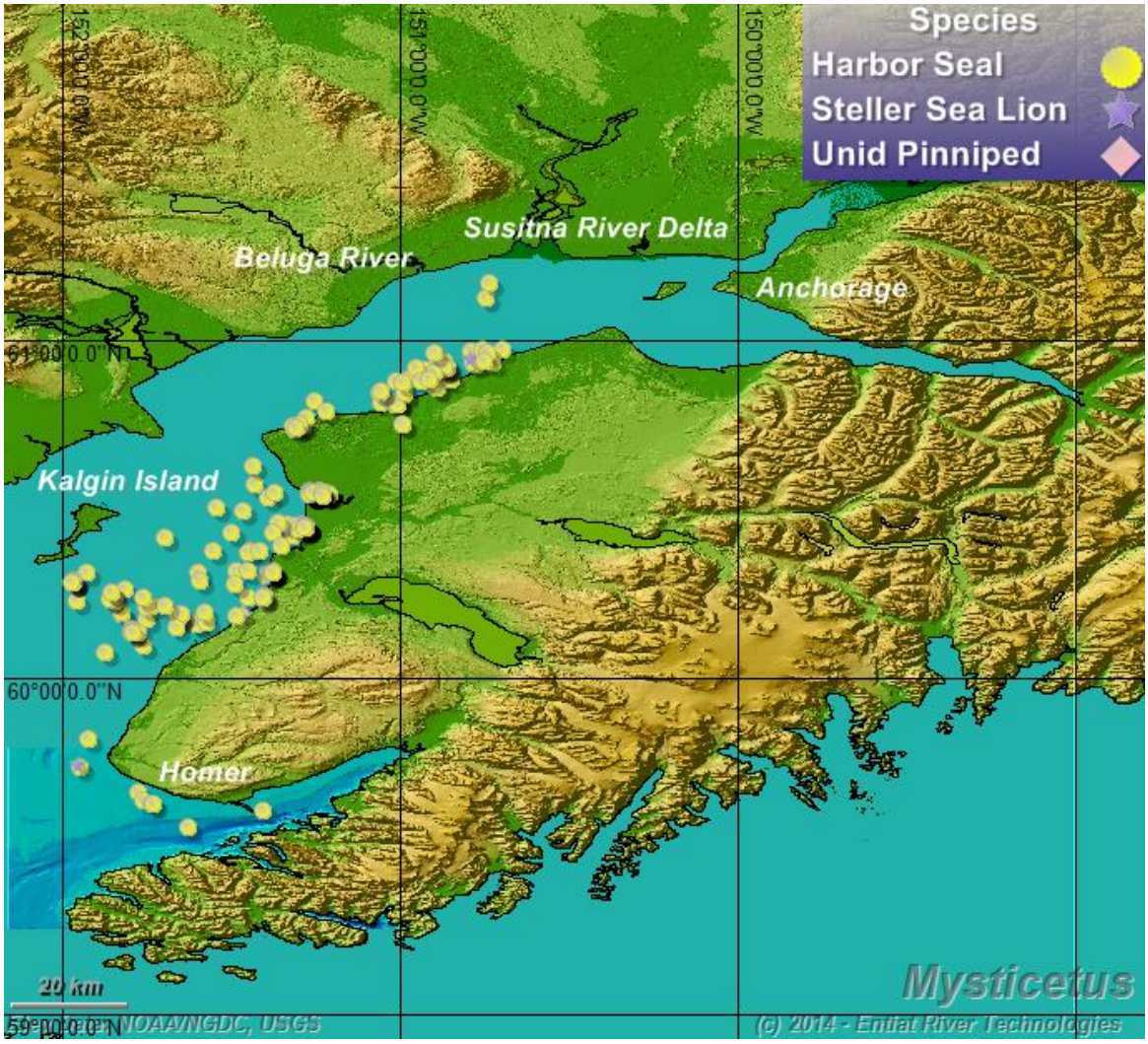


Figure 9. Map of all large whale (humpback, gray and minke whale) groups observed from vessel and land platforms.

Figure 10. Map of all dolphin and porpoise groups observed from vessel and land platforms.

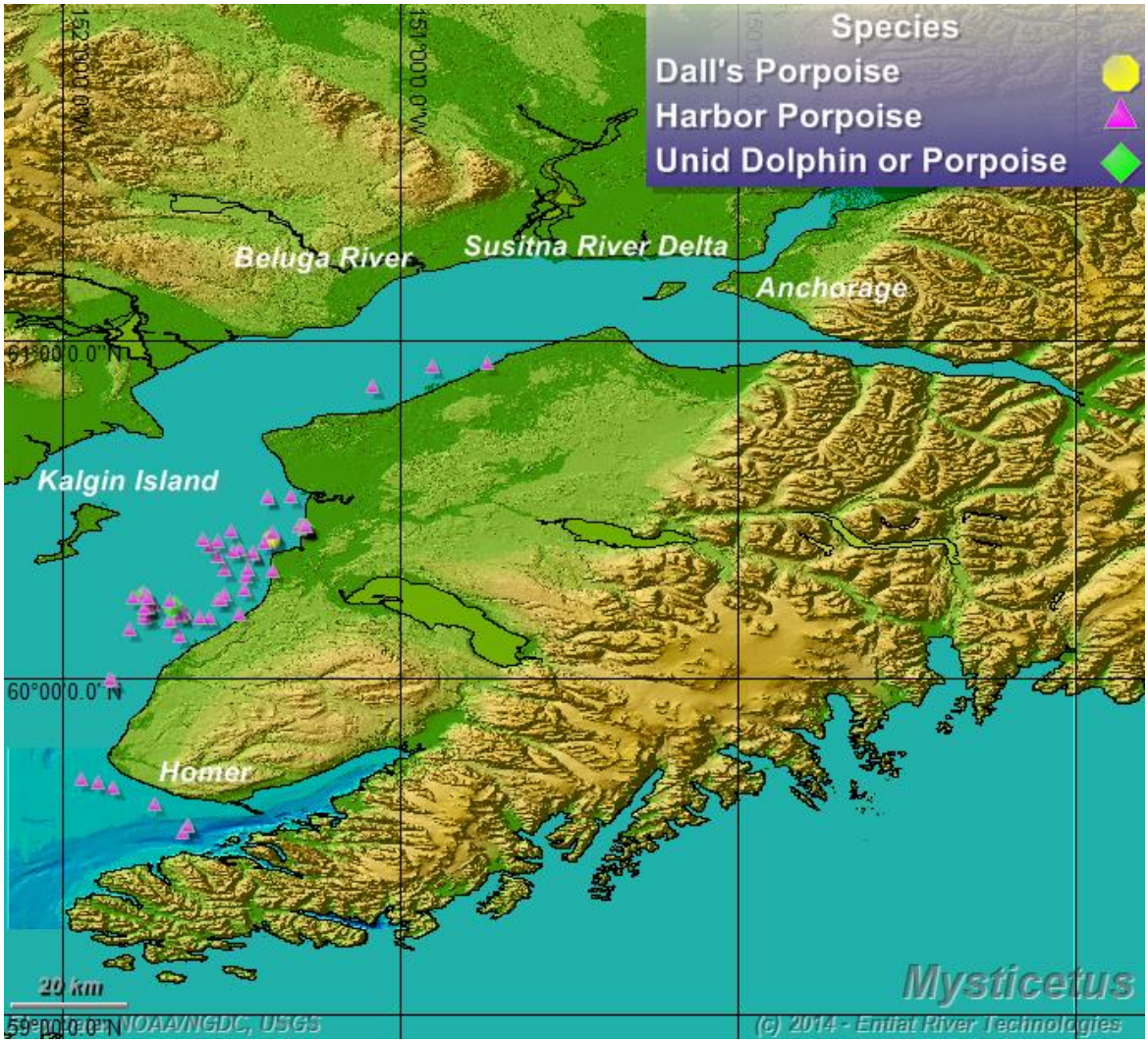
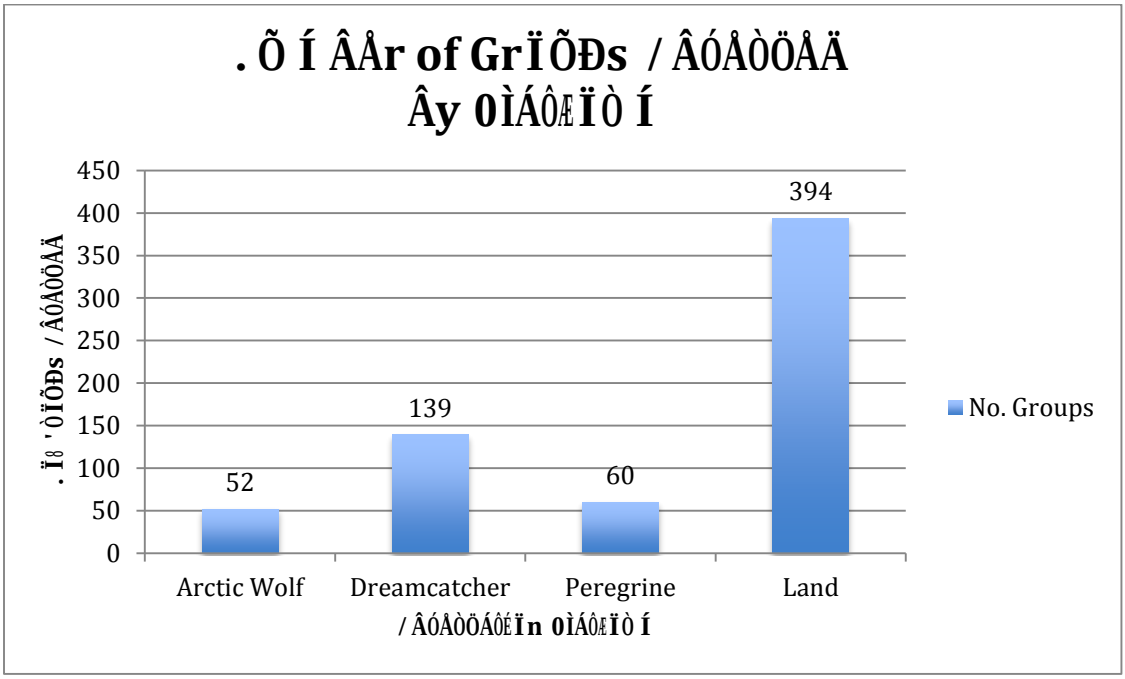


Figure 11. Number of marine mammal groups observed from vessel and land platforms.



5.2.2. Sightings by Environmental Conditions

The number of marine mammal groups observed generally decreased with increasing Bf sea state conditions (Figure 12). Most marine mammal groups (37 %) were seen during < Bf 3 observation conditions. Higher Bf conditions characterized by many whitecaps made it difficult to see marine mammals, especially seals (Figure 12). As expected, sightings were most frequent during visibility conditions when PSOs could see further away (Figure 13).

Figure 12. Number of marine mammal groups observed per effort hour from vessel and land platforms during Beaufort sea states (Bf) 0-6.

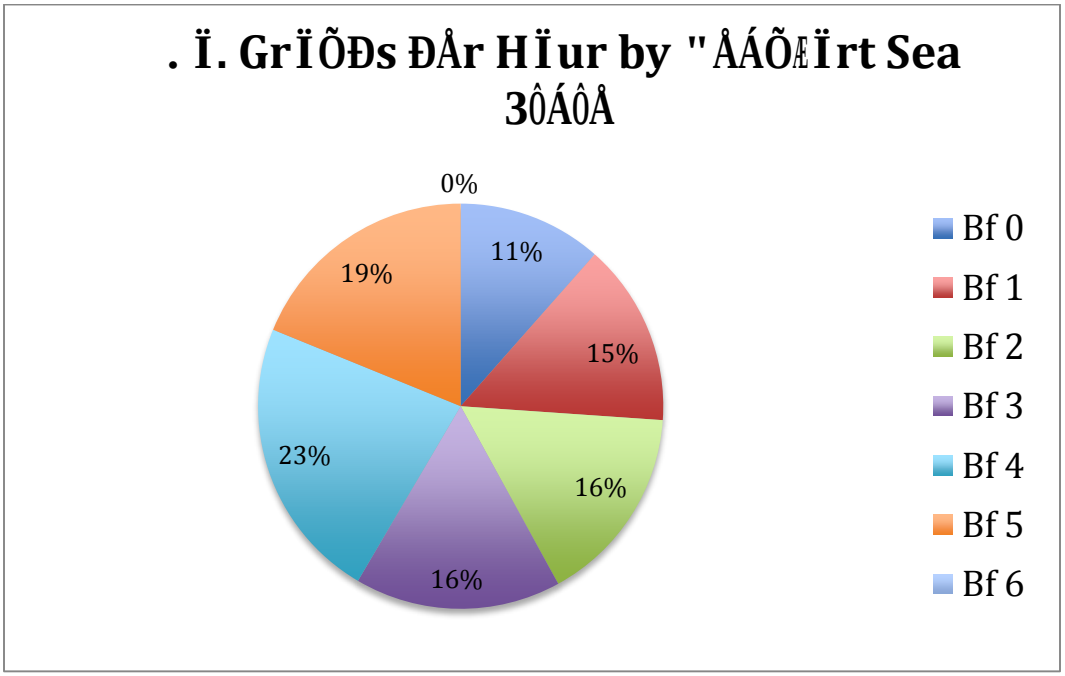
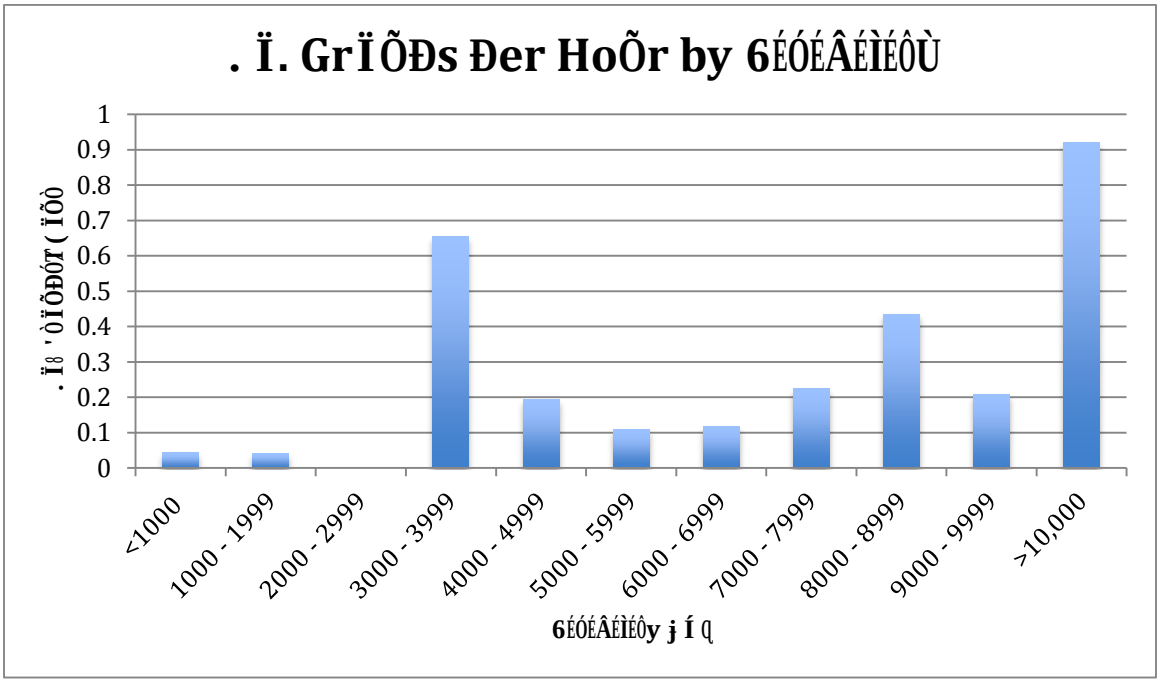


Figure 13. Number of marine mammal groups observed per effort hour from vessel and land platforms by visibility distance categories.



5.2.3. Marine Mammal Behavior

Behavior, sightings, and sighting rates by seismic and non-seismic periods are described separately below for beluga whales, other odontocetes, mysticetes and pinnipeds (Table 11). Behavior was recorded for 607 (94 %) of the total 645 marine mammal groups observed. No behavior was recorded for the remaining 38 (6 %) sightings, typically because behavior was difficult to determine for distant sightings or because viewing conditions were limited at the time (e.g., high Bf sea state).

Table 11. Number of marine mammal groups observed during seismic and non-seismic periods, based on pooled vessel and land data.

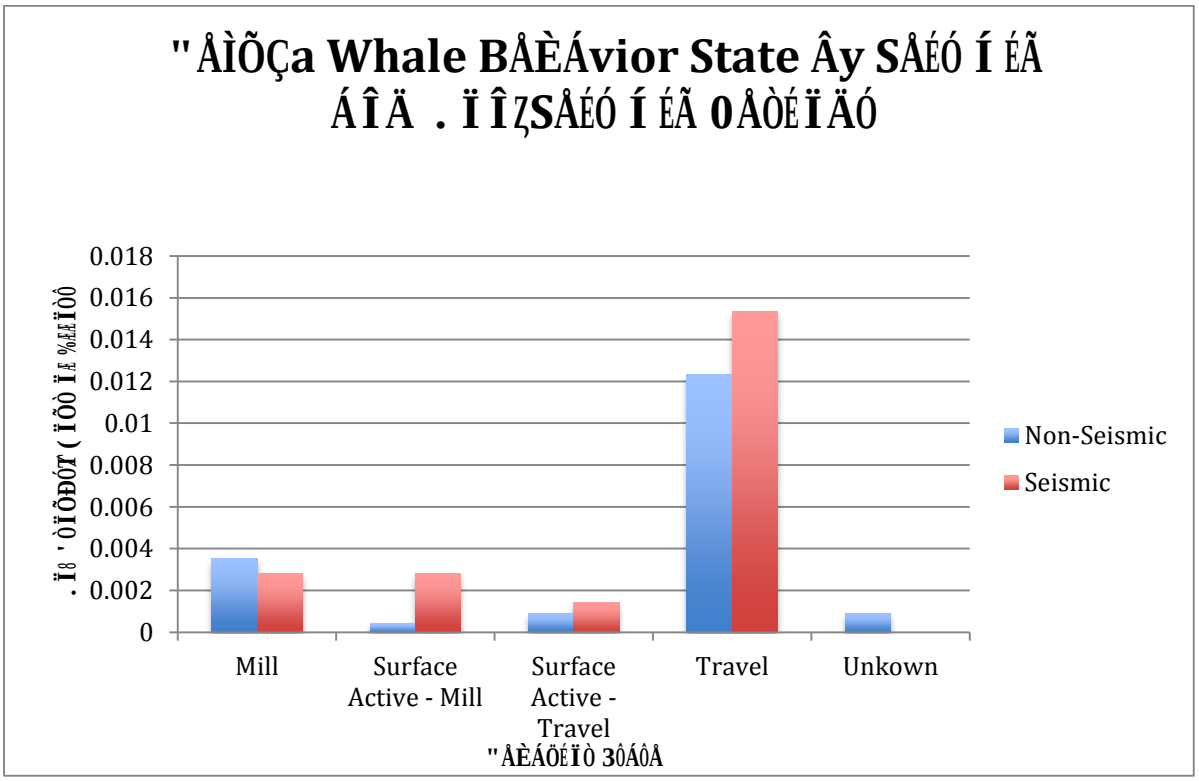
Species	Non-Seismic (2,273.0 hr effort)	Seismic (716.8 hr effort)	Total
Beluga Whale	41	16	57
Dall's Porpoise	2	0	2
Gray Whale	1	0	1
Harbor Porpoise	61	16	77
Harbor Seal	441	51	492
Humpback Whale	3	2	5
Minke Whale	2	0	2
Steller Sea Lion	2	0	2
Unid. Baleen Whale	1	0	1
Unid. Dolphin or Porpoise	4	0	4
Unid. Pinniped	2	0	2
Totals	**560**	**85**	**645**

Beluga whales

A total of 57 beluga whale groups (*n* = ~170 estimated individuals) were observed from vessel and land platforms during the Cook Inlet 2014 Seismic Survey (Table 11). More beluga whale groups (*n* = 41 groups) were observed during non-seismic periods (2,273.0 hr PSO effort) than during seismic periods (*n* = 16 during 716.8 hr effort) (Tables 11). This resulted in similar numbers of groups observed per hour during both seismic and non-seismic periods (described further in Section 5.4, "Usable Data & Sighting Rates").

Behavior states based on the number of groups observed per hour engaged in each activity are shown in Figure 14. The most frequently observed behavior was travel (based on *n* = 30 groups) followed by mill (*n* = 10). Surface-active behaviors (mill and travel) were observed relatively infrequently during both seismic and non-seismic periods.

Figure 14. Sighting rates of initial behavior state of beluga whale groups during seismic and non-seismic periods, based on pooled vessel and land data.

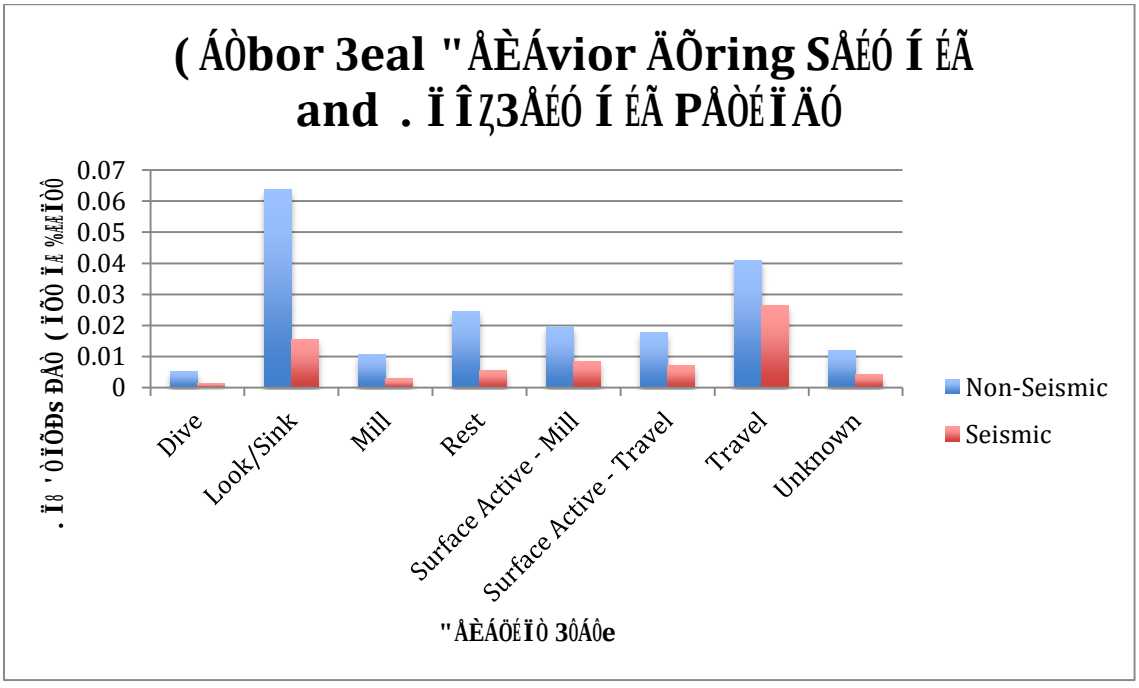


Pinniped

A total of 496 pinniped groups (*n* = 617 estimated individuals) were observed from vessel and land platforms during the Cook Inlet 2014 Seismic Survey. Nearly all (99 %) of the total pinniped groups sighted were harbor seals (Table 11). Thus, pinniped behavior was summarized for seismic and non-seismic periods only for harbor seals; sample sizes were too small for the other species (Steller sea lion and unidentified pinniped) to provide meaningful results (Figure 15). Most (90 %) of the 492 harbor seal groups were seen during non-seismic conditions (Table 11). This resulted in a higher harbor seal sighting rate during seismic compared to non-seismic periods (described further in Section 5.4, "Usable Data & Sighting Rates").

Behavior states based on the number of groups observed per hour engaged in each activity are shown in Figure 15. The most commonly seen harbor seal behavior per hr of effort during non-seismic periods was look/sink followed by travel. During seismic periods, travel was seen more commonly than look/sink (Figure 15).

Figure 15. Sighting rates of initially observed behavior of harbor seal groups during seismic and non-seismic periods, based on pooled vessel and land data.

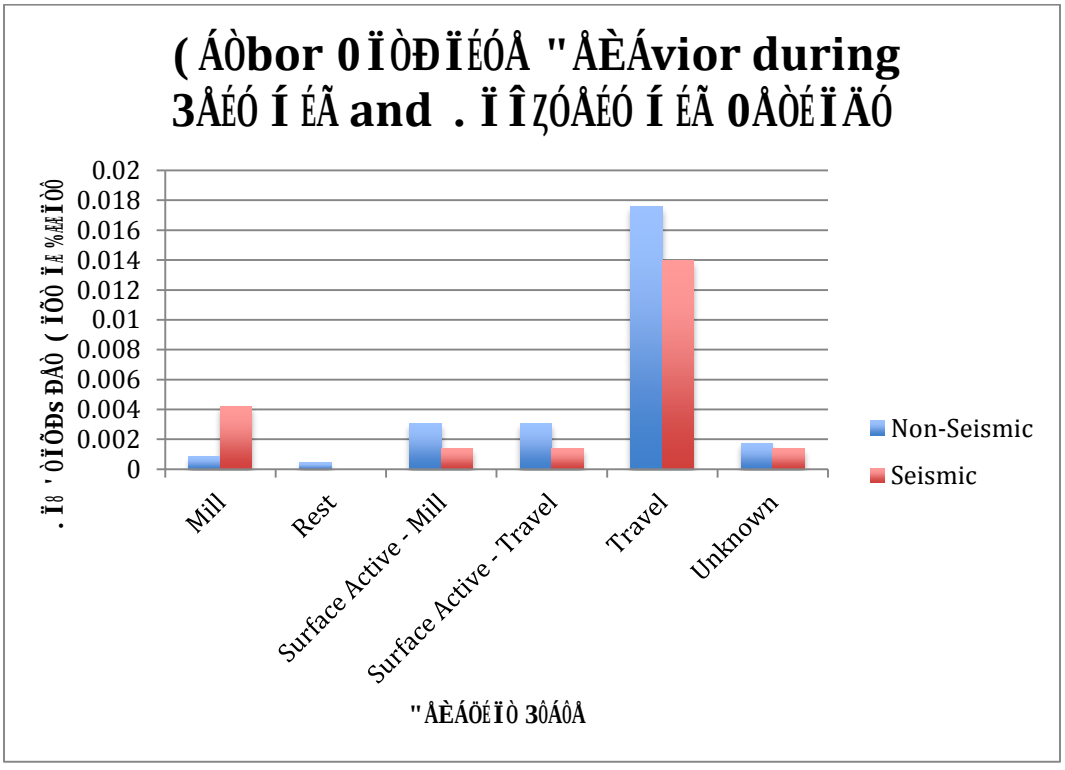


Other Odontocetes

Two species of odontocetes other than beluga whales were identified during the Cook Inlet 2014 Seismic Survey: the harbor porpoise and Dall's porpoise. A total of 67 groups of odontocetes including 61 harbor porpoise, two Dall's porpoise and four unidentified dolphin or porpoise groups were observed during non-seismic periods (Table 11). During seismic periods, 16 harbor porpoise groups were observed. This resulted in similar group sighting rates of harbor porpoise during non-seismic periods (described further in Section 5.4, "Usable Data & Sighting Rates").

Behavioral analyses during seismic and non-seismic periods were limited to harbor porpoise due to the small number of sightings of Dall's porpoise and unidentified dolphin or porpoise. Among harbor porpoise groups during both seismic and non-seismic periods, travel was the most frequent behavior seen per hr of effort (based on *n* = 40 groups) followed by mill, surface-active mill or travel (*n* = 22 groups) (Figure 16).

Figure 16. Sighting rates of initially observed behavior of harbor porpoise groups during seismic and non-seismic periods, based on pooled vessel and land data.

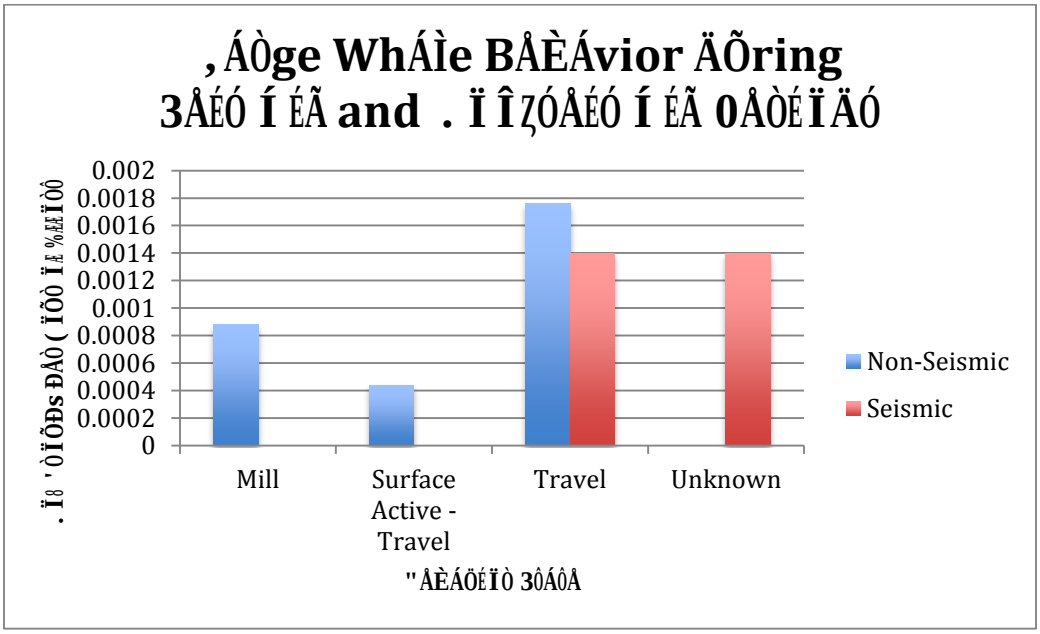


Mysticetes

Three species of large whale (all mysticetes) were identified during the Cook Inlet 2014 Seismic Survey: gray, minke and humpback whales. A total of 9 groups of large whales were observed: a single gray whale, 2 minke whale groups, 5 humpback whale groups (including 1 mom/calf pair) and one unidentified baleen whale (Table 11). Due to the small number of sightings of large whales these species were pooled for behavioral analyses. Of the 9 total large whale groups, 2 were observed during seismic periods and 7 during non-seismic periods. This resulted in a similarly low number of baleen whale groups observed per hour during non-seismic and seismic periods (described further in Section 5.4, "Usable Data & Sighting Rates").

Behavior states based on the number of groups observed per hour engaged in each activity are shown in Figure 17. During non-seismic periods, travel was the most frequently observed behavior (based on n = 5 groups), followed by mill (n = 2 groups). The two sightings during seismic periods were both traveling humpback whales and are described in further detail below.

Figure 17. Sighting rates of initially observed behavior of large mysticete whale groups observed during seismic and non-seismic periods, based on pooled vessel and land data.



5.3. Closest Point of Approach (CPA)

Closest point of Approach (CPA) was calculated only for marine mammals sighted from the source vessels (the *Arctic Wolf* and *Peregrine*) for comparison between seismic and non-seismic periods. Sightings from these two source vessels were pooled to increase sample size due to the limited number of groups seen separately from the *Arctic Wolf* and *Peregrine* (Figure 18). Overall, during non-seismic periods,

the number of marine mammal groups observed per hr decreased with increasing distance from the vessel based on CPA distance categories. This was to be expected since most sightings consisted of seals, which are increasingly difficult to see with increasing distance, particularly beyond about 500 m per Figure 18.

CPA patterns differed somewhat by species. Overall, during non-seismic periods, the vast majority (85 %) of all harbor seal group CPAs occurred within 500 m of the source vessel, with relatively few groups seen during seismic periods (Figure 21). Harbor porpoise CPAs showed a similar pattern, with the majority of porpoise groups seen < 500 m from the source vessel during non-seismic periods. However, during seismic periods, all harbor porpoises were seen > 500 m from the source vessel, based on a small sample size (*n* = 4 groups seen during seismic periods) (Figure 20). Most beluga whale group CPAs (*n* = 7 or 58 %) occurred 500-1999 m from the source vessel; only two groups were seen during seismic periods, one of which had a CPA of < 500 m from the source vessel (Figure 19).

Figure 18. CPA sighting rates for all marine mammal groups observed from the source vessel (*Arctic Wolf* or *Peregrine*) during seismic and non-seismic periods, based on pooled vessel and land data.

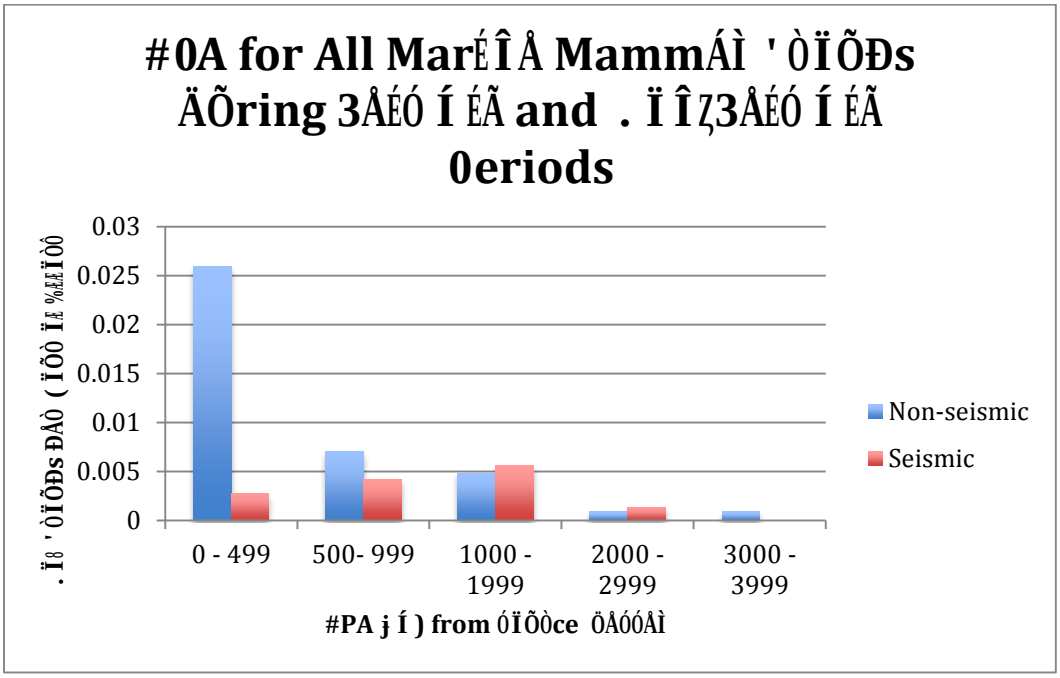


Figure 19. CPA sighting rates for beluga whale groups observed from the *source* vessel *(Arctic Wolf or Peregrine)* during seismic and non-seismic periods, based on pooled vessel and land data.

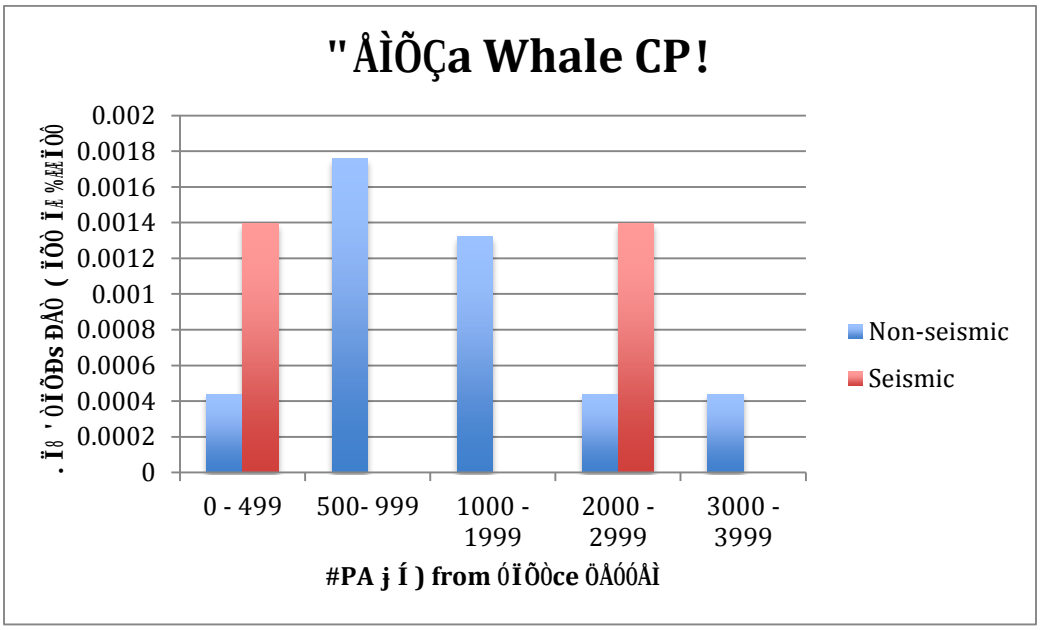


Figure 20. CPA sighting rates for harbor porpoise groups observed from the source vessel (*Arctic Wolf* or *Peregrine*) during seismic and non-seismic periods, based on pooled vessel and land data.

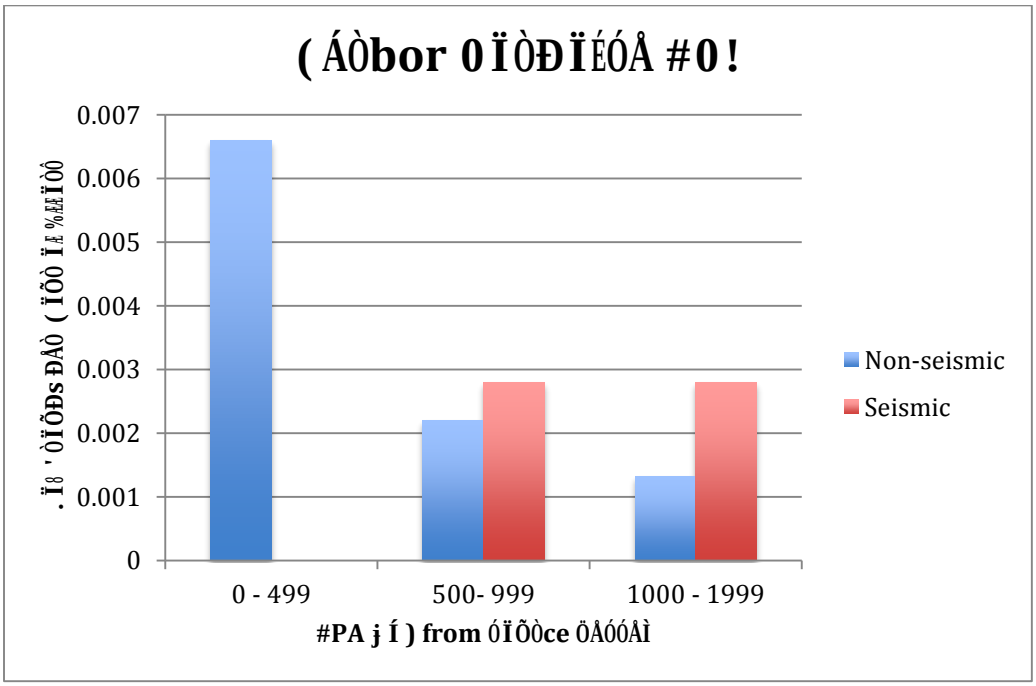


Figure 21. CPA sighting rates for harbor seal groups observed from the source vessel (*Arctic Wolf* or *Peregrine*) during seismic and non-seismic periods, based on pooled vessel and land data.

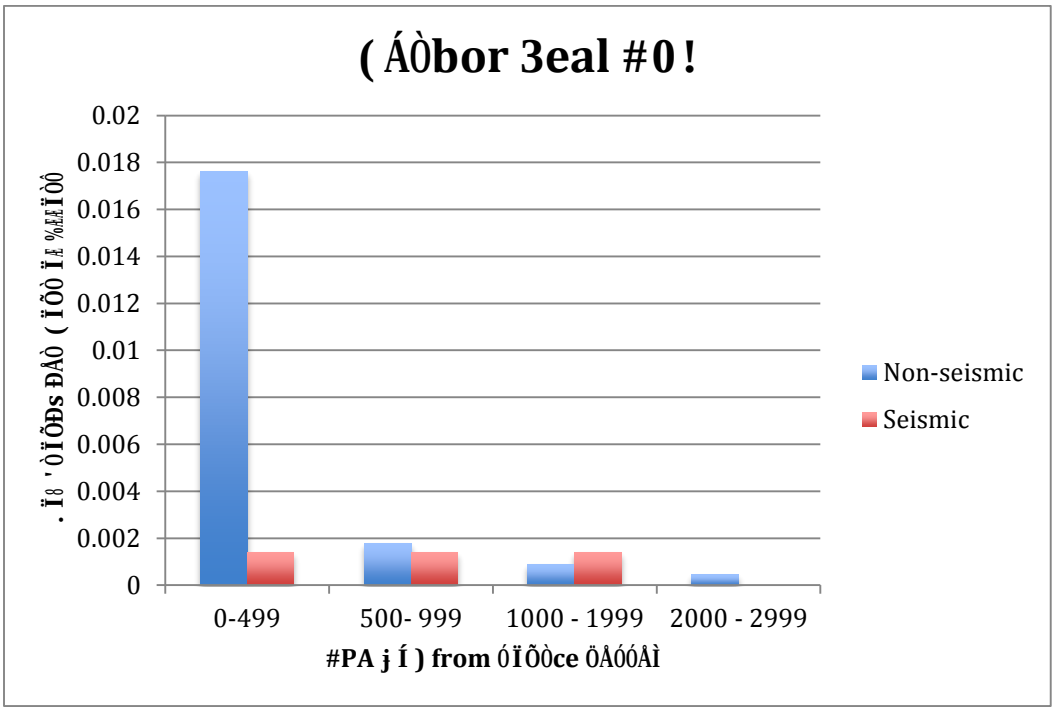
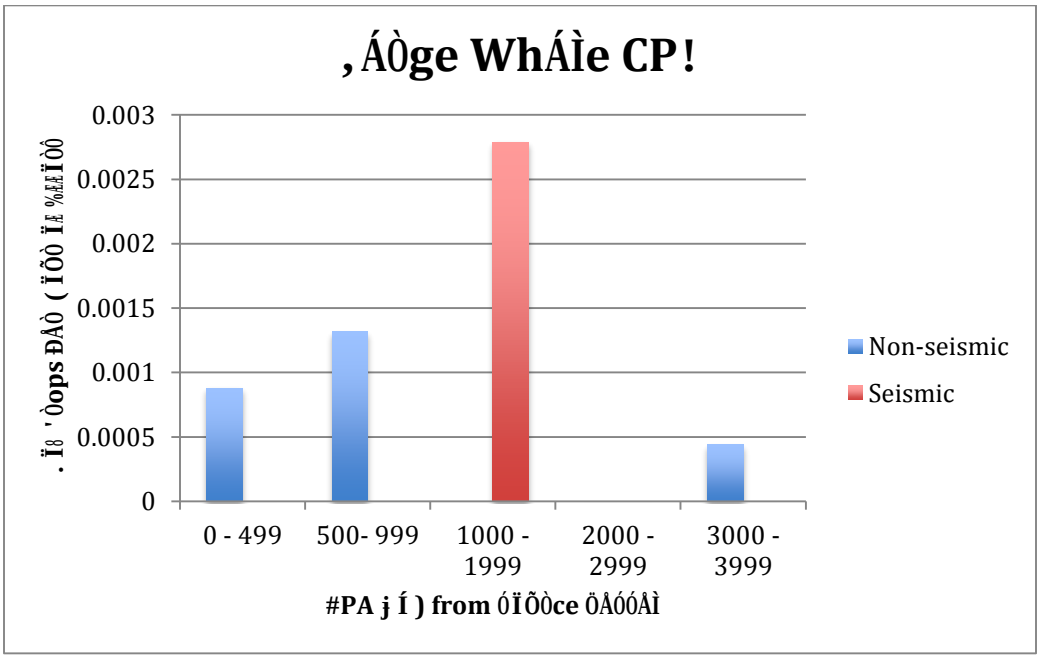


Figure 22. CPA sighting rates for large mysticete whale groups observed from the source vessel (*Arctic Wolf* or *Peregrine*) during seismic and non-seismic periods, based on pooled vessel and land data.



5.4. Usable Data & Sighting Rates

Sighting rates were calculated only for periods and sightings made during "usable effort" to standardize sighting conditions. Usable effort was defined in Table 6 (i.e., limited to periods when PSOs were on watch under the following conditions: visibility > 1 km, daylight, Bf) < 5). Total hr of usable effort was 2,707.0, consisting of 680.4 hr (25 %) during seismic periods and 2026.7 hr (75 %) during non-seismic periods (Table 12). Usable sightings were limited to those made during usable effort periods. Sighting rates (number of groups seen per hr) were calculated based as follows: total number of groups observed during usable effort divided by total usable effort hr. Sighting rates were calculated separately for seismic and non-seismic periods.

Table 12. "Usable" effort by vessel and land platforms during seismic and non-seismic periods.

Platform	"Usable" Seismic Effort (hr)	"Usable" Non-Seismic Effort (hr)	Total "Usable" Effort (hr)
Vessel	491.9	1,577.5	2,069.4
Land	188.5	449.1	637.6
Total	**680.4**	**2,026.6**	**2,707.0**

Overall, harbor seals had the highest sighting rate (0.169 groups/hr), followed by harbor porpoises (0.025) and beluga whales (0.020). Only four of the total 8 species seen during the survey were seen during seismic periods: the beluga whale, harbor porpoise, harbor seal and humpback whale (Table 13, Figure 23). Sample sizes were too small for the humpback whale and the remaining species/species groups to provide meaningful sighting rates by seismic vs. non-seismic periods, though they are presented in Table 13.

Sighting rates were generally similar during seismic and non-seismic periods for beluga whales and harbor porpoises. However, the harbor seal sighting rate was over twice as high during non-seismic vs. seismic periods (Figure 24). Notably, seismic operations occurred primarily during slack tides, thus most seismic PSO effort also occurred during slack tides. In contrast, most non-seismic PSO effort occurred during non-slack tides. It is therefore possible that differences in harbor seal sighting rates for non-seismic and seismic periods may have been influenced by difference in the tidal cycle.

Table 13. Species group sighting rates during seismic and non-seismic periods.

Species	Non-Seismic (2,026.6 hr usable effort)		Seismic (680.4 hr usable effort)		Non-Seismic & Seismic Combined (2,707.0 hr usable effort)	
	No. Groups	Sighting Rate (grp/hr)	No. Groups	Sighting Rate (grp/hr)	No. Groups	Sighting Rate (grp/hr)
Beluga Whale	39	0.019	16	0.024	55	0.020
Dall's Porpoise	2	0.001	0	0	2	0.001
Gray Whale	1	0.000	0	0	1	0.000
Harbor Porpoise	54	0.027	14	0.021	68	0.025
Harbor Seal	409	0.202	48	0.071	457	0.169
Humpback Whale	3	0.001	1	0.001	4	0.001
Minke Whale	1	0.000	0	0	1	0.000
Steller Sea Lion	2	0.001	0	0	2	0.001
Unid. Baleen Whale	1	0.000	0	0	1	0.000
Unid. Dolphin or Porpoise	2	0.001	0	0	2	0.001
Unid. Pinniped	2	0.001	0	0	2	0.001
Totals	**516**	**0.255**	**79**	**0.116**	**595**	**0.220**

Figure 23. Sighting rates (number of groups per hr) for all marine mammals during seismic and non-seismic periods based on "usable" sightings and effort from vessel and land platforms.

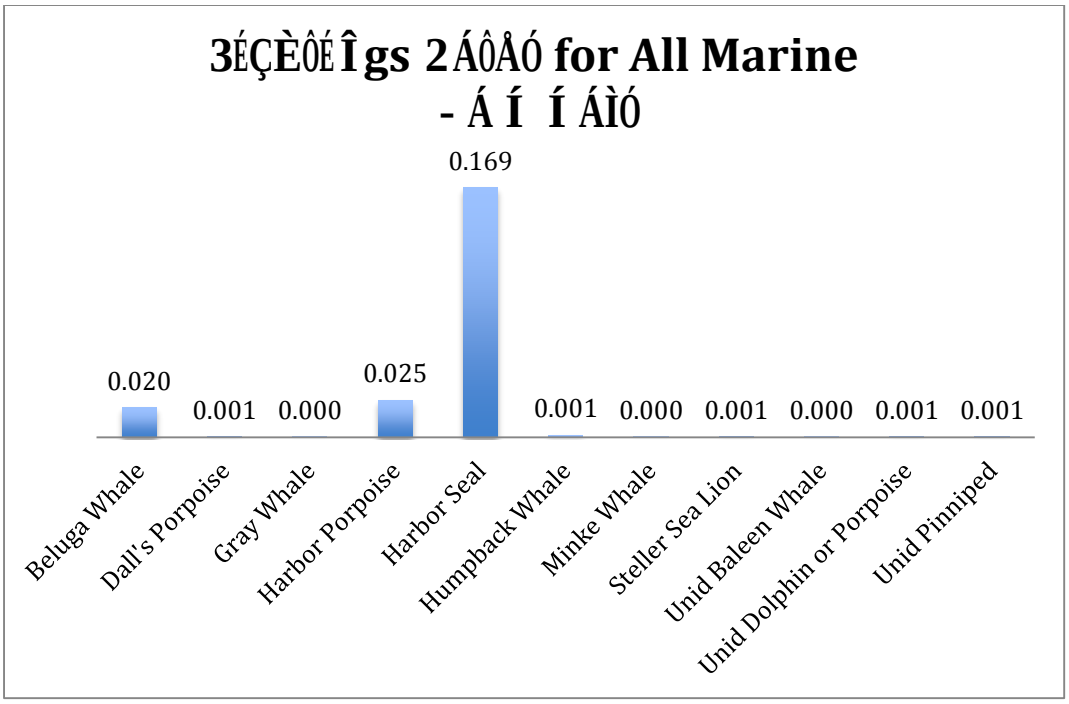
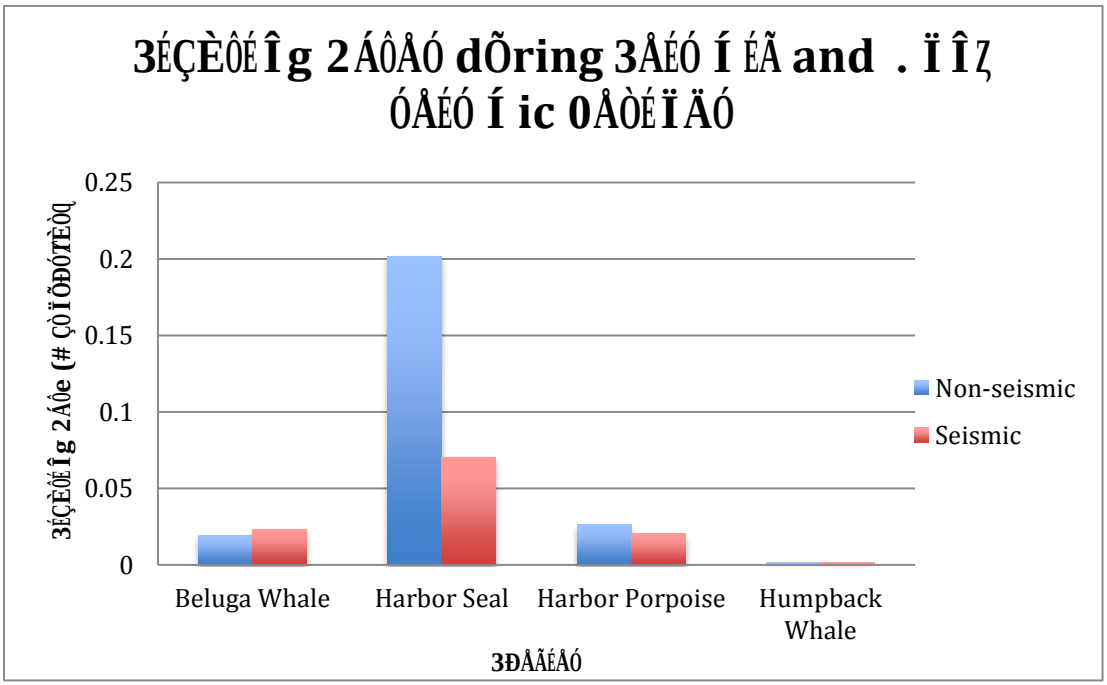


Figure 24. Sighting rates (number of groups per hr) during seismic and non-seismic periods for all marine mammals observed from vessel and land platforms.



5.5. Aerial Results

Flight paths followed during the aerial survey corresponded to those as described in the IHA, which identified two different areas to monitor depending on where project operations were occurring as follows. While project operations occurred in Zone 1, aerial surveys occurred in the upper inlet including the Susitna and Beluga river areas. Zone 1 operations and monitoring corresponded to the period from 2 April – 4 May. During the remainder of the project period from 5 May–27 June, when operations occurred in Zone 2, aerial monitoring was stipulated to occur within 30 km of the source vessel.

5.5.1. Aerial Effort

Aerial surveys occurred daily (weather permitting) for a total of ~1.5 hr in the survey area (Table 14). During the 88 days of operations aerial surveys flew 76 days and were canceled 11 days due to inclement weather. Most of the aerial effort (83 %) occurred during non-seismic periods with the remaining 17 % occurring during seismic periods (Table 14). Aerial tracklines corresponding to this effort are shown in Figure 3.

Table 14. Total aerial effort by seismic and non-seismic effort in the survey area.

Seismic Effort	Non-Seismic Effort	Totals
6.7 hr	32.7 hr	**39.4 hr**
1,206.2 km	5,696.8 km	**6,903.0 km**

5.5.2. Sightings from Aircraft

A total of 71 marine mammal groups (442 individuals) were observed from the aerial platform during the Cook Inlet 2014 Seismic Survey (Figure 25). The beluga whale was the most frequently observed species with 62 groups (~401 individuals), followed by the harbor seal (7 groups of ~39 individuals), and harbor porpoise (2 groups of 2 individuals) (Table 15).

Table 15. Sighting summary of marine mammals observed from the aerial platform.

Species	No. Groups	No. Estimated Individuals
Beluga Whale	62	401
Harbor Porpoise	2	2
Harbor Seal	7	39
Total	**71**	**442**

Figure 25. Map of species observed from aerial platform.

5.5.3. Behavior Observed from Aircraft

Behavior state was recorded for 67 (94 %) of the total 71 marine mammal groups observed from the aircraft. Overall, among beluga whales, travel was the most commonly seen behavior state (64 % of 62 groups), followed by milling and resting (Figure 26). Surface-active belugas whales were rarely observed. All 7 beluga groups seen during seismic periods were traveling (Figure 28).

Behavior state was more variable among the 7 harbor seal groups. Six different behavior states were seen among these 7 groups: surface active (*n* =2 groups) (e.g., involving behaviors that created splashing at the water surface), mill, rest, travel/swim and other (Figure 27). Of the two harbor seal groups seen during seismic periods, one was milling and one was "other behavior". The five groups seen during non-seismic periods were surface-active, resting, or swimming/traveling.

The two harbor porpoise groups observed from the aircraft were both seen during non-seismic periods and were engaged in travel and unknown behavior.

Figure 26. Beluga whale initial behaviors observed from the aerial platform.

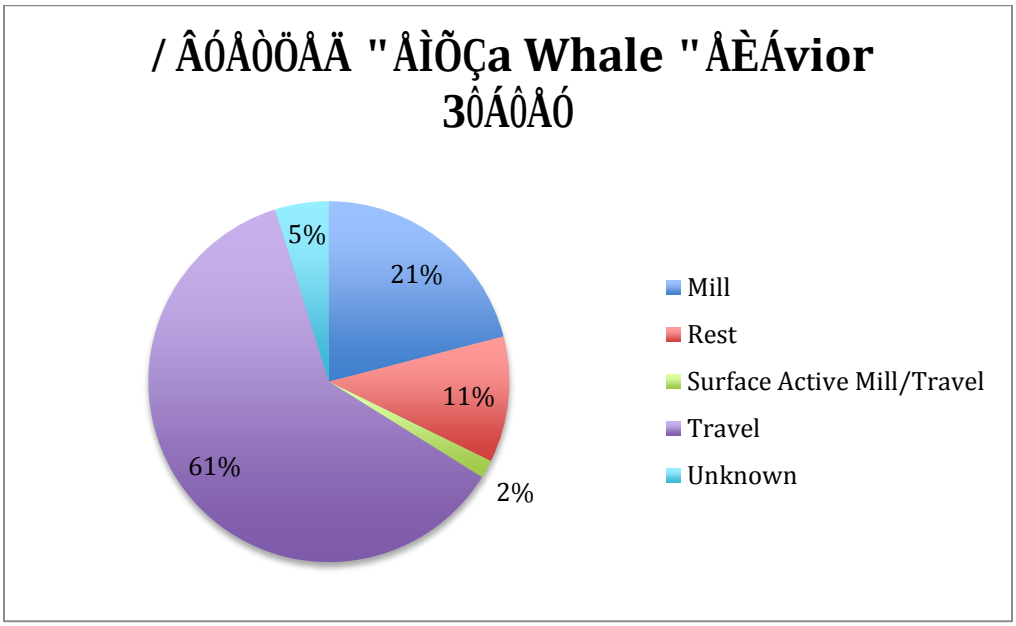


Figure 27. Harbor seal initial behaviors observed from the aerial platform.

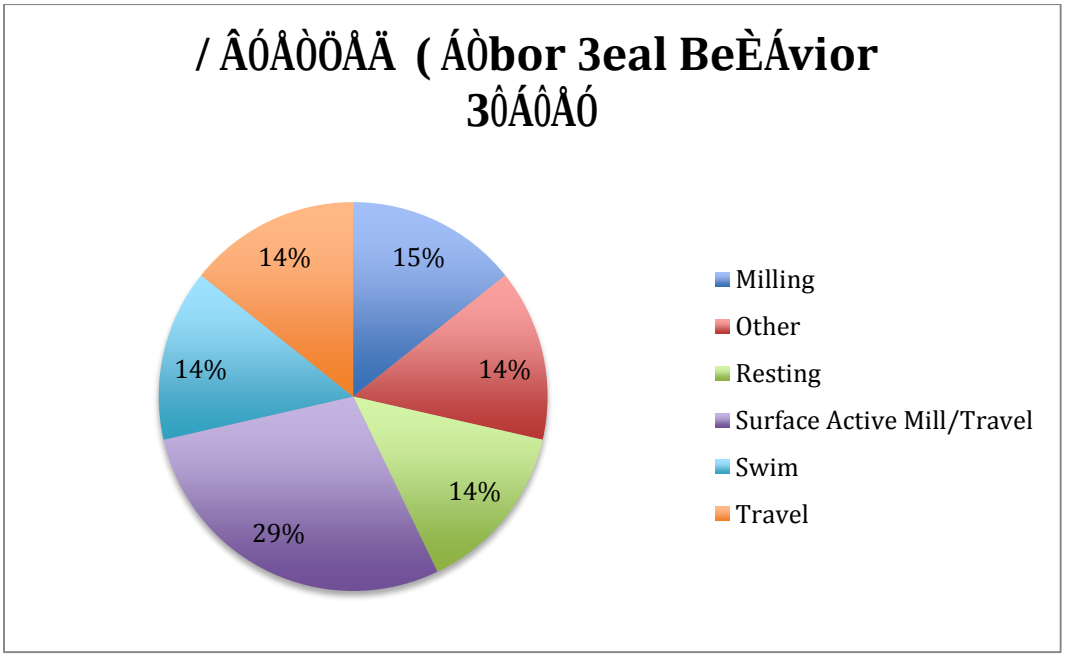


Table 16. Sighting summary of marine mammal groups observed from the aerial platform during seismic and non-seismic periods.

Species	Seismic	Non-Seismic	Total
Beluga	7	55	**62**
Harbor Seal	2	5	**7**
Harbor Porpoise	0	2	**2**

Figure 28. Beluga whale behavior state during seismic and non-seismic periods as observed from the aerial platform. Based on number of groups per hour of aerial effort (seismic and non-seismic).

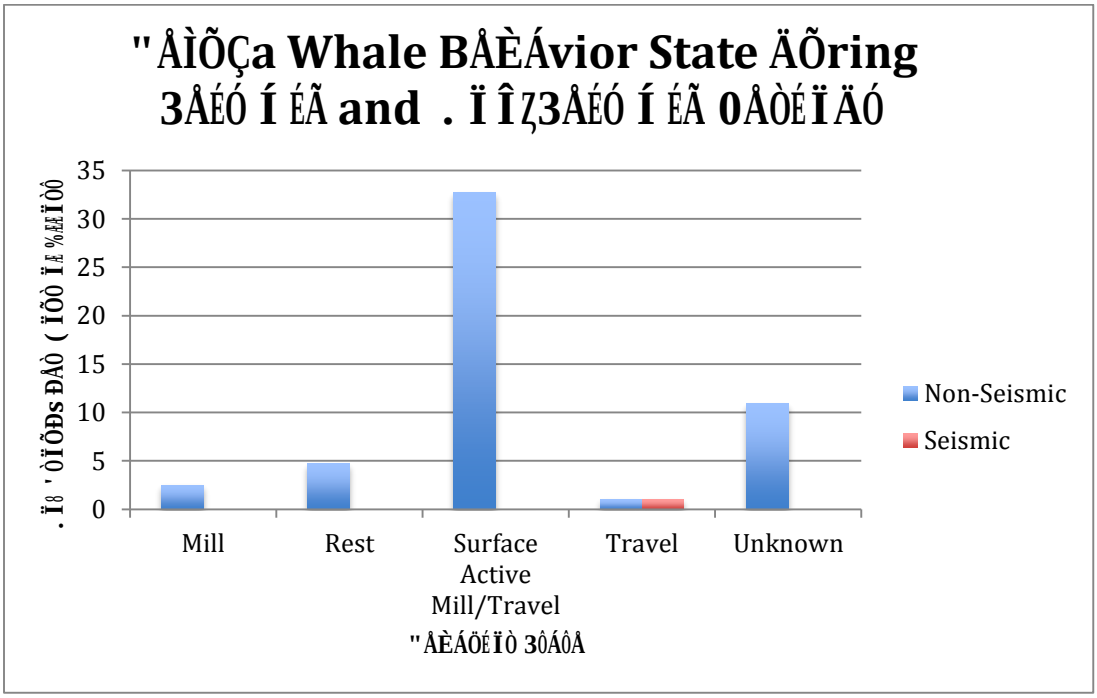
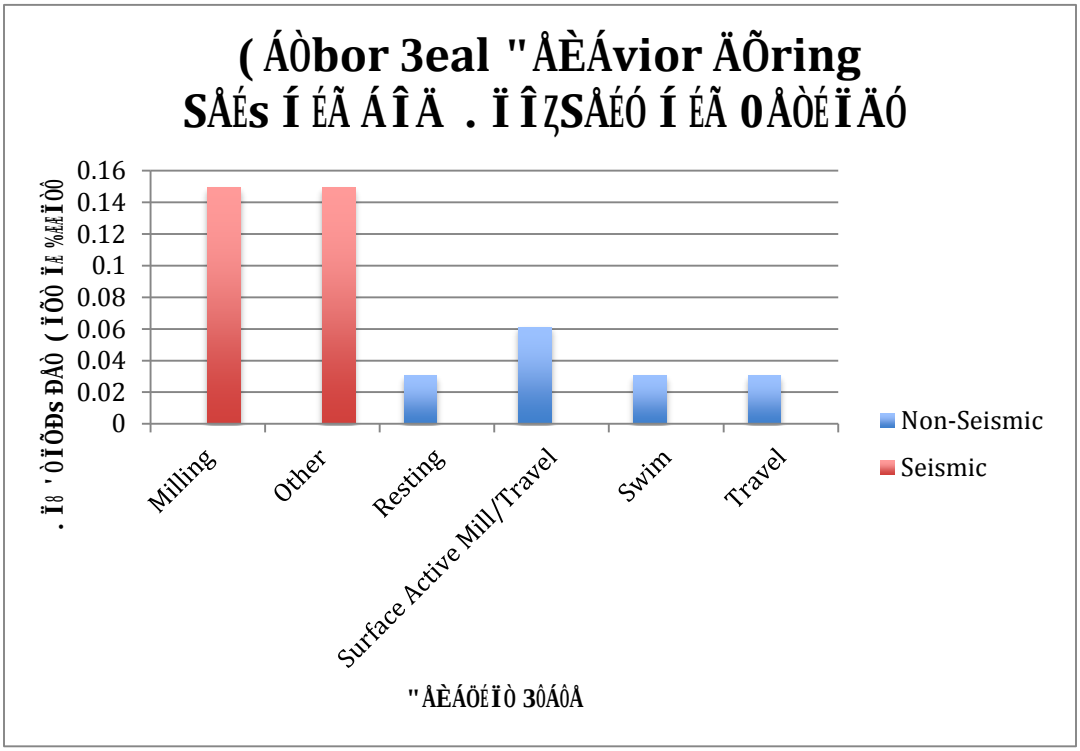


Figure 29. Harbor seal behavior state during seismic and non-seismic periods as observed from the aerial platform. Based on number of groups per hour of aerial effort (seismic and non-seismic).



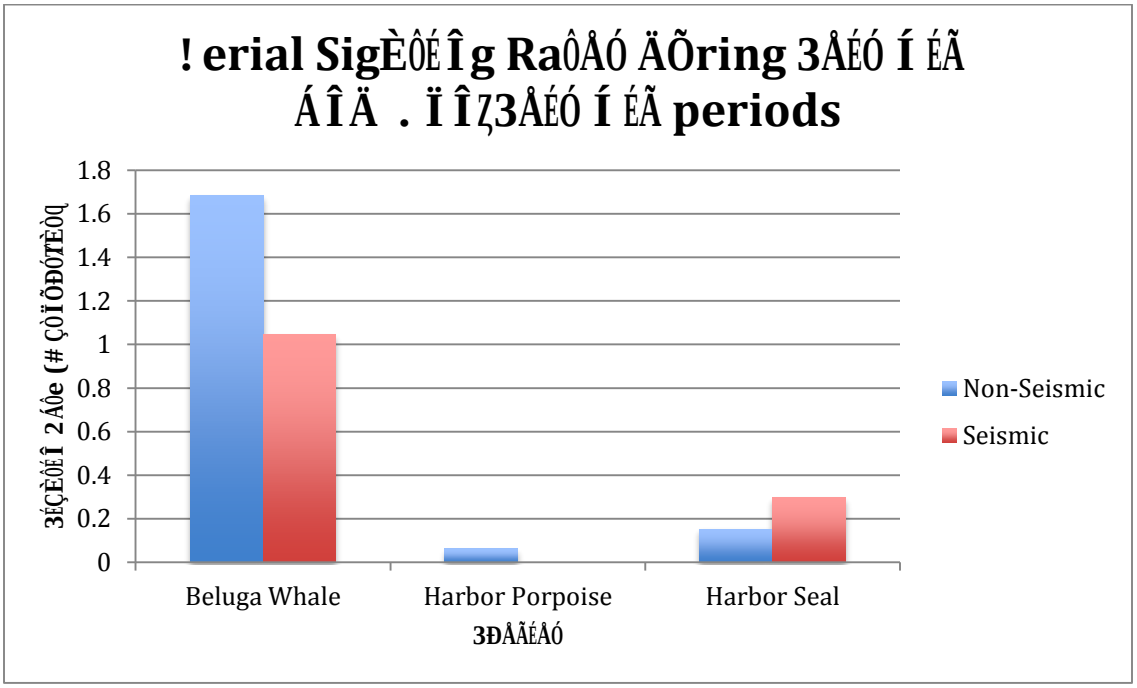
5.5.4. Sighting Rates from Aircraft

Sighting rates (number of groups seen per hr) were calculated based as follows: total number of groups observed during aerial flights divided by total aerial effort hr. Sighting rates were calculated separately for seismic and non-seismic periods. Total hr of this aerial effort was 39.4, consisting of 6.7 hr (17%) during seismic periods and 32.7 hr (83 %) during non-seismic periods (Table 17). Beluga whale sighting rates were more than 8 times higher than sighting rates of harbor seals and more than 31 times higher than sighting rates of harbor porpoise, (Figure 30). Beluga whale sighting rates were higher during non-seismic than seismic periods (Figure 30). However, the relatively small amount of observation effort during seismic periods (6.7 hr) limits the ability to make meaningful comparisons of sighting rates between seismic and non-seismic periods by species.

Table 17. Marine mammal sighting rates (number of groups per hr) from the aerial platform during seismic and non-seismic periods.

	Non-Seismic (32.7 hr aerial effort)		Seismic (6.7 hr aerial effort)		Non-Seismic & Seismic Combined (39.4 hr aerial effort)	
Species	**No. Groups**	**Sighting Rate (Grp/hr)**	**No. Groups**	**Sighting Rate (Grp/hr)**	**No. Groups**	**Sighting Rate (Grp/hr)**
Beluga Whale	55	1.68	7	1.04	62	1.57
Harbor Porpoise	2	0.06	0	0	2	0.05
Harbor Seal	5	0.15	2	0.30	7	0.18

Figure 30. Sighting rates (number of groups per hr) during seismic and non-seismic periods for marine mammal species observed from the aerial platform.



5.6. Mitigation Measures Implemented

A total of 20 mitigation measures were implemented during the Cook Inlet 2014 Seismic Survey. These consisted of 7 "ramp up delays" (delays to initiating seismic operations after clearing the EZ), all for beluga whales, plus 13 shut down mitigation measures (7 for beluga whales, 4 for harbor porpoise and 2 for humpback whales). All shut downs were implemented within a "one shot" period, in other words, when a PSO requested a shut down the operations team ceased all airgun operations

before the next shot was fired. Further details relative to mitigation measures are found in Appendix E, "Summary and Description of Mitigation Measures during the Cook Inlet 2014 Seismic Survey."

Table 18. Summary of all mitigation measures implemented for each marine mammal species.

Species	Ramp Up Delay	Shut Down	Total Mit. Measures
Beluga whale	7	7	14
Harbor porpoise	0	4	4
Humpback whale	0	2	2
Total	**7**	**13**	**20**

5.7. Marine Mammal Exposures

NMFS authorized Apache the incidental taking of marine mammals during seismic activity by Level B harassment only, and takes were limited to several species typically found in Cook Inlet (Table 19). Per the NMFS-issued IHA, if any other marine mammal species not listed in the IHA were encountered during seismic activity and potentially exposed to seismic sounds ≥ 160 dB (rms), then a shutdown was to be implemented immediately (Section 3.3, "Seismic Survey Mitigation Measures").

Table 19. Authorized number of "takes" during the Cook Inlet 2014 Seismic Survey identified by NMFS in the IHA.

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Beluga whale (*Delphinapterus leucas*)	30
Killer whale (*Orcinus orca*)	10
Harbor Porpoise (*Phocoena phocoena*)	20
0É Î ÎÉÐÅÄÓ	
Steller sea lion (*Eumetopias jubatus*)	20
Harbor seal (*Phoca vitulina richardsi*)	440

As requested by NMFS in section 8(v) of the IHA, estimates of take by Level B harassment were based on presence in the 160 dB (rms) disturbance zone. During the Cook Inlet 2014 Seismic Survey "presence" was interpreted as visual observation. Estimates of exposures (i.e., marine mammals observed within the DZ or EZ) are provided in Table 20 with further details of each event in Appendix F, "Summary and Description of Marine Mammal Exposures during the Cook Inlet 2014 Seismic Survey."

Table 20. Summary of the number of individual marine mammal observed within the DZ and EZs during the Cook Inlet 2014 Seismic Survey.

- ÁÒÉÎe Ma Í ÍÁÌ 3ÐÅÅĂÉÅÓ	4ÏÔÁÌ NÏ of / ÂÓÅÒÖÅd %ØÐÏÓÕÒes É Î DZ	4ÏÔÁÌ NÏ of / ÂÓÅÒÖÅd %ØÐÏÓÕÒes É Î %:	4ÏÔÁÌ NÏ of / ÂÓÅÒÖÅd %ØÐÏÓÕÒes
Beluga Whale	12	-	ρς
Killer Whale	-	-	ζ
Harbor Porpoise	4	2	φ
Steller Sea Lion	-	-	ζ
Harbor Seal	9	-	ω
Humpback Whale	-	2	ς

5.8. Humpback Sightings Summary

A single humpback whale was seen on three separate dates during the Cook Inlet 2014 Seismic Survey. It is unknown whether this was the same whale seen on different occasions or not. During all three sighting events, the humpback whale(s) was observed simultaneously from multiple PSO observation platforms. When applicable, additional mitigation and monitoring measures were implemented due to the rarity of the sighting and because it was not listed on the IHA issued by NMFS to Apache. These three sighting events are summarized below and include a description of extra search efforts conducted from the aerial platform in an attempt to relocate the whale(s).

The first humpback whale sighting (a single animal) was made by the Captain of the *Peregrine* at an estimated distance of 1.5 km away at 10:30:00 on 25 April 2014. The full seismic array (1,760 cui) was operating at the time from aboard the *Peregrine*. PSOs requested a shutdown, which was implemented by the airgun crew at 10:30:17. Following the initial sighting the humpback was observed by PSOs aboard the *Peregrine, Dreamcatcher* and land PSOs over periods ranging from <1-20 minutes. The last sighting occurred at 11:20:32 by PSOs aboard both the *Peregrine* and *Dreamcatcher*. Behaviors observed included travel, blow and dive. The closest

observed distance to the source vessel was estimated to be 1.5 km when the whale was first seen from the *Peregrine*, and the last sighting was 4.6 km from this vessel.

The second sighting of a single humpback was made at 19:27:20 on 29 April 2014 by PSOs on the *Peregrine.* The full seismic array (1,760 cui) was operating at the time from aboard the *Peregrine*. PSOs requested a shut down which was implemented by the airgun crew at 19:27:25. The PSO on the *Dreamcatcher* observed the whale again at 19:27:53 and both vessel PSOs continued to observe the animal until 21:32:51 after which it was not resighted. Repeated sightings of the whale prevented resuming seismic activities and the vessel captain decided to stop all operations for the remainder of the tide cycle. At 20:59:30 the *Peregrine* started the 10 cui mitigation gun with the intention of starting seismic operations during the following tide cycle for night operations. However, this mitigation gun was shut down at 21:07:31 when the humpback was seen 1.75 km from the *Peregrine* indicating that the whale had moved over 2 km closer to the source vessel since the previous sighting, and was thus potentially approaching the DZ. Following this observation, the operations team agreed to cease all operations until the following morning and dock vessels at the OSK dock for the night. Behaviors observed included travel, blow and dive. A PSO on the *Peregrine* was able to get usable photos of the whale's dorsal fin during this sighting confirming the species identification (Appendix G, "Cook Inlet 2014 Seismic Survey Photo Log").

The final sighting of a single humpback occurred on 30 April 2014 by PSOs on the *Dreamcatcher* prior to sunrise, however an exact time was not recorded as the PSO was not on effort. The humpback whale was determined to be approximately 3.5 km from the *Peregrine.* After sunrise, the vessel crew on the *Peregrine* observed the whale at 06:10:00 and the *Peregrine and Dreamcatcher* PSOs both sighted the animal at 06:13:00 and 06:13:30 (respectively). There were no additional humpback whale sightings after this from any platform. This sighting was made 3 minutes into the morning clearing and since the whale was not seen again it did not delay ramp up. Behaviors observed included travel and dive.

Due to multiple sightings of a humpback whale on three different dates spanning 25-30 April, and the unusual occurrence of humpback whales in Cook Inlet, the aerial team altered the aerial monitoring route to search for the whale. The search included regions where the whale had last been observed by PSOs as well as reported sightings made by the public. On 28 April 2014 the aerial team extended the flight route up Turnagain Arm and past mile 93, where the whale had reportedly been observed. The animal was not observed during this flight. Additional aerial coverage up Turnagain Arm and along Point Possession to East Foreland was implemented on 2, 3 and 4 May 2014. Aerial flights were canceled due to inclement weather on 5, 6 and 7 May. The regular flight path was resumed on 8 May. Despite the additional aerial search effort and coverage no humpback whale was observed from the aerial platform.

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Appendix A. Incidental Harassment Authorization and Take Statement

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

MAR 0 4 2014

John Hendrix
Apache Alaska Corporation
510 L Street
Suite 310
Anchorage, Alaska 99501

Dear Mr. Hendrix:

Enclosed is an Incidental Harassment Authorization (IHA) issued to the Apache Alaska Corporation, 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 marine seismic survey in Cook Inlet from March 4, through December 31, 2014.

You are required to comply with the conditions contained in the IHA. In addition, you must submit reports to the National Marine Fisheries Service's (NMFS) Office of Protected Resources on a weekly and monthly basis during the survey and within 90 days of its completion. 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 Candace Nachman, Office of Protected Resources, NMFS, at 301-427-8429.

Sincerely,

Perry GAYALDO

for Donna S. Wieting
Director
Office of Protected Resources

Enclosures

Incidental Harassment Authorization

Apache Alaska Corporation (Apache), 510 L Street, Suite 310, Anchorage, Alaska 99501, is hereby authorized under section 101(a)(5)(D) of the Marine Mammal Protection Act (MMPA; 16 U.S.C. 1371(a)(5)(D)), to harass small numbers of marine mammals incidental to specified activities associated with a marine geophysical (seismic) survey in Cook Inlet, Alaska, contingent upon the following conditions:

1. This Authorization is valid from March 1, 2014, through December 31, 2014.

2. This Authorization is valid only for Apache's activities associated with seismic survey operations that shall occur within the areas denoted as Zone 1 and Zone 2 as depicted in Figure 2 of Apache's November 2013 application to the National Marine Fisheries Service.

3. Species Authorized and Level of Take

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

(i) Odontocetes: see Table 1 (attached) for authorized species and take numbers.

(ii) Pinnipeds: see Table 1 (attached) for authorized species and take numbers.

(iii) If any marine mammal species are encountered 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 sound source to avoid take.

(b) The taking by injury (Level A harassment) serious injury, or death of any of the species listed in Table 1 or the taking of any kind of any other species of marine mammal is prohibited and may result in the modification, suspension or revocation of this Authorization.

(c) If the number of detected takes of any marine mammal species listed in Table 1 is met or exceeded, Apache shall immediately cease survey operations involving the use of active sound sources (e.g., airguns and pingers) and notify NMFS.

4. The authorization for taking by harassment is limited to the following acoustic sources (or sources with comparable frequency and intensity) without an amendment to this Authorization:

(a) Two airgun arrays, each with a capacity of 2,400 in^3;
(b) Two airgun arrays, each with a capacity of 1,200 in^3;

(c) A 440 in^3 airgun array;
(d) A 10 in^3 airgun;
(e) A Scott Ultra-Short Baseline (USBL) transceiver; and
(f) A Lightweight Release USBL transponder.

5. The taking of any marine mammal in a manner prohibited under this Authorization must be reported immediately to the Chief, Permits and Conservation Division, Office of Protected Resources, NMFS or her designee at (301) 427-8401.

6. The holder of this Authorization must notify the Chief of the Permits and Conservation Division, Office of Protected Resources, or her designee at least 48 hours prior to the start of seismic survey activities (unless constrained by the date of issuance of this Authorization in which case notification shall be made as soon as possible) at 301-427-8401 or to Candace.Nachman@noaa.gov.

7. 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 a sufficient number of 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 vessels during daytime operations (from nautical twilight-dawn to nautical twilight-dusk) and before and during start-ups of sound sources day or night. Two PSVOs will be on each source vessel, and two PSVOs will be on the support vessel to observe the exclusion and disturbance zones. PSVOs shall have access to reticle binoculars (7x50 Fujinon), big-eye binoculars (25xI50), and night vision devices. PSVO shifts shall last no longer than 4 hours at a time. PSVOs shall also make observations during daytime periods when the sound sources are not operating for comparison of animal abundance and behavior, when feasible. When practicable, as an additional means of visual observation, Apache's vessel crew may also assist in detecting marine mammals.

(b) In addition to the vessel-based PSVOs, utilize a shore-based station to visually monitor for marine mammals. The shore-based station will follow all safety procedures, including bear safety. The location of the shore-based station will need to be sufficiently high to observe marine mammals; the PSOs would be equipped with pedestal mounted "big eye" (20 x 110) binoculars. The shore-based PSOs would scan the area prior to, during, and after the survey operations involving the use of sound sources, and would be in contact with the vessel-based PSOs via radio to communicate sightings of marine mammals approaching or within the project area.

(c) Weather and safety permitting, aerial surveys shall be conducted on a daily basis when there are any seismic-related activities (including node laying/retrieval and airgun operations). Surveys are to be flown even if the airguns are not being fired. If weather or safety conditions prevent Apache from conducting aerial surveys, seismic survey operations may proceed subject to the terms and conditions of the IHA.

(i) When survey operations occur near a river mouth, Apache shall conduct aerial surveys to identify large congregations of beluga whales and harbor seal haul-outs.

(ii) When operating north or east of a line from Tyonek across to the eastern side of Number 3 Bay of the Captain Cook State Recreation Area, Cook Inlet, Apache will fly daily aerial surveys (safety and weather permitting). Flight paths shall encompass areas from Anchorage, along the coastline of the Susitna Delta to Tyonek, across the inlet to Point Possession, around the coastline of Chickaloon Bay to Burnt Island, and across to Anchorage (or in reverse order). These designations apply when Apache is operating in Zone 1 (see Figure 2 in the IHA application).

(iii) When operating in Zone 2 (see Figure 2 in the IHA application), Apache will conduct aerial surveys, safety and weather permitting, a minimum distance of 30 km (18.6 mi) around the seismic operating area expected for that day.

(iv) Aerial surveys may be conducted from either a helicopter or fixed-wing aircraft. A fixed-wing aircraft may be used in lieu of a helicopter. If flights are to be conducted with a fixed-wing aircraft, it must have adequate viewing capabilities, i.e., view not obstructed by wing or other part of the plane.

(v) Weather and safety permitting, aerial surveys will fly at an altitude of 305 m (1,000 ft). In the event of a marine mammal sighting, aircraft will attempt to maintain a radial distance of 457 m (1,500 ft) from the marine mammal(s). Aircraft will avoid approaching marine mammals from head-on, flying over or passing the shadow of the aircraft over the marine mammal(s).

(d) 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;

(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 7(d)(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.

(e) Establish a 180 dB re 1 µPa (rms) and 190 dB re 1 µPa (rms) "exclusion zone" (EZ) for marine mammals before the full array (2400 in^3) is in operation; and a 180 dB re 1 µPa (rms) and 190 dB re 1 µPa (rms) EZ before a single airgun (10 in^3) is in operation, respectively.

(f) Visually observe the entire extent of the EZ (180 dB re 1 µPa [rms] for cetaceans and 190 dB re 1 µPa [rms] for pinnipeds) using NMFS-qualified PSVOs, for at least 30 minutes (min) prior to starting the airgun array (day or night). If the PSVO finds a marine mammal within the EZ, Apache 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 min. If the PSVO sees no marine mammals during that time, they should assume that the animal has moved beyond the EZ. If for any reason the entire radius cannot be seen for the entire 30 min (i.e., rough seas, fog, darkness), or if marine mammals are near, approaching, or in the EZ, the airguns may not be ramped-up.

(g) Implement a "ramp-up" procedure when starting up at the beginning of seismic operations or any time after the entire array has been shut down for more than 10 min, which means start the smallest sound source first and add sound sources in a sequence such that the source level of the array shall increase in steps not exceeding approximately 6 dB per 5-min period. During ramp-up, the PSVOs shall monitor the EZ, and if marine mammals are sighted, a power-down, or shutdown shall be implemented as though the full array were operational. Therefore, initiation of ramp-up procedures from shutdown requires that the PSVOs be able to visually observe the full EZ as described in Condition 7(e) (above).

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

(i) Power-down or shutdown the sound source(s) if a marine mammal is detected within, approaches, or enters the relevant EZ. A shutdown means all operating sound sources are shut down (i.e., turned off). A power-down means reducing the number of operating sound sources to a single operating 10 in^3 airgun, which reduces the EZ to the degree that the animal(s) is no longer in or about to enter it.

(j) Following a power-down, if the marine mammal approaches the smaller designated EZ, the sound sources must then be completely shut down. Seismic survey activity shall not resume until the PSVO has visually observed the marine mammal(s) exiting the EZ and is not likely to return, or has not been seen within the EZ for 15 min for species with shorter dive durations (small odontocetes and pinnipeds) or 30 min for species with longer dive durations (large odontocetes, including killer whales and beluga whales).

(k) Following a power-down or shutdown and subsequent animal departure, survey operations may resume following ramp-up procedures described in Condition 7(g).

(l) Marine geophysical surveys may continue into night and low-light hours if such segment(s) of the survey is initiated when the entire relevant EZs can be effectively monitored visually (i.e., PSVO(s) must be able to see the extent of the entire relevant EZ).

(m) No initiation of survey operations involving the use of sound sources is permitted from a shutdown position at night or during low-light hours (such as in dense fog or heavy rain).

(n) If a beluga whale is visually sighted approaching or within the 160-dB disturbance zone, survey activity will not commence or the sound source(s) shall be shut down until the animals are no longer present within the 160-dB zone.

(o) Whenever aggregations or groups of killer whales and/or harbor porpoises are detected approaching or within the 160-dB disturbance zone, survey activity will not commence or the sound source(s) shall be shut-down until the animals are no longer present within the 160-dB zone. An aggregation or group of whales/porpoises shall consist of five or more individuals of any age/sex class.

(p) Apache must not operate airguns within 10 miles (16 km) of the mean higher high water (MHHW) line of the Susitna Delta (Beluga River to the Little Susitna River) between April 15 and October 15 (to avoid any effects to belugas in an important feeding and breeding area).

(q) Seismic survey operations involving the use of airguns and pingers must cease if takes of any marine mammal are met or exceeded.

(r) The mitigation airgun will be operated at approximately one shot per minute and will not be operated for longer than three hours in duration during daylight hours and good visibility. In cases when the next start-up after the turn is expected to be during lowlight or low visibility, use of the mitigation airgun may be initiated 30 minutes before darkness or low visibility conditions occur and may be operated until the start of the next seismic acquisition line. The mitigation gun must still be operated at approximately one shot per minute.

8. Reporting Requirements: The Holder of this Authorization is required to:

(a) Submit a weekly field report, no later than close of business (Alaska time) each Thursday during the weeks when in-water seismic survey activities take place. The field reports will summarize species detected, in-water activity occurring at the time of the sighting, behavioral reactions to in-water activities, and the number of marine mammals taken.

(b) Submit a monthly report, no later than the 15th of each month, to NMFS' Permits and Conservation Division for all months during which in-water seismic survey activities occur. These reports 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 shutdowns), observed throughout all monitoring activities;

(iii) An estimate of the number (by species) of: (A) pinnipeds that 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 190 dB re 1 µPa (rms) with a discussion of any specific

behaviors those individuals exhibited; and (B) cetaceans that 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.

(iv) A description of the implementation and effectiveness of the: (A) terms and conditions of the Biological Opinion's Incidental Take Statement (ITS); and (B) mitigation measures of this 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.

(c) Submit a draft Technical Report on all activities and monitoring results to NMFS' Permits and Conservation Division within 90 days of the completion of the seismic survey. The Technical Report will include the following information:

(i) Summaries of monitoring effort (e.g., total hours, total distances, and marine mammal distribution through the study period, accounting for sea state and other factors affecting visibility and detectability of marine mammals);

(ii) Analyses of the effects of various factors influencing detectability of marine mammals (e.g., sea state, number of observers, and fog/glare);

(iii) Species composition, occurrence, and distribution of marine mammal sightings, including date, water depth, numbers, age/size/gender categories (if determinable), group sizes, and ice cover;

(iv) Analyses of the effects of survey operations; and

(v) Sighting rates of marine mammals during periods with and without seismic survey activities (and other variables that could affect detectability), such as: (A) initial sighting distances versus survey activity state; (B) closest point of approach versus survey activity state; (C) observed behaviors and types of movements versus survey activity state; (D) numbers of sightings/individuals seen versus survey activity state; (E) distribution around the source vessels versus survey activity state; and (F) estimates of take by Level B harassment based on presence in the 160 dB harassment zone.

(d) 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.

(e) Apache must immediately report to NMFS if 25 belugas are detected within the 160 dB re 1 µPa (rms) disturbance zone during seismic survey operations to allow NMFS to consider making necessary adjustments to monitoring and mitigation.

9. (a) 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), Apache 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, or

her designees by phone or email (telephone: 301-427-8401 or Candace.Nachman@noaa.gov), the Alaska Regional Office (telephone: 907-271-1332 or Mandy.Migura@noaa.gov), and the Alaska Regional Stranding Coordinators (telephone: 907-586-7248 or Aleria.Jensen@noaa.gov or Barbara.Mahoney@noaa.gov). The report must include the following information:

(i) Time, date, and location (latitude/longitude) of the incident;
(ii) The name and type of vessel involved;
(iii) The vessel's speed during and leading up to the incident;
(iv) Description of the incident;
(v) Status of all sound source use in the 24 hours preceding the incident;
(vi) Water depth;
(vii) Environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover, and visibility);
(viii) Description of marine mammal observations in the 24 hours preceding the incident;
(ix) Species identification or description of the animal(s) involved;
(x) The fate of the animal(s); and
(xi) 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 Apache to determine what is necessary to minimize the likelihood of further prohibited take and ensure MMPA compliance. Apache may not resume their activities until notified by NMFS via letter or email, or telephone.

(b) In the event that Apache 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), Apache will immediately report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, her designees, and the NMFS Alaska Stranding Hotline (see contact information in Condition 9(a)). The report must include the same information identified in the Condition 9(a) above. Activities may continue while NMFS reviews the circumstances of the incident. NMFS will work with Apache to determine whether modifications in the activities are appropriate.

(c) In the event that Apache 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), Apache shall report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, her designees, the NMFS Alaska Stranding Hotline (1-877-925-7773), and the Alaska Regional Stranding Coordinators within 24 hours of the discovery (see contact information in Condition 9(a)). Apache 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.

10. Apache is required to comply with the Reasonable and Prudent Measures and Terms and Conditions of the ITS corresponding to NMFS' Biological Opinion issued to both U.S. Army Corps of Engineers and NMFS' Office of Protected Resources.

11. 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.

12. Penalties and Permit Sanctions: Any person who violates any provision of this Incidental Harassment Authorization is subject to civil and criminal penalties, permit sanctions, and forfeiture as authorized under the MMPA.

13. This Authorization may be modified, suspended or withdrawn if the Holder fails to abide by the conditions prescribed herein or if the authorized taking is having more than a negligible impact on the species or stock of affected marine mammals, or if there is an unmitigable adverse impact on the availability of such species or stocks for subsistence uses.

PERRY GAMMUDO

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

MAR 0 4 2014
Date

Attachment

Attachment

Table 1. Authorized Take Numbers for Each Marine Mammal Species in Cook Inlet.

Species	Authorized Take in the Cook Inlet Action Area
Odontocetes	
Beluga whale (*Delphinapterus leucas*)	30
Killer whale (*Orcinus orca*)	10
Harbor porpoise (*Phocoena phocoena*)	20
Pinnipeds	
Steller sea lion (*Eumetopias jubatus*)	20
Harbor seal (*Phoca vitulina richardsi*)	440

10. INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined in regulations to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of this incidental take statement.

Section 7(b)(4)(C) of the ESA provides that the operator needs to obtain authorization under section 101(a)(5) of the MMPA before this incidental take statement can become effective. Accordingly, the terms of this statement and the exemption from Section 9 of the ESA that the statement affords are conditional upon the issuance of MMPA authorization to take the marine mammals identified here. Similarly, this biological opinion and incidental take statement cover the entire scope of the proposed activities, *i.e.*, two years of seismic survey operations in Cook Inlet (2013 and 2014). The operator will need MMPA authorization each year for this take statement to become effective. Absent such authorization, this statement is inoperative.

Amount or Extent of the Take

Available information indicates that incidental acoustic harassment of small numbers of Cook Inlet beluga whales and Steller sea lions may occur during Apache's Cook Inlet 3D Seismic Program. NMFS does not expect beluga whales or sea lions to be injured or killed by the Apache marine surveys. It is possible that the hearing systems of marine mammals very close to an airgun would be at risk of temporary or permanent hearing impairment, and temporary hearing threshold shift is a possibility for animals in close proximity to the source. However, planned monitoring and mitigation measures are designed to avoid sudden onsets of seismic pulses at full power, to detect marine mammals occurring near the array, and to avoid exposing them to sound pulses that may cause hearing impairment.

NMFS AKR anticipates that the non-lethal incidental take of no more than 30 Cook Inlet beluga whales and no more than 20 Steller sea lions per year for the remaining two years as a result of exposure to impulsive sounds with received levels ≥ 160 dB re:1 μPa_{RMS}. The amount of take authorized by this ITS will be exceeded if the number of beluga whales or Steller sea lions taken exceeds this level in any calendar year. The amount of take authorized does not carry over into the following year. This ITS will expire on December 31, 2014.

Reasonable and Prudent Measures:

NMFS AKR believes the following Reasonable and Prudent Measure are necessary and appropriate to minimize the impact of incidental take of the endangered Cook Inlet beluga whale and Steller sea lion.

1) All seismic-related activity must comply with all terms, conditions, and requirements listed in each valid, current Incidental Harassment Authorization (IHA), or incidental take authorization, issued under MMPA section 101(a)(5) and 50 CFR 216.107 to the operator for this project.

2) The taking of Cook Inlet beluga whales and Steller sea lions shall be by incidental harassment only. The taking by serious injury or death, or the taking by harassment of greater numbers of animals than authorized in this ITS, is prohibited and may result in the modification, suspension, or revocation of the ITS.

3) A comprehensive monitoring and reporting program shall be implemented to ensure that Cook Inlet beluga whales and Steller sea lions are not taken in numbers or in a manner not anticipated by the biological opinion.

4) Airgun operations shall not occur within the Susitna Delta buffer zone, as described in the NMFS' 2013 Biological Opinion for this action, to prevent any likelihood of behavioral impacts during critical feeding and reproductive periods for Cook Inlet beluga whales.

5) In addition to the aerial surveys of river mouths described in section 1.3.3.2, aerial surveys shall be conducted on a daily basis (weather and safety permitting) when there are any seismic-related activities (including but not limited to node laying/retrieval or airgun operations) occurring north or east of a line from Tyonek across to the eastern side of Number 3 Bay of the Captain Cook State Recreation Area, Cook Inlet (roughly the southern-most point of Corps defined Region 9). Surveys are to be flown even if the airguns are not being fired. In light of the June 2012 observation of belugas in Trading Bay and the location of this next phase of Apache's operations closer to high value summer beluga feeding areas, these surveys are important to mitigate impacts and reduce incidental take by confirming the presence of Cook Inlet belugas near the Susitna Delta and alert the vessels accordingly of necessary actions to avoid or minimize potential disturbance, to monitor the effects of the seismic program on Cook Inlet belugas and their primary feeding and reproductive areas, and to ensure that any displacement from the Susitna Delta region is temporary and would not be likely to cause harm to whales by reducing their ability to feed. These surveys should also inform managers as to any changes in the distribution, movements, and abundance of beluga whales in these areas.

Terms and Conditions:
For any incidental takes that result from the actions of NMFS PR1, Corps, or their applicant Apache and its contractors to be exempt from the prohibitions of section 9 of the ESA, the action which causes the take must comply with the following terms and conditions. These terms and conditions implement the reasonable and prudent measures described above and are non-discretionary.

1) All seismic-related activity must comply with all terms, conditions, and requirements listed in each valid, current Incidental Harassment Authorization (IHA), or incidental take authorization, issued under MMPA section 101(a)(5) and 50 CFR 216.107 to the operator for this project.

2) In the event that the specified activity clearly causes the take of a marine mammal in a manner other than that described by this ITS, such as serious injury or mortality (e.g., Level A harassment; ship-strike; gear interaction; and/or entanglement), Apache shall immediately cease

the specified activities and immediately report the incident to NMFS AKR Protected Resources Division at 907-271-5006, and/or by email to Brad.Smith@noaa.gov and Mandy.Migura@noaa.gov.

3) The sound source verification studies using the actual airgun arrays shall be conducted prior to beginning any in-water seismic operations in order to obtain definitive measurements for received sound levels that are below 190, 180 and 160 dB re: 1 μPa for each airgun size (10, 440, and 2,400 cui). An acoustic radii of 9.5 km (representing the 160 dB distance) shall be monitored until notified by NMFS in writing that the radius has changed.

3.1) All mitigation measures as outlined in section 1.3.3 of this Biological Opinion must be implemented.

3.2) At all times when it is conducting seismic-related activity, the operator must possess on board the seismic source vessel a current and valid Incidental Harassment Authorization or incidental take authorization issued by NMFS to Apache under section 101(a)(5) of the MMPA. Any take must be authorized by one or more valid, current IHAs or incidental take authorizations issued by NMFS to Apache under section 101(a)(5) of the MMPA, and such take must occur in compliance with all terms, conditions, and requirements included in such authorizations.

3.3) Submit copies of all reports required by all MMPA authorizations and within the same timeframes to:

NMFS AKR
ATTN Mandy Migura
222 W. 7th Ave, Box 43
Anchorage, AK 99513
mandy.migura@noaa.gov

3.4) In addition to the above-mentioned reports, submit a report at the end of each operational year summarizing the content provided in the monthly reports as well as the operational plan (specific locations and dates) for the next year to NMFS AKR.

4) No airgun activities shall occur within 10 miles (16 km) of the mean higher high water (MHHW) line from the Beluga River to the Little Susitna River (a.k.a., the Susitna Delta) from mid-April to mid-October. The 10 mi (16 km) radius extends in all directions from both the Beluga River and the Little Susitna River, and the MHHW line in between. Once results of the sound source verification study in the upper Cook Inlet are available, Apache will contact NMFS AKR to determine if a new minimum setback distance is required for this area during this time. If Apache does not consult with NMFS, NMFS may enforce a minimum set back distance determined by NMFS to be protective of the beluga whales based upon a review of the sound source verification study.

5) When Apache is operating north or east of a line from Tyonek to the eastern side of Number 3 Bay of the Captain Cook State Recreation Area, Cook Inlet, they shall fly daily aerial surveys (weather and safety permitting) around the most important forage and reproductive areas of the upper Inlet. Flights are to be conducted with a plane with adequate viewing capabilities, i.e., view not obstructed by wing or other part of the plane. Flight paths should encompass areas

from Anchorage, along the coastline of the Susitna Delta to Tyonek, across the inlet to Point Possession, around the coastline of Chickaloon Bay to Burnt Island, and across to Anchorage (or in reverse order). Flying so that the PSO has the "inside" view while following the exterior boundary line of the coverage area should reduce the need for flying tracklines back and forth across the coverage area. The PSO will document the presence/absence of belugas and any Steller sea lions, and record their position and relative numbers. Occasionally, it may be necessary to deviate from the flight path to get an estimated count if the whales are too far from the flight path. In such instances, the plane should return to the point of deviation and continue along the flight path. These surveys should continue daily when Apache has any activities north or east of a line from Tyonek across to the eastern side of Number 3 Bay of the Captain Cook State Recreation Area, even on days when the airguns are not operating. The information obtained from these surveys should be analyzed and included in all of the above-mentioned reports. These surveys are in addition to the aerial surveys of river mouths discussed in section 1.3.3.2.

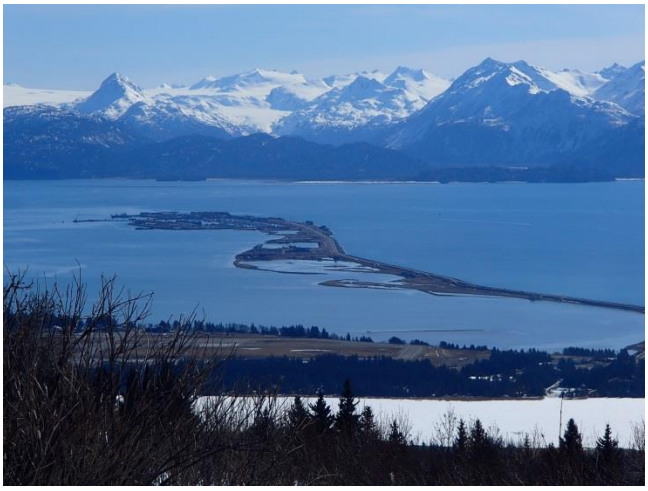
Effective Date:
This ITS will be in effect immediately upon issuance of an IHA, or MMPA incidental take authorization, and remain in effect through December 31, 2014, provided the operator possesses a current and valid MMPA IHA or incidental take authorization at all times throughout each operational year. Should the operator fail to possess such an authorization, this ITS shall become ineffective immediately and shall remain ineffective until such time as the operator again possesses a current and valid IHA or incidental take authorization.

Appendix B. Sound SourceVerification Report

Seiche Measurements Ltd
Bradworthy Industrial Estate
Langdon Road, Bradworthy
Holsworthy, Devon EX22 7SF
United Kingdom
Tel: +44 (0) 1409 404050
Fax: +44 (0) 1409 240276
Email: info@seiche.eu.com
Web: www.seiche.eu.com

Sound Source Verification Final Report

Cook Inlet Seismic Survey, Apache, Alaska.



Authors;

Brian Heath
Guillermo Jiménez
Kaya Marks

9th May 2014

Doc 1404A – Revision 1.0

Contents

1 Introduction 4
2 Acoustic Sources 5
2.1 440 in^3 Seismic Airgun 5
2.1.1 440 in^3 Seismic Airgun - SPL Calculation 6
2.2 1760 in^3 Seismic Airgun 7
2.2.1 1760 in^3 Seismic Airgun - SPL Calculation 8
3 Acoustic Metrics 9
4 Seismic Survey 10
4.1 Methodology 10
4.1.1 Study One - 440 in^3 Airgun in Shallow Water Location 11
4.1.2 Study Two - 1760 in^3 in Shallow Water Location 11
4.1.3 Study Three - 1760 in^3 in Deep Water Location 12
4.2 Equipment and Calibration 12
5 Data Analysis and Results 13
5.1 Data Processing & Analysis 13
5.2 Results 13
5.2.1 440 in^3 Seismic Array in Shallow Water. 13
5.2.2 1760 in^3 Seismic Array in Shallow Water. 14
5.2.3 1760 in^3 Seismic Array in Deep Water 15
6 Modelling 16
6.1 Bathymetry 16
6.2 Geology 19
6.3 Sound Velocity 19
6.4 Modelling Assumptions 19
6.5 Mitigation Zones Calculation 19
7 Modelling Results 21
7.1.1 Deep & Shallow Water Extents 22
8 Conclusion 25
9 References 28

Figures

Figure 1 - Acoustic Array Prior to Deployment. 5
Figure 2 - SeaScan USW 440 2M 5
Figure 3 - SeaScan USW 440 @ 2M Far Field signature 6
Figure 4 - SeaScan 2 x 880 7
Figure 5 - SeaScan 2 x 880 @ 3M Far Field Signature 8
Figure 6 - Survey Location 10
Figure 7 - 440 in^3, Test Buoy Tracks 3rd April 2014 11
Figure 8 - 1760 in^3, Test Buoy Tracks 5th April 2014 11
Figure 9 - 1760 in^3, Test Buoy Tracks 6th April 2014 12
Figure 10 - Drift Buoy 12
Figure 11 - 440 in^3 Source SPL dB_{rms} Levels vs Distance 13
Figure 12 - 1760 in^3 Source SPL dB_{rms} Levels vs Distance 14
Figure 13 - 1760 in^3 Source SPL dB_{rms} Levels vs Distance (Deep Water) 15
Figure 14 - Cook Inlet Topology 16
Figure 15 - Deep Water Bathymetry 17
Figure 16 - Shallow Water Bathymetry 17
Figure 17 - Shallow Water Profiles 17
Figure 18 - Deep Water Profiles 18
Figure 19 - Modelled Zone 440 in^3, Shallow Water, Depth 2.5m 21
Figure 20 - Modelled Zone 440 in^3, Shallow Water, Depth 5.5m 21
Figure 22 - Modelled Zone 1760 in^3, Shallow Water, Depth 3.5m 21
Figure 21 - Modelled Zone 1760 in^3, Shallow Water, Depth 5.5m 21
Figure 23 - Modelled Zone 1760 in^3, Deep Water, Depth 5.5m 22
Figure 24 - Modelled Zone 1760 in^3, Deep Water, Depth 3.5m 22
Figure 25 - Depth 10 m 23
Figure 26 - Depth 15.3 23
Figure 27 - Depth 20.3m 23
Figure 28 - Depth 25.7 m 23
Figure 29 - Depth 35.6 m 23
Figure 30 - Depth 46.1 m 23
Figure 31 - Depth 15.3 m 24
Figure 32 - Depth 10 m 24
Figure 33 - Depth 20.3 m 24
Figure 34 - Depth 25.7 m 24
Figure 35 - Depth 35.6 m 24
Figure 36 - Depth 46.1 m 24

Tables

Table 1 - 440 in^3 Source dB Radii 13
Table 2 - 1760 in^3 Source dB Radii (Shallow Water) 14
Table 3 - 1760 in^3 Source dB Radii (Deep Water) 15
Table 4 - Geo-acoustic Profile 19
Table 5 - Modelled Maxima Zone Distances 22
Table 6 - Maximum Sound Threshold Distances 25
Table 7 - Modelled vs Measured 80th Percentile 27
Table 8 - Modelled vs Measured 90th Percentile 27
Table 9 - Modelled vs Measured 95th Percentile 27

1 Introduction

This report presents the findings of the Sound Source Verification study carried out by Seiche Measurements on behalf of the Apache Corporation, Alaska. It will outline the sound propagation from these sources in seawater and identify the extents to which 160 dB, 180 dB and 190 dB re 1µPa_{rms} limits are in relation to that source both modelled and measured.

The sound from the source can propagate great distances however, the amplitude will vary as the distance increases so the SPL's defined above can be calculated and described as a distance from the source. Many factors can affect this propagation including, but not limited to, water temperature, salinity and bathymetry.

The report will describe the computer model and acquisition methods used and present the results for the different sources at the prescribed sound pressure levels (SPL_{rms}). There are many thousands of randomized data points acquired during this study in order to give as accurate a prediction as possible. The modelling is used as a guide to the expected limits.

2 Acoustic Sources

Two different airgun arrays are to be used for this acoustic study and are detailed in sections 2.1 & 2.2, one having a volume of 440 in^3 and the other 1760 in^3.There is a single location for 440in^3 plus a shallow and deep location for the 1760 in^3.An example of the 1760 in^3 array is shown in Figure 1.

Figure 1 - Acoustic Array Prior to Deployment.

2.1 440 in^3 Seismic Airgun

This array comprises of a SeaScan USW 440 2M, having a total volume of 440.0 in^3 and an expected SPL of 9.00 bar m. This will be a small array of 4 cluster guns (Figure 2) each producing 2000 psi.

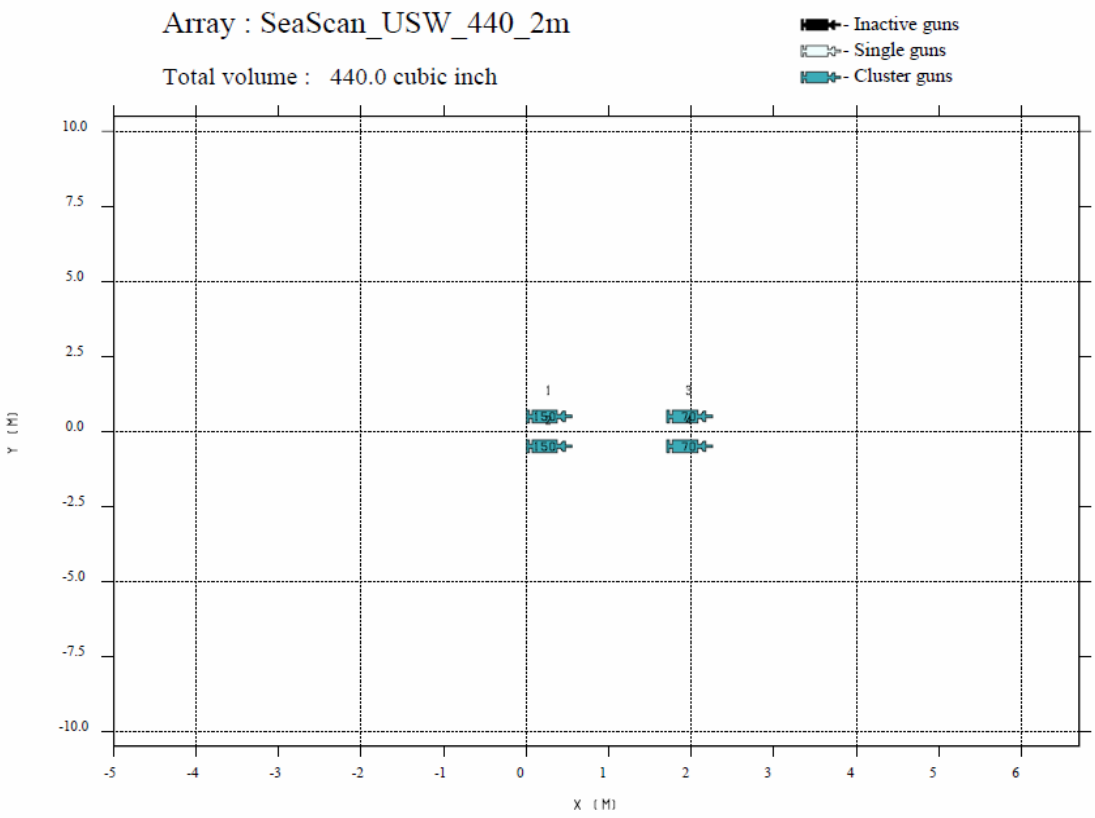


Figure 2 - SeaScan USW 440 2M

This source array will operate at a constant 2 m depth and the modelled far field signature is shown in Figure 3. The source directivity is primarily omni-directional and this has been assumed for the purpose of the modelling.

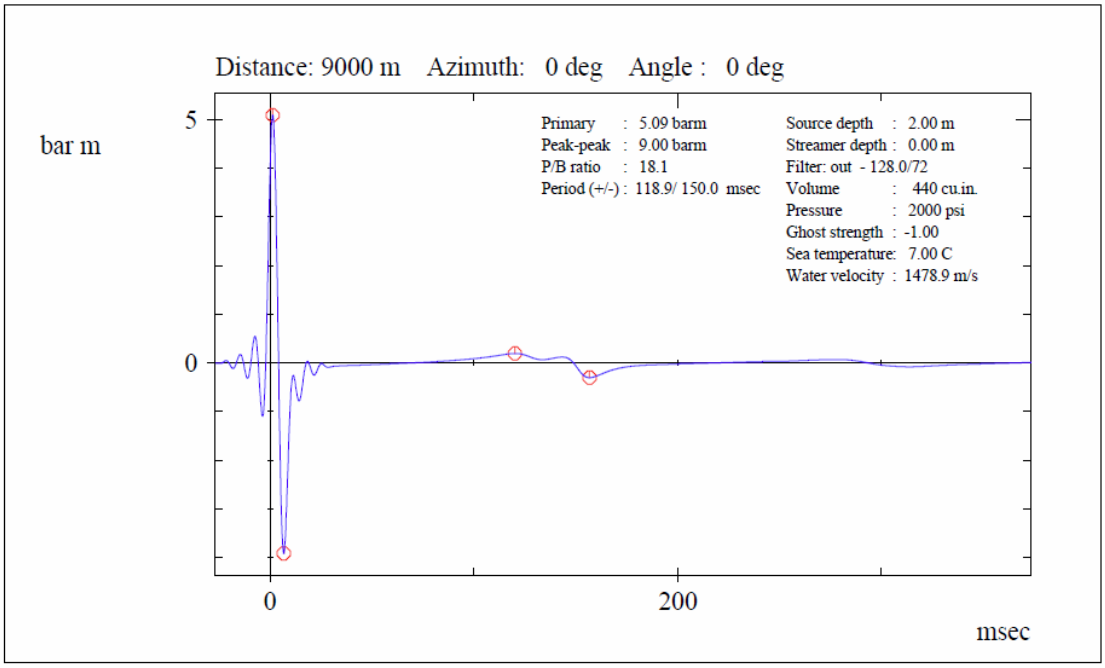


Figure 3 - SeaScan USW 440 @ 2M Far Field signature

2.1.1 440 in^3 Seismic Airgun - SPL Calculation

In order to model the propagation it is necessary to convert the predicted SPL from bar m to dB re 1 µPa. The following equations are applied to generate the equivalent SPL.

$$PL_{Pascals} = SPL_{bar} \times 100000$$

Equation 1

$$dB\ re\ 1\ \mu Pa = 20Log\left(\frac{PL_{Pascals}}{0.000001}\right)$$

Equation 2

$$\therefore 9.00\ barm = 239.08\ dB\ re\ 1\quad Pa$$

2.2 1760 in^3 Seismic Airgun

Array B comprises of a SeaScan 2x880 3M, having a total volume of 1760 in^3 and an expected SPL of 50.70 bar m. This will be a larger array of 16 guns arranged in 6 clusters (Figure 4) each producing 2000 psi.

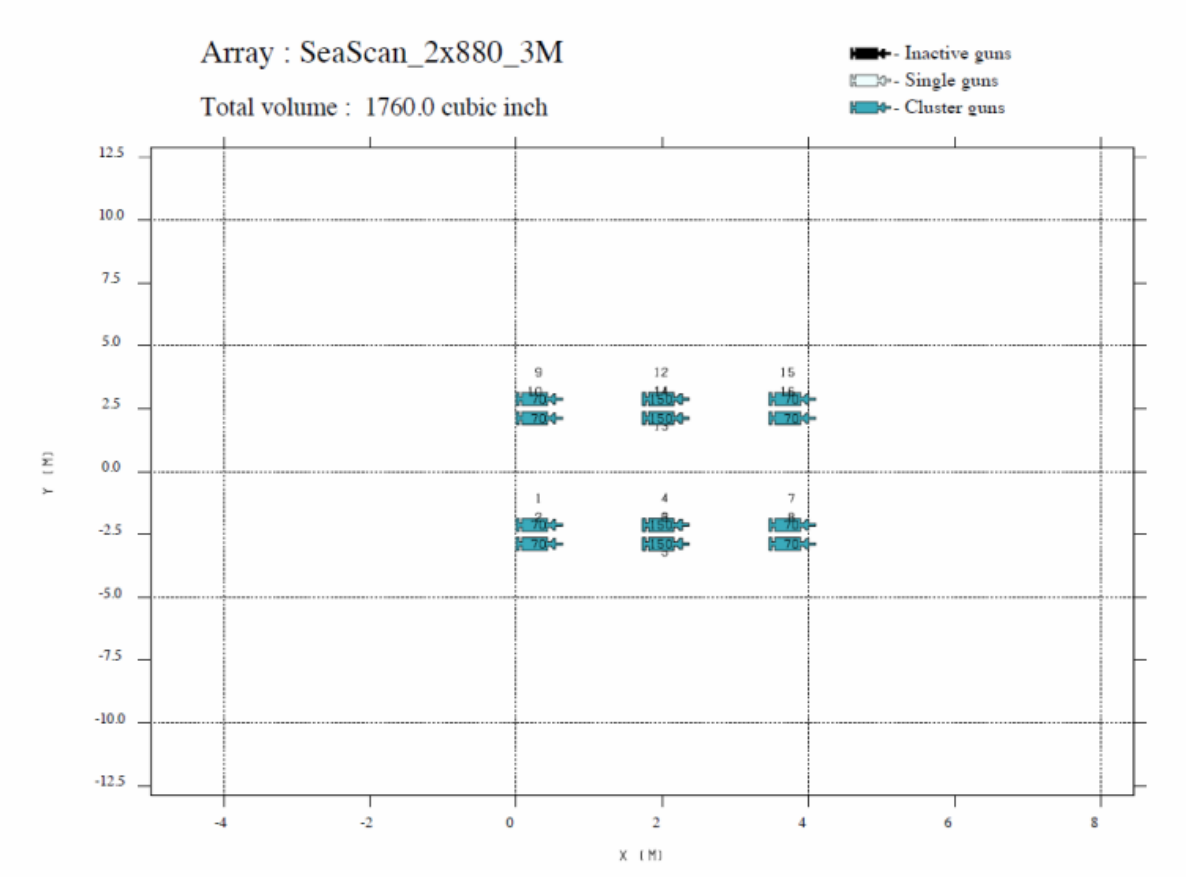


Figure 4 - SeaScan 2 x 880

This array will operate at a constant 3 m depth and the modelled far field signature is shown in Figure 5. The source directivity is again, primarily omni-directional and this has been assumed for the purpose of the modelling.

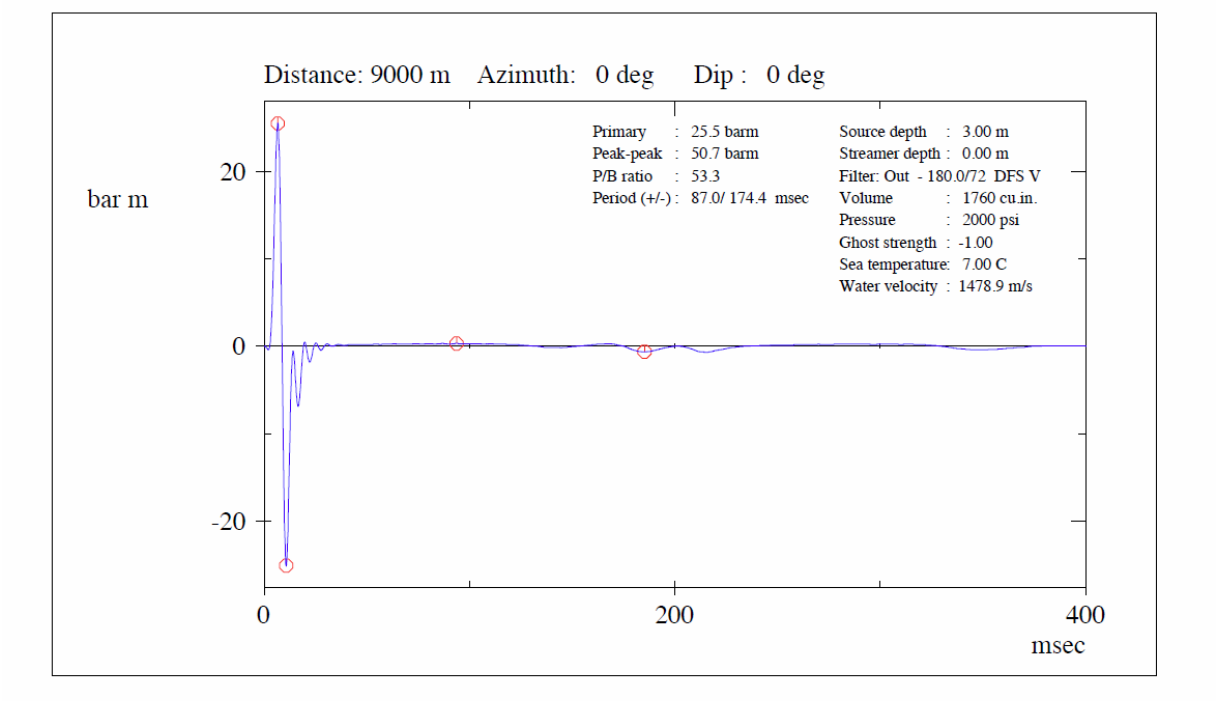


Figure 5 - SeaScan 2 x 880 @ 3M Far Field Signature

2.2.1 1760 in^3 Seismic Airgun - SPL Calculation

In order to model the propagation it is necessary to convert the predicted SPL from bar m to dB re 1 µPa. Applying equations from section 2.2.1 the SPL becomes;

$$\therefore 50.7\ barm = 254.10\ dB\ re\ 1\ \ Pa$$

3 Acoustic Metrics

This report will focus on arguably the most important metrics used in underwater sound; SPL_{peak}, SPL_{rms} and SEL.

All have their uses in marine acoustics, particularly when the effect of noise is to be related to marine mammals and the like.

The peak SPL can typically be portrayed in two different forms; Peak-to-Peak or Zero-to-Peak.

Theobalda et al. (2009), describe the benefits of this metric being used to describe the instantaneous sound pressure at a given location and can, if loud enough, be linked to Permanent Threshold Shift (PTS) in marine mammals.

However, due to the amplitude required to induce PTS, expressed by NOAA (2013) [Ref: 8] as 230 dB re 1 Pa Peak for Low frequency Cetaceans, it is highly unlikely that this amplitude could occur in this scenario.

Therefore, it may be appropriate to specify sound levels using Root Mean Square (rms) values because there is a direct relationship between the rms value and energy. By using this method, both the amplitude of the seismic shot and the duration of that shot are defined in a signal unit, both of which are of in great importance when estimating physical and neurological effects to marine mammals.

The duration of the pulse, T, has been calculated using the 90% rule formed by Greene (1997) [Ref: 4] and also cited in Needham (2010) [Ref: 6]. The suggestion is based on using a time window that removes the first and last 5% from the seismic pulse.

The rms is the mean square sound pressure level typically integrated over a window, T, encompassing the energy in the pulse.

$$rms = 20Log\left(\sqrt{\frac{1}{T}\int_0^T {}^2(t)\,dt}\right)$$

Where:

P_0= 1 µPa

T= duration, seconds

P(t)=sound pressure

4 Seismic Survey

The survey has been undertaken in the Cook Inlet, Alaska. The location for the survey is in close proximity of the Kenai Peninsula and immediately adjacent to Kenai. This is shown in Figure 6.

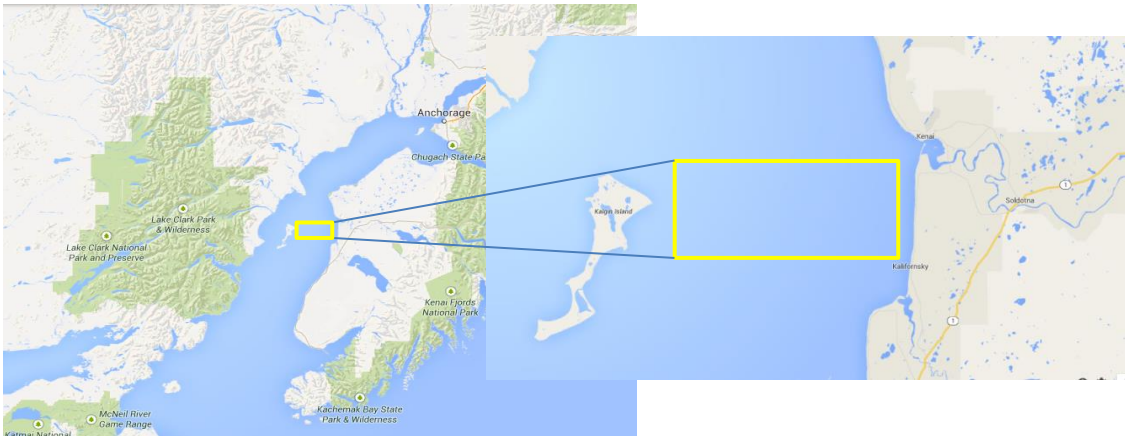


Figure 6 - Survey Location

4.1 Methodology

Seiche Measurements Ltd novel method for the characterisation of seismic sources alleviates many of the problems associated with a typical static hydrophone deployment.

Robinson et all (2014) [Ref: 5] suggests that static deployments often suffer from tidal flow and debris noise during the survey. Due to the unique tidal flow conditions presented in the Cook Inlet, this could have proved very difficult to utilise effectively.

The main disadvantage with a static system is that by definition they are static. This means that the bathymetry profile and other important sound propagation factors will only be gathered at the location of the static recorders. The other disadvantage of a static system is the need to secure the recorder to the seabed-which would consequently need permission from the regulatory office in that constituency and have potential environmental effects.

The drift buoy method however, provides a dynamic method of capturing the sound at many locations, providing a large and well defined data set that illustrates the effect of a seismic source much more accurately than a limited number of static points.

An added benefit of the drift buoy solution is the scalability of the deployment-more buoys would yield better fidelity when interpolating between measurement locations.

During the survey, six data recording buoys have been deployed and allowed to drift in the tidal flow past the airgun sound source. The source was maintained in one position throughout each test run and the buoys were positioned at various intervals, covering a 8 km radius from the 440 in^3 source and 10 km from the 1760 in^3 source, across the survey area in order to maximise the coverage and to represent a wide variety of distances from the source airgun.

5 Data Analysis and Results

5.1 Data Processing & Analysis

Collected data has been verified and analysed used Seiche Measurements proprietary Sound Source Verification software. The data has been processed using the following method.

- Peak detection algorithm has been applied in order to detect the sound shot peaks from the time line.
- The Peak to Peak values identified are correlated with the GPS positional data to provide an accurate distance from the source.
- The signal values are converted to dB re 1 V and then converted to SPL_{rms} giving full consideration to the calibration for each individual system.

5.2 Results

Results have been plotted as SPL_{rms} dB values against the calculated distance from the source.

5.2.1 440 in^3 Seismic Array in Shallow Water.

The calculated results of all the valid acoustic data from the buoys has been plotted as SPL_{rms} levels against distance from the source and are shown in Figure 11. The data shows a wide ranging distance spread over approximately 8.5 km for valid data. Three percentiles have been calculated for the 160 dB threshold and are shown on the graph. These are also detailed in Table 1 along with the information regarding the 180 dB and 190 dB zones. Levels for 190 dB have been estimated from the trend as no sound levels have been recorded this high.

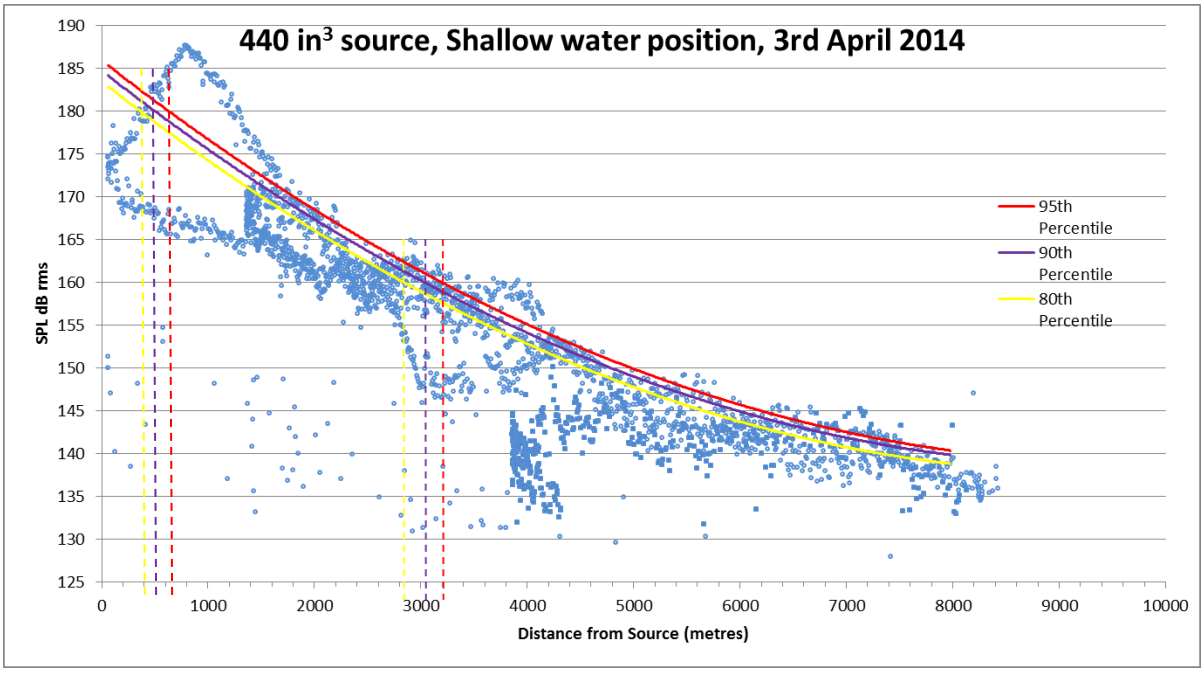


Figure 11 - 440 in^3 Source SPL dB_{rms} Levels vs Distance

	Range in Metres		
SPL_{rms} Level	**80th Percentile**	**90th Percentile**	**95th Percentile**
190 dB	<50	<100	<150
180 dB	400	500	650
160 dB	2850	3050	3210

Table 1 - 440 in^3 Source dB Radii

4.1.1 Study One - 440 in^3 Airgun in Shallow Water Location

The airgun source was positioned at 60.460254, -151.372638 and maintained this position for the tidal buoy run. The repetition rate was 10 seconds. The buoys were allowed to drift, in the tide, for over 3 hours collecting data from each sound shot. Over 8000 data points were recorded on this run. The buoy tracks can be seen in Figure 7 and the source is located at the centre of the 8 km circular marker zone.

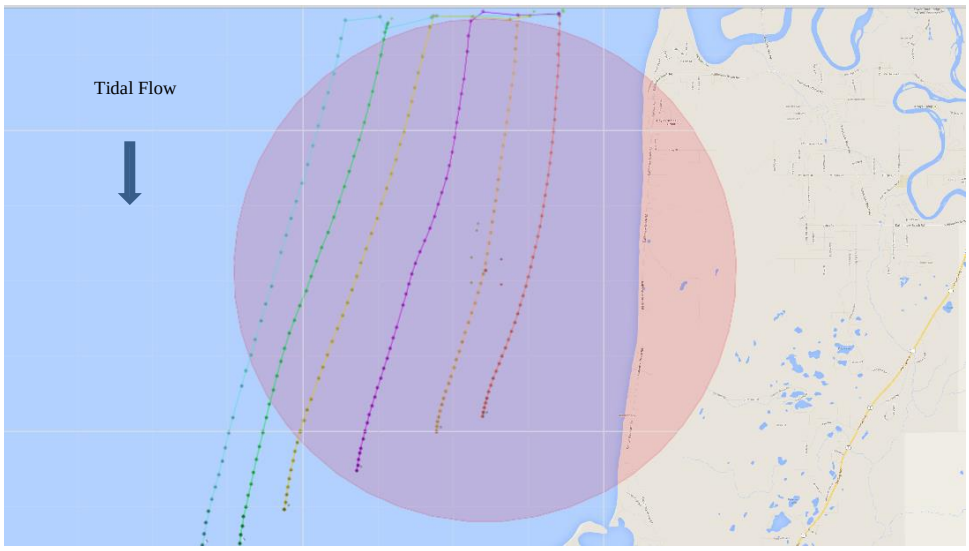


Figure 7 - 440 in^3, Test Buoy Tracks 3rd April 2014

4.1.2 Study Two - 1760 in^3 in Shallow Water Location

The same location has been used for the source, 60.460254, -151.372638 and again was maintained throughout the buoy run. The repetition rate for this source was set at 30 seconds. The buoys were allowed to drift, in the tide, for over 3 hours collecting data from each sound shot. Over 2000 data points were recorded on this run. The buoy tracks can be seen in Figure 8 with the source in the centre of the 10 km marker circle.

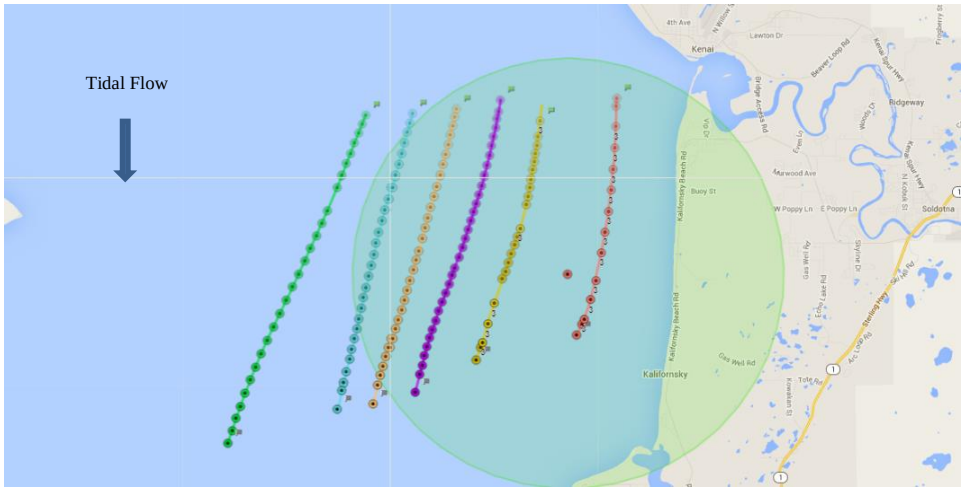


Figure 8 - 1760 in^3, Test Buoy Tracks 5th April 2014

4.1.3 Study Three - 1760 in^3 in Deep Water Location

The location of the source for the deep water study was 60.507910, -151.574560 and was maintained throughout the buoy run. The repetition rate for this source was set at 30 seconds. The buoys were allowed to drift, in the tide, for over 5½ hours collecting data from each sound shot. Over 3000 data points were recorded on this run. The buoy tracks can be seen in Figure 9 with the source in the centre of the 10 km marker circle. One of the buoys drifted quite wide and was physically repositioned within the zone. Data from this buoy during this process has been disregarded.

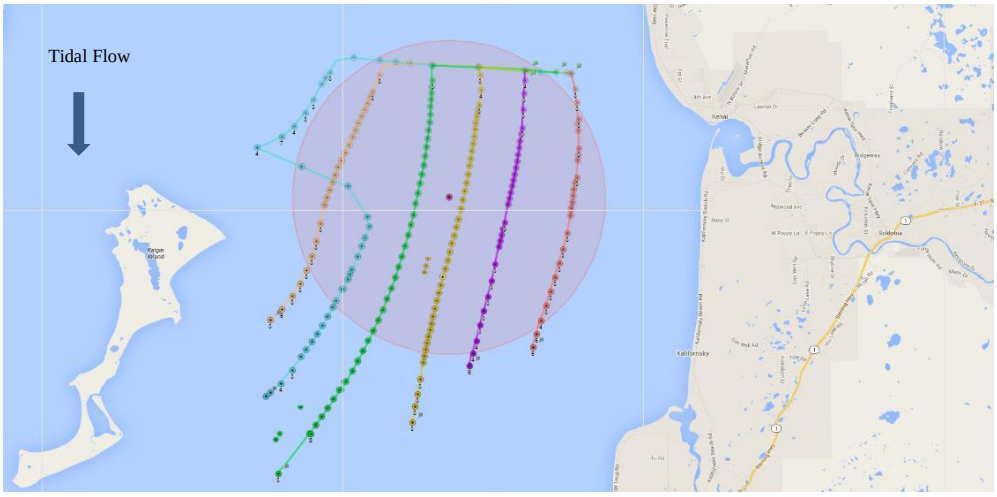


Figure 9 - 1760 in^3, Test Buoy Tracks 6th April 2014

4.2 Equipment and Calibration

Each drift buoy has been designed to house an autonomous data recording system, hydrophones, GPS location system, satellite location system and batteries. An example of the buoy can be seen in Figure 10. Each buoy is able to record 2 channels of high resolution acoustic data from two separate hydrophones. They are fitted with two Seiche Measurements propriety hydrophones and have individual nominal sensitivities of -200 dB re 1 V/µPa and -188 dB re 1 V/µPa respectively and have a frequency response range of 10 Hz – 100 kHz. The buoys data capture system has been individually calibrated prior to deployment and the actual sensitivities have been applied to the recorded digital data throughout. The acoustic data has been captured in 16 bit resolution at 96 kHz on this deployment.

Figure 10 - Drift Buoy

5.2.2 1760 in^3 Seismic Array in Shallow Water.

The calculated results of all the valid acoustic data from the buoys has been plotted as SPL_{rms} levels against distance from the source and are shown in Figure 12. The data shows a distance range spread over approximately 17.5 km for valid data. Three percentiles have been calculated for the 160 dB threshold and are shown on the graph. These are also detailed in Table 2 along with the information regarding the 180 dB and 190 dB zones which have been estimated from the trend as no sound levels of this intensity have been recorded.

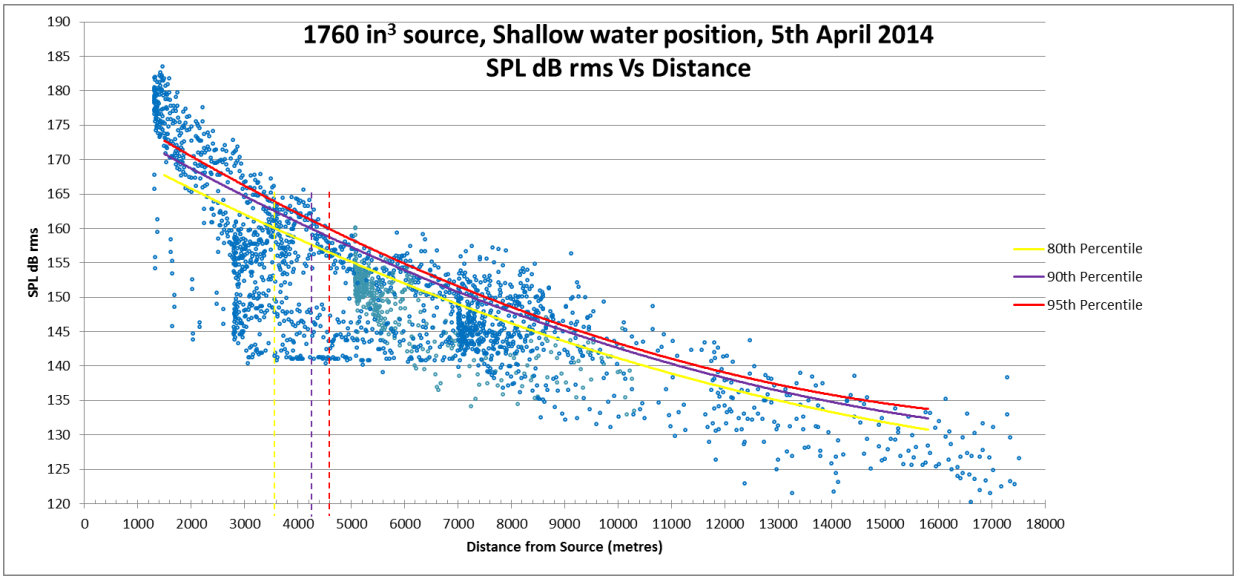


Figure 12 - 1760 in^3 Source SPL dB_{rms} Levels vs Distance

	Range in Metres		
SPL_{rms} Level	**80th Percentile**	**90th Percentile**	**95th Percentile**
190 dB	<700	<850	<1000
180 dB	1451	1514	1543
160 dB	3580	4270	4600

Table 2 - 1760 in^3 Source dB Radii (Shallow Water)

5.2.3 1760 in^3 Seismic Array in Deep Water

The calculated results of all the valid acoustic data from the buoys has been plotted as SPL_{rms} levels against distance from the source and are shown in Figure 13. The data shows a distance range spread over approximately 17.5 km for valid data. Three percentiles have been calculated for the 160 dB threshold and are shown on the graph. These are also detailed in Table 3 along with the information regarding the 180 dB and 190 dB zones.

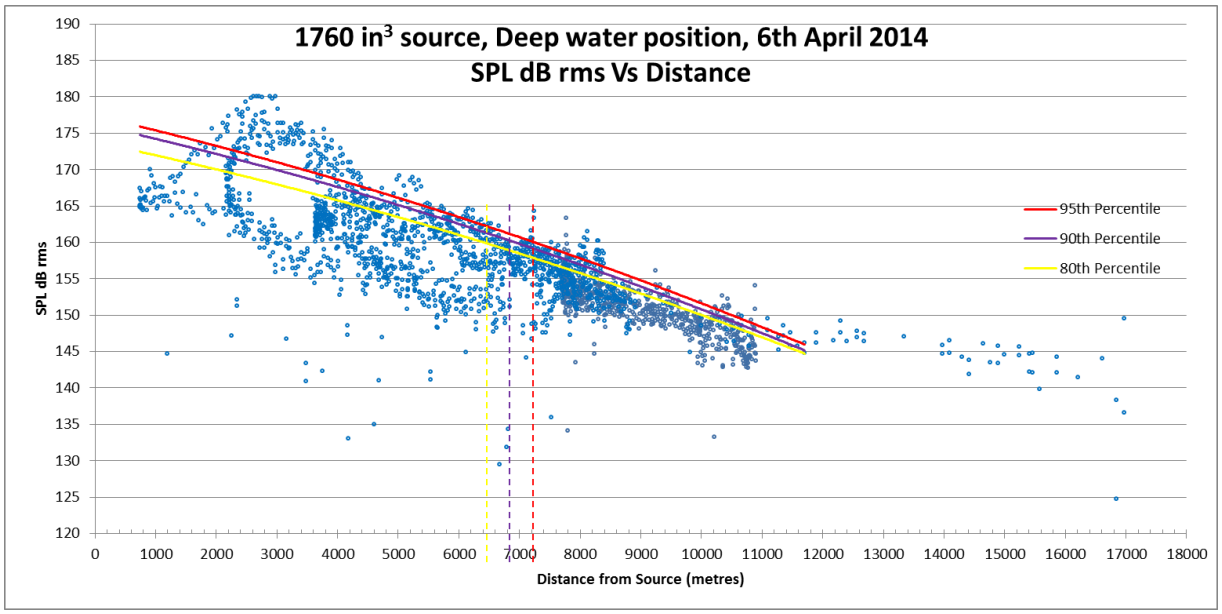


Figure 13 - 1760 in^3 Source SPL dB_{rms} Levels vs Distance (Deep Water)

	Range in Metres		
SPL_{rms} Level	**80th Percentile**	**90th Percentile**	**95th Percentile**
190 dB	<850	<1000	<1200
180 dB	2780	2832	2859
160 dB	6450	6830	7190

Table 3 - 1760 in^3 Source dB Radii (Deep Water)

6 Modelling

Modelling has been implemented using AcTUP (Acoustic Toolbox User interface and Post-processor, v.2.2l), a powerful software for sound propagation simulation in underwater environment. AcTUP core is based on consistent and thoroughly developed theories for prediction of sound behaviour in water, nevertheless as a model the results should be taken with caution. Accuracy of simulated models is always better when supported by measurements (empirical results) and a good definition of model parameters. In order to ensure model accuracy and comparison with survey results a dense set of official bathymetry data from NOAA and parameters of the environment from a previous survey in the Cook Inlet [Ref: 1] and position, depth and performance parameters from the sources and hydrophones deployed has been used.

The method chosen for the acoustic modelling is the parabolic equation, in particular RAMGeo model, which provides the best results for low frequencies both in shallow or deep water.

6.1 Bathymetry

High density bathymetry data from NOAA has been utilised to extract appropriate profiles relative to the test area and have been used in the acoustic propagation model. A set of 18 bathymetry profiles, at 20˚ steps, have been introduced into the data modelling software AcTUP to obtain the respective transmission loss profiles.

The Bathymetry along the Cook Inlet survey test area suggests it is fairly uniform, ranging in depth from 2m to 80m and as such a few data points are enough to define the bathymetry profile for each angle considered. For this model points at 250 m steps have been taken. A modelled topology of the Cook Inlet is shown in Figure 14.

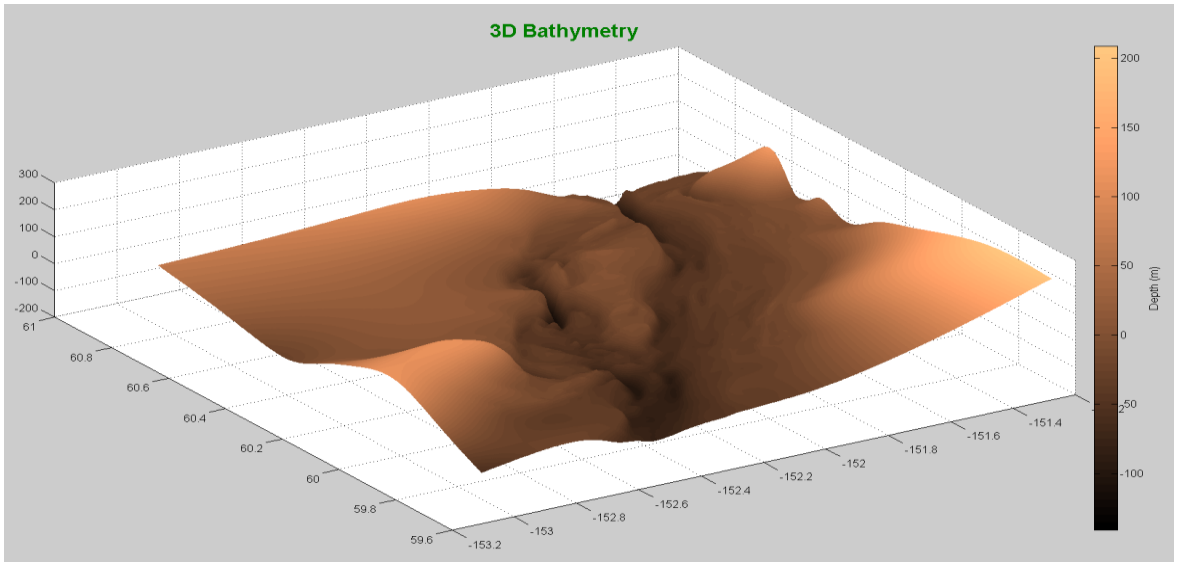


Figure 14 - Cook Inlet Topology

These bathymetry profiles have been extracted for two source positions, the same as used in the survey: one for shallow water, located at (60.460254, -151.372638); and another one for deep water, located at (60.507910, -151.574560).

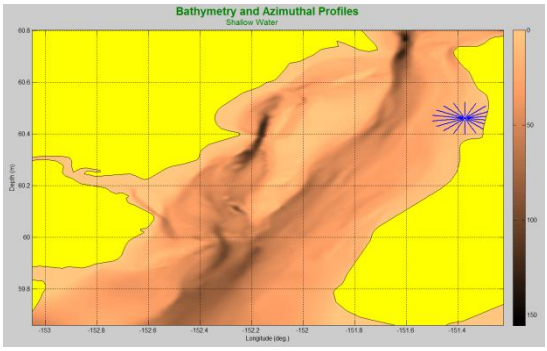


Figure 15 - Deep Water Bathymetry

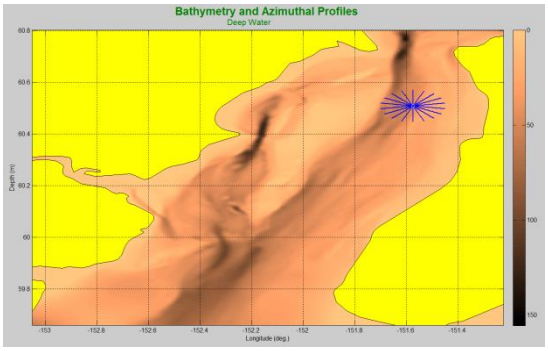


Figure 16 - Shallow Water Bathymetry

Both source positions, along with the profile segments, are represented in Figure 15 and Figure 16. The corresponding bathymetry profiles are drawn in Figure 17 and Figure 18, respectively.

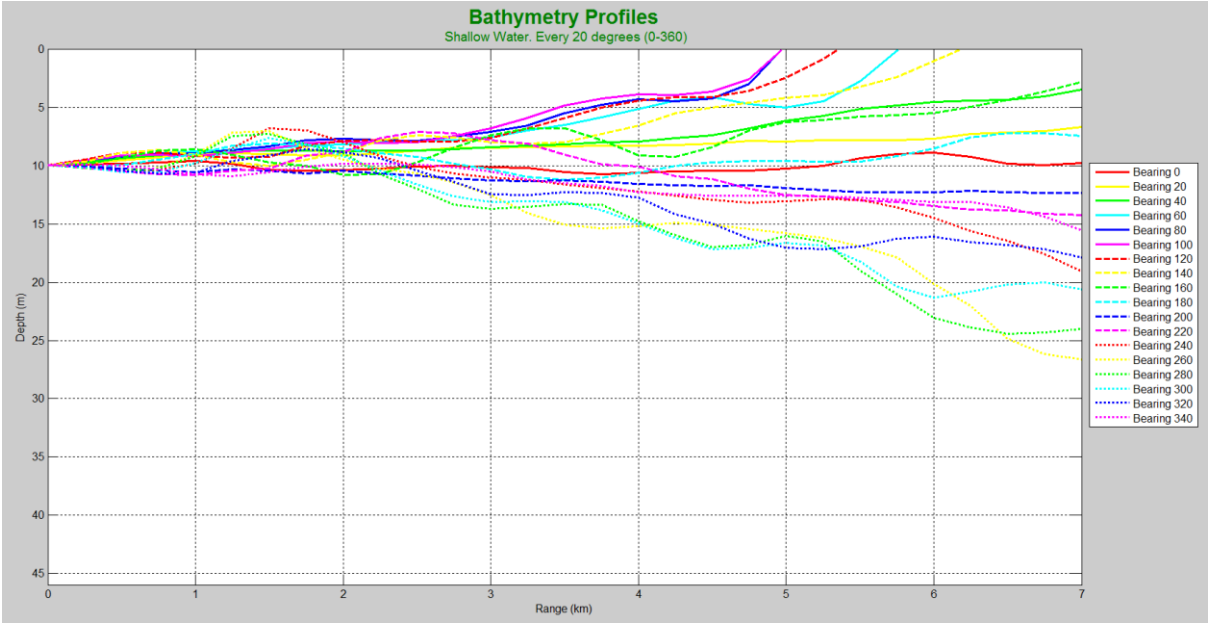


Figure 17 - Shallow Water Profiles

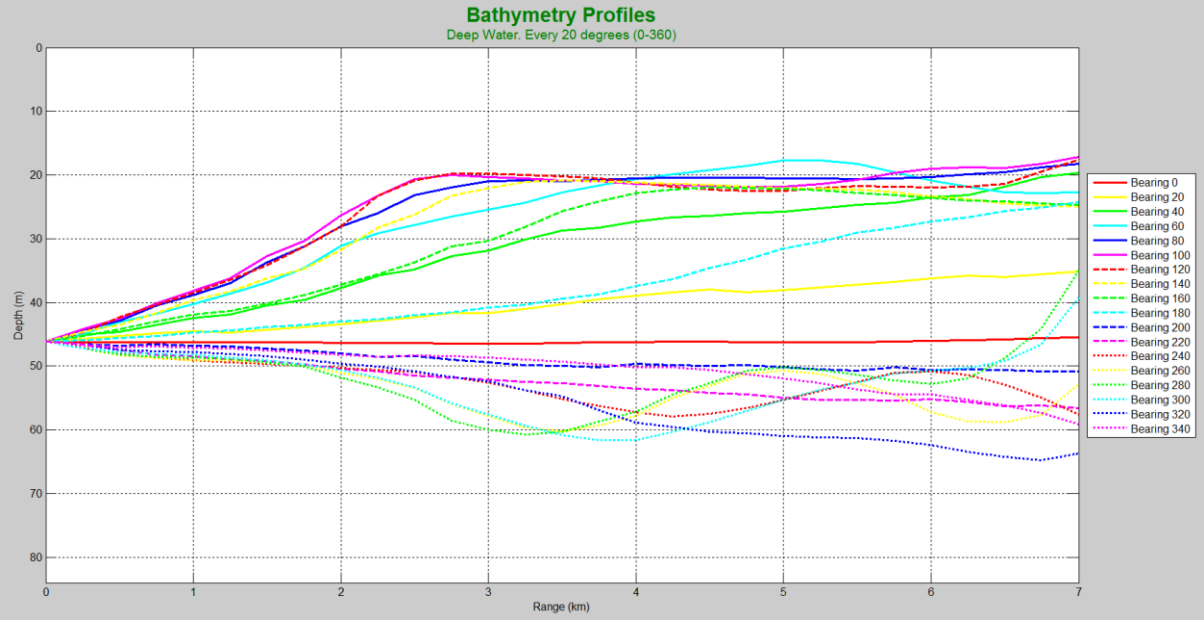


Figure 18 - Deep Water Profiles

6.2 Geology

The Cook Inlet comprises, in the main from two types of layers;

- Soil layer, a combination of sand, silt and clay
- Glacial layer, a combination of glacial fluvial sands, gravels and glacial till.

Applying methods originally described by Hamilton (1980) qualitative descriptions have been used to define the geo-acoustic properties in this area and have then been applied in the model.

6.3 Sound Velocity

The value applied for the model is 1436 ms^{-1}. Previous survey data has been used to establish a unique average sound velocity value for sea water in the area for this study [Ref: 1].

Table 4 shows the parameters used within the model.

	Compressional Sound Speed C_p (ms^{-1})	Shear Sound Speed C_p (ms^{-1})	Density (Kgm^{-3})	Compressional Attenuation ($dB\lambda^{-1}$)	Shear Attenuation ($dB\lambda^{-1}$)	Depth (m)
Water	1436	0	1024	0	0	Bathymetry
Soil Layer	1480	110	1580	0.17	2	108
Glacial Layer	1844	0	2180	0.5	0	Half-space

Table 4 - Geo-acoustic Profile

6.4 Modelling Assumptions

The modelling predictions provided are independent for both sources and use the following parameters throughout.

- Sound sources are primarily omni-directional
- Source frequency fundamental @ 90 Hz
- Source depth of 2 m (440 in^3) and 3 m (1760 in^3)
- Modelled Maximum range 7000m
- Low tide (distance from water surface to seabed defined by the bathymetry)

The frequency of the analysis has been matched to the highest energy content of the source frequency and has been modelled to a range of 7000 m in order to include the 160 dB, 180 dB and 190 dB mitigation zones.

6.5 Mitigation Zones Calculation

The transmission loss profiles obtained from AcTUP are combined with the source level (dB re 1 μPa_{rms}) of each source to get the receiver level profiles. The latter contains all the information about the propagation of sound and these are used to represent a SPL_{rms} map around the source, from which exclusion zones of 160, 180 and 190 dB can be extracted.

Peak to peak source levels have been extracted from sound pressure and impulsive signal information from the sources. In order to calculate rms it has been assumed that the value at a single frequency of 90 Hz contains all the energy of the pulse. This way the rms value can be estimated as:

$$\text{rms} = \text{SPLpp} - 20\log(2\sqrt{2})$$

This equates to a figure which is around 9 dB less than peak to peak value.

The SPL_{rms} map has been calculated by interpolation of the 18 transmission loss profiles. Data from transmission loss profiles has been used to calculate the mitigation zones. This way the exclusion lines are sharper but more realistic than if interpolation methods were applied.

The mitigation zones of 80th, 90th and 95th percentiles have been calculated for each exclusion level (160, 180 and 190 dB). A mitigation zone of a particular percentile is represented by a closed line around the source. The area inside this line is the region where exists a particular probability (determined by the associated percentile) to find that exclusion level. For example, the 90th percentile of the 160dB mitigation zone provides the limit at which there is a 90% probability of 160 dB exposure being contained inside. In practice, a single exclusion level value is not used; it is necessary to establish a small range around it to get a set of values to average and process using simple statistic techniques. Then, for each transmission loss profile a set of distance values corresponding to that set of sound level values is obtained. The set of exclusion level values is defined by exclusion level ±1.5 dB. If the probability distribution function of those distances is represented, a bell shape or Gaussian distribution will be observed. This way the distance of a particular percentile for each of the 18 directions considered and a particular exclusion level can be calculated as:

$$\bar{x} + z\sigma$$

Equation 3

Where x is the set of distances, $\bar{x}$ and σ are average and standard deviation and z the standard score or z-score for that percentile. The z-score values for the three percentiles considered (left tail probabilities) are the following:

$$80\% \rightarrow z = 0.842$$

$$90\% \rightarrow z = 1.282$$

$$95\% \rightarrow z = 1.645$$

7 Modelling Results

Two models have been computed in AcTUP in order to extract the transmission loss profiles: a shallow and a deep water model. They have been modelled to 7000 m extents and the 160 dB, 180 dB and 190 dB mitigation zones have been identified for both the lower pressure (LP) sound source (9 barm, 440 in^3) and the higher pressure (HP) one (50.7 barm, 1760 in^3) . The same three situations as in the Cook Inlet study have been modelled: HP source in deep water, HP source in shallow water and LP source in shallow water. Each case has been modelled for two different receiver depths: about 3 m (2.5 m for LP source and 3.5 m for HP source, taking into account the different depth for both sources) and 6 m. The SPL map (receiver levels) and the three mitigation zones can be seen in Figure 19 to Figure 24, for each source-depth context case and receiver depth. The frequency of the analysis has been matched to the highest energy content of the source frequency and has been modelled to a range of 7000 m in order to include the 160 dB, 180 dB and 190 dB mitigation zones. The modelled results for the 90th percentile are shown in Table 5.

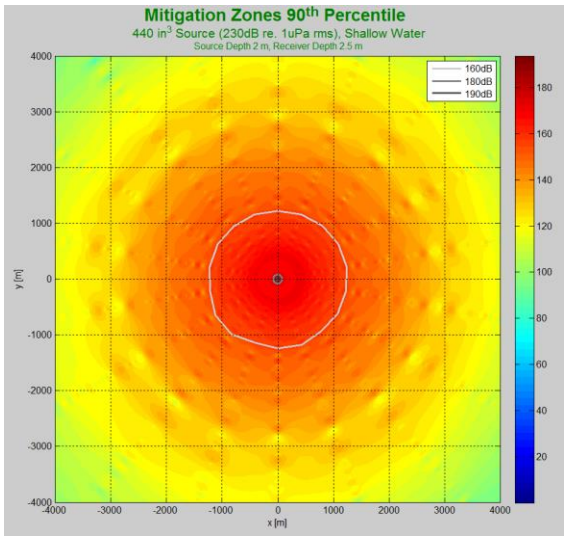


Figure 19 - Modelled Zone 440 in^3, Shallow Water, Depth 2.5m

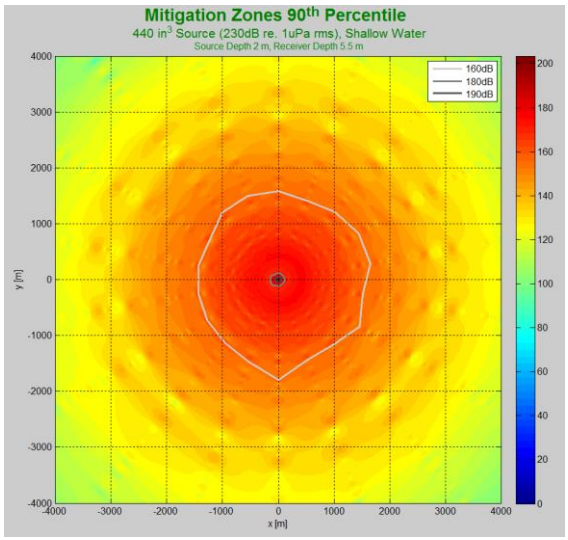


Figure 20 - Modelled Zone 440 in^3, Shallow Water, Depth 5.5m

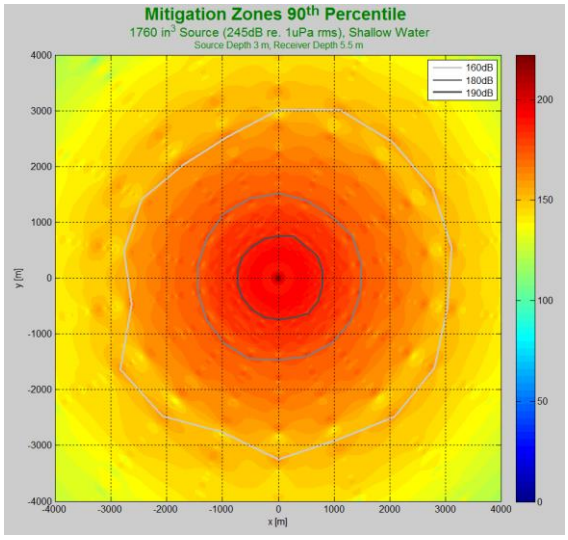


Figure 22 - Modelled Zone 1760 in^3, Shallow Water, Depth 5.5m

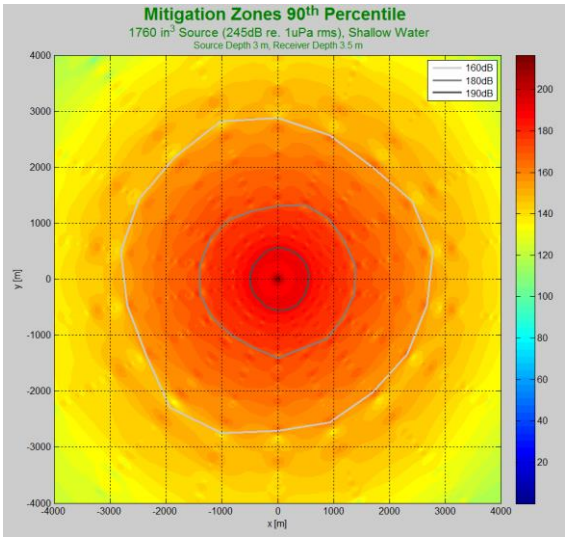


Figure 21 - Modelled Zone 1760 in^3, Shallow Water, Depth 3.5m

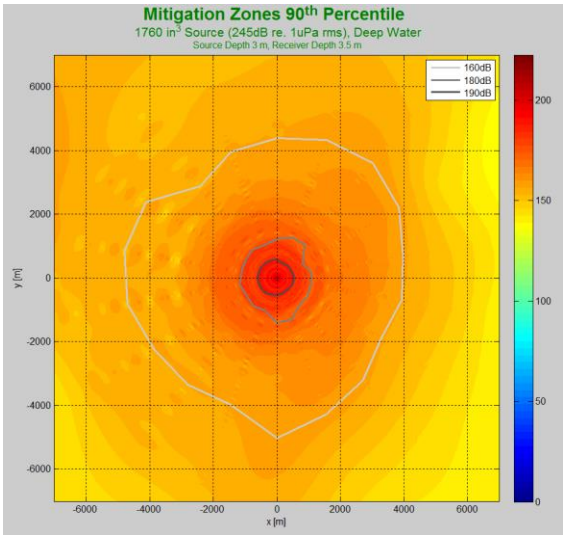


Figure 24 - Modelled Zone 1760 in^3, Deep Water, Depth 3.5m

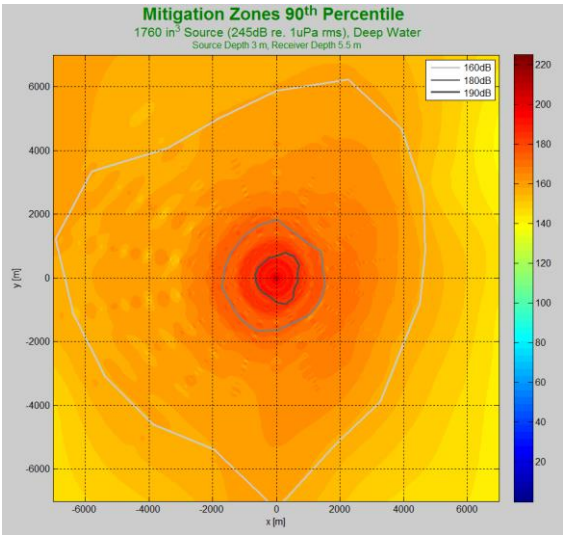


Figure 23 - Modelled Zone 1760 in^3, Deep Water, Depth 5.5m

	Modelled Distance in Metres for 90th percentile		
SPL_{rms} Level dB re 1 µPa	**440 in^3**	**1760 in^3 Shallow Study**	**1760 in^3 Deep Study**
190 dB	50	830	880
180 dB	150	1530	1840
160 dB	1690	3280	7250

Table 5 - Modelled Maxima Zone Distances

7.1 Deep & Shallow Water Extents

In the preliminary report two mitigation zones were obtained from numerical modelling for the same source locations used in Cook Inlet deployment, one for shallow water (60.460254, -151.372638) and another one for deep water (60.507910, -151.574560). The mitigation zones extents are different when modelled at different water depths. In order to identify at which depth the transition between shallow and deep water behaviour occurs, further investigation have been undertaken.

To achieve this six models have been ran using six source positions along a line that starts and ends at the aforementioned shallow and deep water points (see Figure 25~30). The aim is to assess the variation of the exclusion zones at different source to seabed distances; the results will help us define the context at which a shallow or deep water mitigation zone should be used.

The distance between source points has been chosen to get 5 m depth steps in the initial positions (flat bathymetry) and 10 m depth steps in the last ones (steep slope). The SPL map and exclusion zones (see Figure 31~36) have been simulated considering a 90 Hz and 1760 in^3 seismic source, with receiver and source at 3 m depth. The environment parameters applied to the model have not been altered.

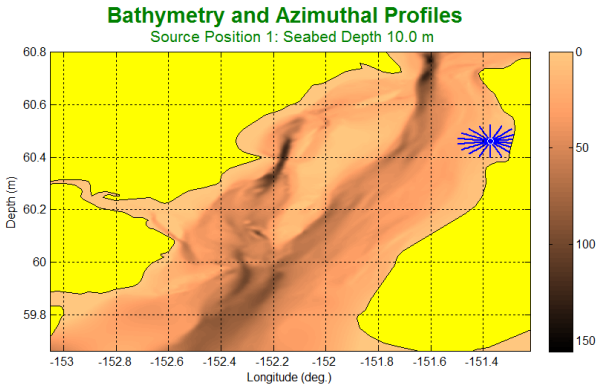


Figure 25 - Depth 10 m

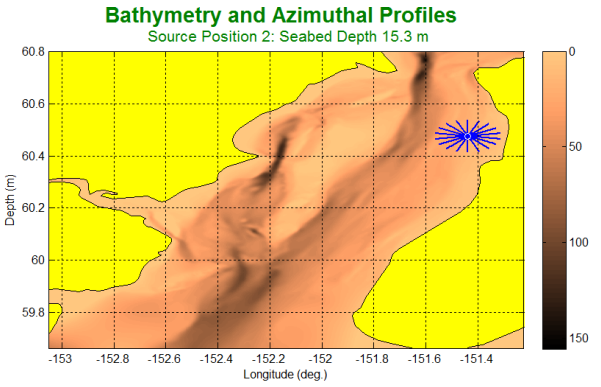


Figure 26 - Depth 15.3

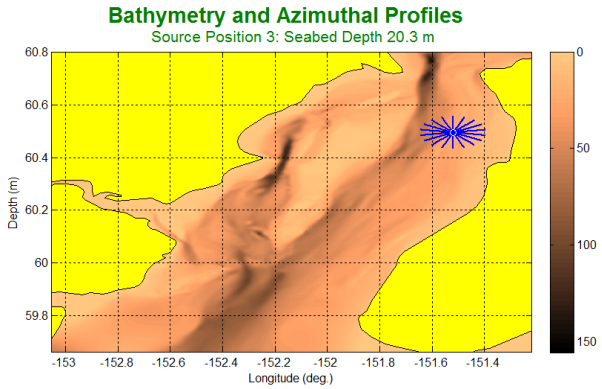


Figure 27 - Depth 20.3m

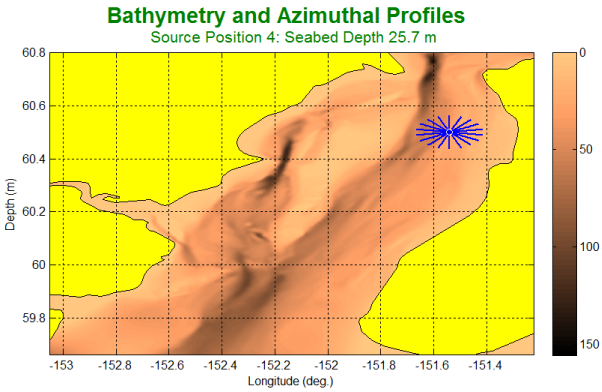


Figure 28 - Depth 25.7 m

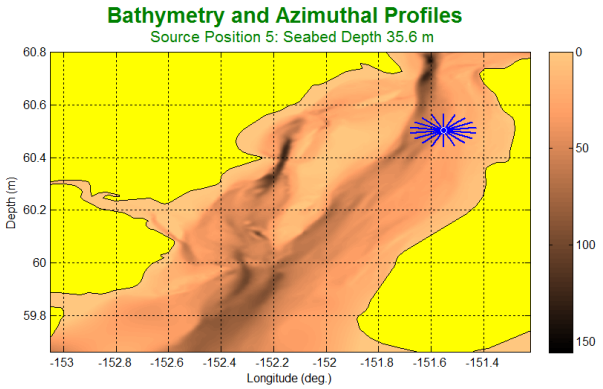


Figure 29 - Depth 35.6 m

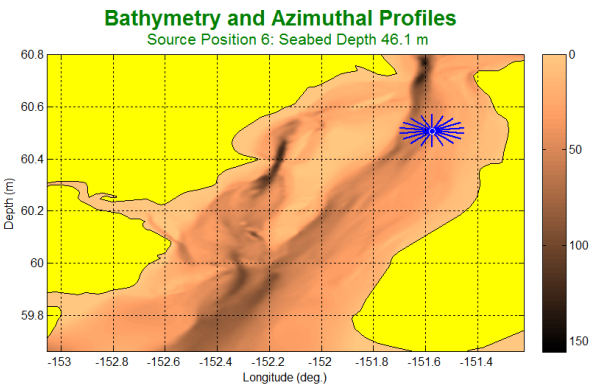


Figure 30 - Depth 46.1 m

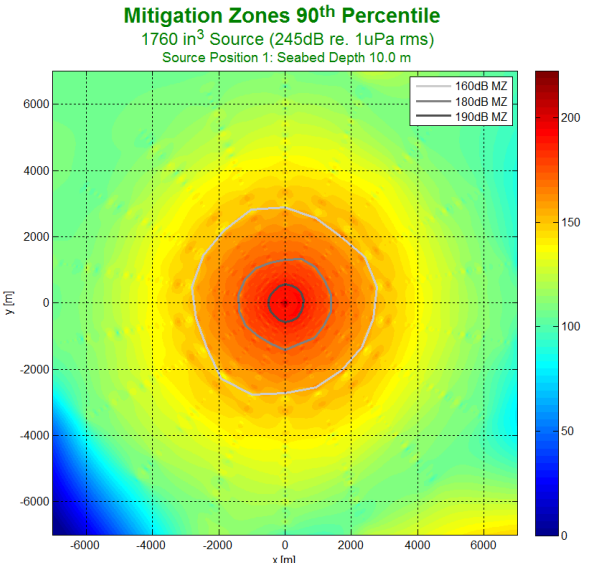


Figure 31 - Depth 15.3 m

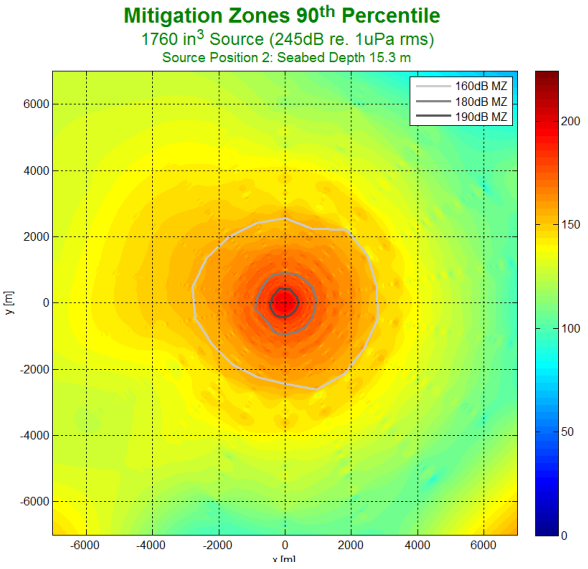


Figure 32 - Depth 10 m

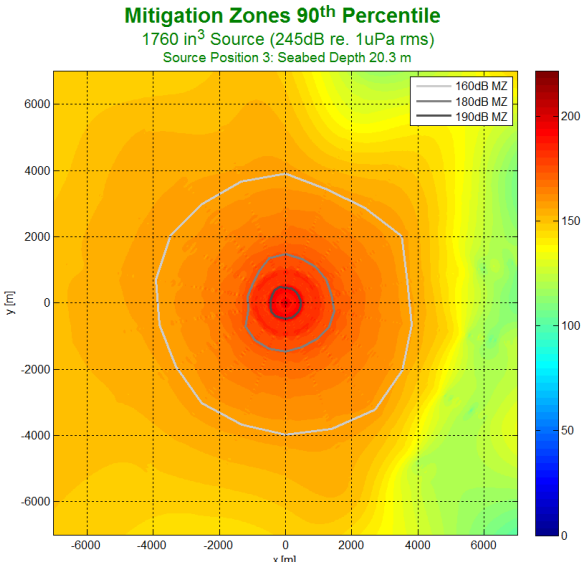


Figure 35 - Depth 35.6 m

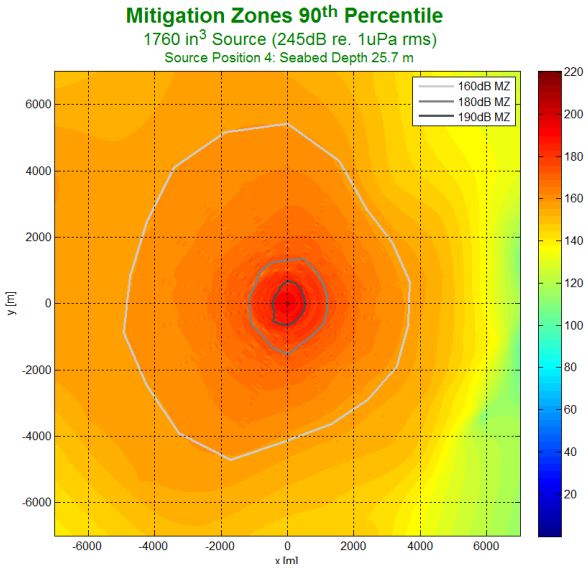


Figure 36 - Depth 46.1 m

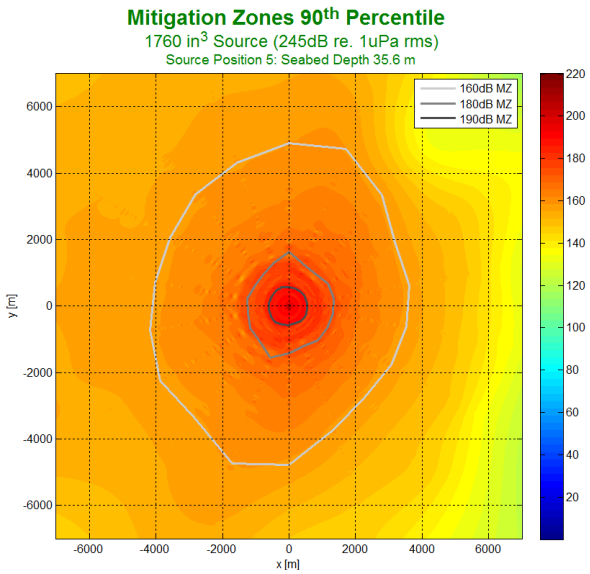


Figure 34 - Depth 25.7 m

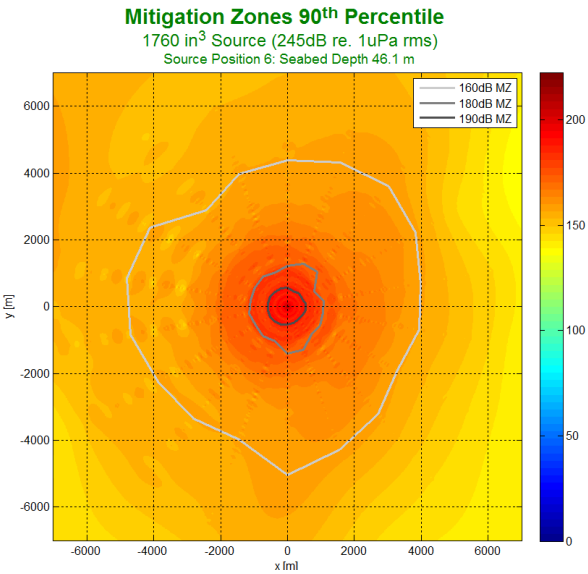


Figure 33 - Depth 20.3 m

Considering the results it can be clearly seen that there is strong relationship between the depth of the water column and the sound pressure level measured around the source. As the source moves towards the slope, the received amplitude increases. High sound pressure regions seem to originate in deep water is related with the main wavelength of the source. The size of the mitigation zone keeps fairly constant to depths of 15 m or less (see Figure 31 & 32) but above 15 m its size increases quickly, then keeps fairly constant above 25 m just with changes in shape due to the nature of the bathymetry. Then there is a transition point where the depth equals the source's fundamental frequency wavelength and from which the exclusion area experiences a big change.

According to these results it can be said that at depths above 15 m it should be applied the deep water mitigation zone and below 15 m the shallow water mitigation zone. This assumption is constrained by a few simulated points at a specific area of Cook Inlet, so is more a guideline than a general rule. The size of the exclusion zones will be affected by the particular bathymetry and seabed properties at each source point.

8 Conclusion

The nature of the deployment and data capture methodology ensured a wide, full and randomised data set. More than 13000 individual data points have been captured and analysed during this study. The results from the study are summarised in Table 6. The distances shown represent the maximum recommended zones for 160, 180 and 190 dB re 1 V/µPa sound levels based on the 90th percentile. There is a significant difference in the zone sizes between the 1760 in^3 arrays when deployed in shallow or deep water. The pre survey model has proven to provide a guide as to the expected zone requirements. Table 6 provides the zone data, where no valid data has been acquired then we have used the model to provide the values. These values are shown in italics Table 5.

	Distance in Metres for 90th percentile		
SPL_{rms} Level dB re 1 µPa	**440 in^3**	**1760 in^3 Shallow Study**	**1760 in^3 Deep Study**
190 dB	*50*	*830*	*880*
180 dB	182	*1530*	*1840*
160 dB	3050	4270	6830

Table 6 - Maximum Sound Threshold Distances

We would recommend the mitigation zones required are consistent with the levels shown in Table 6, particular attention should be taken of the shorter distances required for shallow water. It's expected that there is a correlation between the distances at shallow and deep water and as such the transition between these could be considered for a dynamic zone size.

As limited data was available in the 190 dB areas, futures deployments may need to take specific measures to ensure the buoys are close enough to the source.

It is proposed that in some cases the buoys could be released from or close to the source and allowed to drift away, how close to the source they need to be will be directly proportional to the source level.

Tables 7, 8 and 9 show the modelled results vs empirical measurements for the 80^{th}, 90^{th} and 95^{th} percentile, respectively.

For each mitigation zone an error factor has been calculated to portray the accuracy of the model in comparison to the measured results. Values with '<' preceding a mitigation zone have been excluded as these results were estimates from the model.

Error values close to 1 portray excellent correlation between model and measure with value <1 represent where the model has overshot the measured results.

Each empirical and measured value is the maximum value found in the band of data.

It can be seen from the three tables that the error factor remains fairly consistent throughout the range of percentiles over a given study, with all three modelled percentiles over estimating the mitigation zone.

The error factor does seem to increase with mitigation zone level, however further investigations and measurements would need to be undertaken as limited empirical measurements exists for 190 dB mitigation zones.

The trend also seems to suggest that the error factor reduces for larger sources/deeper water, with all three percentiles displaying this response-note the much higher error factors are recorder with the $440in^3$ source.

Again further analysis would need to be made to confirm this.

	Modelled 80th percentile (m)			Measured 80th percentile (m)		
SPL_{rms} re 1 µPa	**440 in^3**	**1760 in^3 Shallow Study**	**1760 in^3 Deep Study**	**440 in^3**	**1760 in^3 Shallow Study**	**1760in^3 Deep Study**
190 dB	50	720	770	<50	<750	<850
180 dB	130	1440	1690	400	1451	2780
Error Factor	*3.07 8*	*1.007*	*1.65*			
160 dB	1610	3080	6670	2850	3580	6450
Error Factor	*1.77*	*1.161*	*0.967*			

Table 7 - Modelled vs Measured 80th Percentile

	Modelled 90th Percentile (m)			Measured 90th percentile (m)		
SPL_{rms} re 1 µPa	**440 in^3**	**1760 in^3 Shallow Study**	**1760 in^3 Deep Study**	**440 in^3**	**1760 in^3 Shallow Study**	**1760 in^3 Deep Study**
190 dB	50	830	880	<100	<850	<1000
180 dB	140	1530	1840	500	1514	2832
Error Factor	*3.57*	*0.99*	*1.54*			
160 dB	1790	3270	7250	3050	4270	6830
Error Factor	*1.70*	*1.30*	*0.94*			

Table 8 - Modelled vs Measured 90th Percentile

	Modelled 95th percentile (m)			Measured 95th percentile (m)		
SPL_{rms} re 1 µPa	**440 in^3**	**1760 in^3 Shallow Study**	**1760 in^3 Deep Study**	440 in^3	1760 in^3 Shallow Study	1760 in^3 Deep Study
190 dB	50	920	970	<150	<1000	<1200
180 dB	150	1610	1970	650	1543	2859
Error Factor	*4.33*	0.95	1.45			
160 dB	1940	3470	7720	3210	4600	7190
Error Factor	*1.65*	*1.33*	*0.93*			

Table 9 - Modelled vs Measured 95th Percentile

9 References

Ref: 1 - NOAA. (N/A). Bathymetry. Available: http://maps.ngdc.noaa.gov/viewers/bathymetry/index.html.

Ref: 2 - Application for Incidental Harassment Authorization", Apache Corporation.

Ref: 3 - Edwin L. Hamilton1. (1980). Geoacoustic modelling of the sea floor. J. Acoust. Soc. 68

Ref: 4 - Greene, C.R., Jr. 1997. Physical acoustics measurements. In W. J. Richardson (Ed.), Northstar marine mammal monitoring program, 1996

Ref: 5 - Robinson, S.P., Lepper, P. A. and Hazelwood, R.A. (2014). Good Practice Guide for Underwater Noise Measurement. NPL Good Practice Guide . No. 133

Ref: 6 - Needham,K.. (2010). Underwater noise propagation modelling and estimate of impact zones for seismic operations in the Moray Firth. . . FINAL REPORT 37399 – FR1 (C)

Ref: 7 - Bernard, P. (1975) . Leq, SEL, WHAT? WHY? WHEN?, Bruel&Kjaer Application Note.

Ref: 8 - NOAA. (2013). Draft Guidance for Assessing the Effects of Anthropogenic Sound on 14 Marine Mammals Acoustic Threshold Levels for Onset of Permanent and Temporary Threshold Shifts.

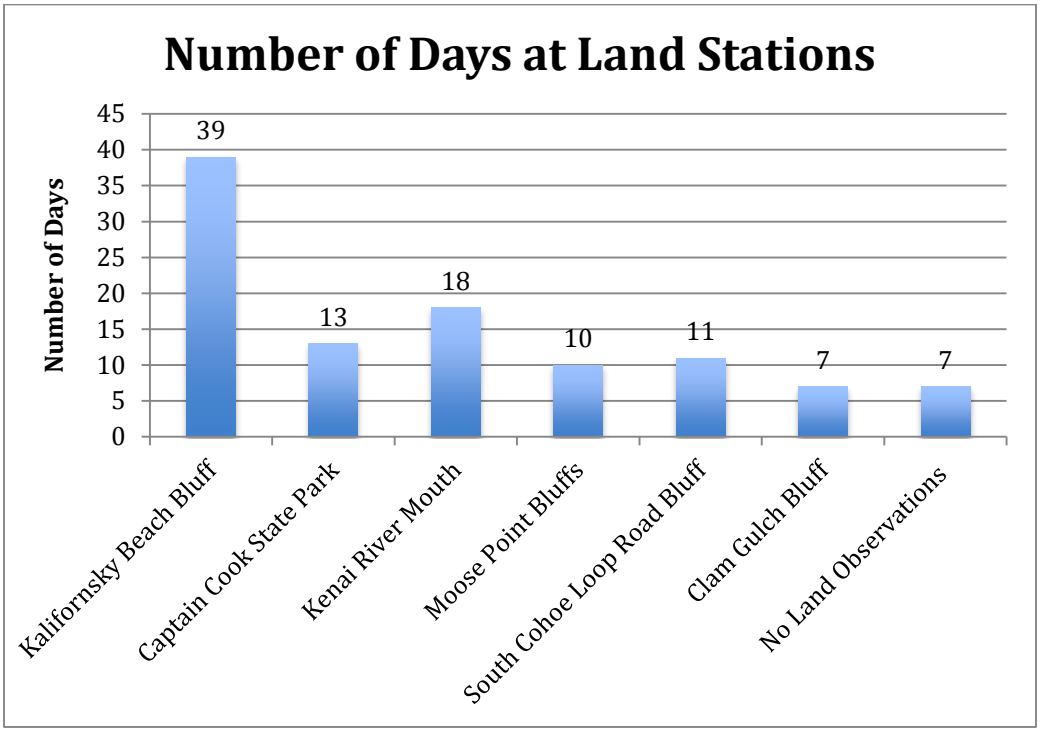
Ref: 9 - Pete Theobalda , Paul Lepper , Stephen Robinsona , Dick Hazelwooda. (2009). CUMULATIVE NOISE EXPOSURE ASSESSMENT FOR MARINE MAMMALS USING SOUND EXPOSURE LEVEL AS A METRIC

Appendix C. Land Observation Effort

Table 21. Chronological schedule and list of land stations used by PSOs.

Date	PSO Location Land
April 2 - 6	Kalifornsky Beach Bluff
April 7	Kenai River Mouth
April 8	Captain Cook State Park
April 9	Kasilof
April 10 - 11	Captain Cook State Park
April 12 - 13	No observations due to inclement weather
April 14 - 15	Captain Cook State Park
April 16 - 20	Kenai River Mouth
April 21	Captain Cook State Park
April 22	Moose Point Bluffs
April 23 - 24	Captain Cook State Park and Moose Point Bluffs
April 25 - 27	Kenai River Mouth
April 28 - 30	Moose Point Bluffs
May 1 - 5	Captain Cook State Park, Moose Point Bluffs and Kenai River mouth
May 6	No observations due to inclement weather
May 7	Kenai River Mouth
May 8 - 9	Clam Gulch
May 10 - 12	Kalifornsky Beach Bluff
May 13	No observations due to inclement weather
May 14 - 18	Kalifornsky Beach Bluff and Clam Gulch
May 19 - 20	No observations due to inclement weather
May 21	Kalifornsky Beach Bluff
May 22	Kalifornsky Beach Bluff and South Cohoe Loop Road
May 23	South Cohoe Loop Road
May 24 - 26	Kalifornsky Beach Bluff
May 27 - 28	Kalifornsky Beach Bluff and South Cohoe Loop Road
May 29 - 30	Kalifornsky Beach Bluff
May 31	No observations due to inclement weather
June 1	South Cohoe Loop Road
June 2 - 4	Kalifornsky Beach Bluff
June 5 - 6	South Cohoe Loop Road and Kenai River Mouth
June 7 - 9	Kalifornsky Beach Bluff
June 10	South Cohoe Loop Road
June 11	Kalifornsky Beach Bluff
June 12 - 14	South Cohoe Loop Road
June 15 - 16	Kalifornsky Beach Bluff
June 17	Kalifornsky Beach Bluff and South Cohoe Loop Road
June 18 - 27	Kalifornsky Beach Bluff

Figure 31. Number of days PSOs observed from each land station.



Appendix D. Definitions of Five Standard Mitigation Measures Implemented during the Cook Inlet 2014 Seismic Survey per the NMFS-Issued IHA.

Ramp-Up

A *ramp-up* is a gradual increase in the number of active airguns before seismic data acquisition. The purpose of a ramp up is to alert and provide marine mammals the opportunity to leave the immediate area before the airgun array reaches full volume. To begin ramp up from a cold start the entire exclusion zone must be visible and free of marine mammals for a consecutive 30 min period, known as a PSO clear. Ramp-up may begin without a PSO clear if the mitigation gun has been in operation following the last PSO clear.

Standard ramp-up procedures were implemented by doubling the number of active airguns approximately every 5 min, starting with the smallest airgun in the array. Ramp up of the 440 in^3 array from a shutdown took approximately 15 min whereas the 1,760 in^3 array from a shutdown took approximately 25 min (Table 22).

Table 22. Ramp-up time for the 440 cui and 1,760 cui arrays

Time (minutes)	Gun Volume (cui) 440 Array	Gun Volume (cui) 1,760 Array
0	70	70
5	140	140
10	290	280
15	440	580
20		880
25		1,760

Power Down

A *power down* is a reduction of the number of active airguns (from a full or partial array) to the smallest-volume single-operating airgun (i.e., the 10 in^3 project mitigation airgun). A power down was implemented when a marine mammal was sighted within or closely approaching the applicable exclusion zone for the full array (1,760 in^3).

Shutdown

A *shutdown* consisted of the full stop of all active airguns due to a marine mammal sighting within or closely approaching the EZ. Throughout the project, operating airgun(s) were shut down completely if a marine mammal approached or entered the applicable 180 or 190-dB (rms) EZ. Airgun activity did not resume until the marine mammal had cleared the exclusion zone radius of the full array. Further details on shutdown procedures can be found in the IHA application (Appendix A, "Incidental Harassment Authorization and ").

Poor Visibility Conditions

During the 30-min clearing period prior to ramp up from a full shut down, the IHA required that the entire 180-dB (rms) EZ be fully visible for the full 30-min clearing period. If the entire EZ was not visible (e.g., due to fog, snow, rain or darkness), ramp up could only commence if one or more airguns had been operating before the visibility decreased.

Mitigation Airgun

The mitigation airgun for the project was a 10 cui airgun and was fired at approximately one shot per minute during mitigation periods as directed by the IHA. The mitigation airgun was intended to (a) alert marine mammals to the presence of airgun activity, and (b) retain the option of initiating a ramp-up to full operations under poor visibility conditions including nighttime operations.

Appendix E. Summary and Description of Mitigation Measures during the Cook Inlet 2014 Seismic Survey.

Date	Time	Species	Platform	General Location	# Ind.	Mitigation Measure	Distance to source vessel (km)	Airgun Array Volume (cui)	Behavior	Notes
4/9/14	10:02:39	Beluga whale	Land	Kenai/ Kasilof	2	Ramp Up Delay	3.05	0	Travel	Observed during 'clearing safety zone', waited 30 minutes after sighting time, did not see them again, production continued as plan (ie; ramp up))
4/9/14	13:01:38	Harbor porpoise	Land	Kenai/ Kasilof	3	Shut Down	10.2	1,760	Mill	Shut down, determined to be outside the EZ and airguns brought back to full volume
4/14/14	11:32	Beluga whale	Peregrine	Susitna	2	Ramp Up Delay	1.3	0	Travel	
4/14/14	12:33	Beluga whale	Dream catcher	Susitna	1	Ramp Up Delay	10.34	70	Travel	
4/14/14	12:38	Beluga whale	Dream catcher	Susitna	1	Ramp Up Delay	7.16	140	Unknown	
4/14/14	12:45	Beluga whale	Dream catcher	Susitna	2	Shut Down	5.3	280	Unknown	
4/14/14	12:51	Beluga whale	Dream catcher	Susitna	1	Ramp Up Delay	5.65	0	Unknown	
4/14/14	12:58	Beluga whale	Dream catcher	Susitna	6	Ramp Up Delay	8.47	280	Unknown	
4/23/14	13:10	Beluga whale	Peregrine	Susitna	1	Shut Down	2.7	140	Travel	

Date	Time	Species	Platform	General Location	# Ind.	Mitigation Measure	Distance to source vessel (km)	Airgun Array Volume (cui)	Behavior	Notes
4/24/14	21:30	Beluga whale	Peregrine	Moose Point	5	Ramp Up Delay	1.4	0	Travel	Delayed ramp up and night operations and advised against use of mitigation gun due to inability to determine EZ clear for operations prior to sunset.
4/25/14	10:36	Humpback whale	Peregrine	Moose Point	1	Shut Down	1.5	1,760	Travel	Observed by PSOs on land, *Dreamcatcher* and *Peregrine*. Operations were ceased immediately and suspended for the remainder of the tide cycle. Aerial survey attempted to locate ~ 1hour later however did not see the whale during the flight.
4/28/14	11:19	Beluga whale	Land	Moose Point	2	Shut Down	>10	1,760	Travel	Animals sighted by PSO on *Peregrine*, called for a shut down, determined to be outside the EZ so operations were brought back to full volume in <10minutes.
4/29/14	13:10	Beluga whale	Land	Moose Point	2	Shut Down			Travel	
4/29/14	13:46	Beluga whale	Dream catcher	Moose Point	6	Shut Down	3	1,760	Surface active travel	
4/29/14	13:10	Beluga whale	Land	Moose Point	2	Shut Down			Travel	
4/29/14	13:46	Beluga whale	Dream catcher	Moose Point	6	Shut Down	3	1,760	Surface active travel	

Date	Time	Species	Platform	General Location	# Ind.	Mitigation Measure	Distance to source vessel (km)	Airgun Array Volume (cui)	Behavior	Notes
4/29/14	19:27	Humpback whale	Dream catcher	Moose Point	1	Shut Down		10	Travel	Slow travel south, first observed ~500m from *Dreamcatcher*, mitigation gun operating and shut down immediately, did not resume operations until following day.
5/9/14	21:44:43	Harbor Porpoise	Peregrine	Clam Gulch	2	Shut Down	3.5	1,760	Travel	
5/11/14	9:29:41	Harbor Porpoise	Peregrine	Clam Gulch	1	Shut down	1.5	1,760	Travel	
5/16/14	13:58:20	Harbor Porpoise	Peregrine	Clam Gulch	1	Shut Down	0.7	1610	Travel	

Appendix F. Summary and Description of Marine Mammal Exposures during the Cook Inlet 2014 Seismic Survey.

Exposure Zone	Date	Project Area	Species	#	Initial Behavior Observed	Behavioral Reaction Observed	NMFS Weekly/Monthly Report Descriptions
DZ	14-Apr	N. Kenai	Harbor seal	1	Mill	None	On April 14th at 14:48 a single harbor seal was observed 600 m, from the *Peregrine*. The *Peregrine* was operating at full volume (1,760 cu in). During this event, Apache was still operating under the zones identified in the 2014 IHA based on the 2012 SSV results. Thus, this sighting of one harbor seal at 600 m from the *Peregrine* source vessel was in the DZ applicable at that time. There was no mitigation measure implemented.
DZ	23-Apr	N. Kenai	Beluga whale	6	Travel	None	On April 23rd at 13:08 a group of 6 beluga whales was first observed from the aerial and vessel platforms. The belugas surfaced 2.7 km from the *Peregrine*. The *Peregrine* was in a "ramp up" procedure and operating at 140 cui. Operations were shut down immediately (within a 1-shot period) when the sighting occurred. There were no behavioral changes or reaction observed by the belugas. After 44 subsequent minutes with no additional sightings of these belugas or other marine mammals, project operations resumed with the required ramp up procedure to full volume. ***Based on clarification from NMFS (email communications May 15, 2014) this event has been determined to NOT be an exposure to the**

Exposure Zone	Date	Project Area	Species	#	Initial Behavior Observed	Behavioral Reaction Observed	NMFS Weekly/Monthly Report Descriptions
							DZ due to the array volume during ramp up (140 cui) and distance of the beluga group to the source vessel (2.7 km).
DZ	23-Apr	N. Kenai	Harbor seal	1	Mill	None	On April 23rd at 17:24 one harbor seal was observed from the *Dreamcatcher* platform. The harbor seal was 3.8 km from the *Peregrine*. The *Peregrine* was operating at full volume (1,760 cu in). No mitigation measure was implemented. There were no behavioral changes or reactions observed.
EZ	25-Apr	N. Kenai	Humpback Whale	1	Travel	None	On April 25th at 10:35 a humpback whale was first observed at 1.5 km from the *Peregrine*. The *Peregrine* was operating at full volume (1,760 cui) and the source was shut down immediately (within a 1-shot period) after the sighting occurred. Operations did not resume until the following day.
EZ	29-Apr	N. Kenai	Humpback Whale	1	Mill	None	On April 29th at 19:57 a humpback whale was observed at 2.8 km from the *Peregrine*. The *Peregrine* was operating at full volume (1,760 cu in) and the source was shut down immediately (within a 1-shot period) after the sighting occurred. Operations did not resume until the following day.

Exposure Zone	Date	Project Area	Species	#	Initial Behavior Observed	Behavioral Reaction Observed	NMFS Weekly/Monthly Report Descriptions
DZ	29-Apr	N. Kenai	Beluga whale	6	Travel	None	On April 29th at 13:46 a group of 6 beluga whales was first observed from the land and *Dreamcatcher* platforms. The beluga group was ~4.4 km from the *Peregrine*. The *Peregrine* was operating at full volume (1,760 cui). Operations were shut down immediately (within a 1-shot period) when the sighting occurred. The whale group was tracked as it moved through the project area and was determined to be outside the EZ (7.7 km from the *Peregrine*) ~23 minutes after the initial sighting.
DZ	30-Apr	N. Kenai	Beluga whale	6	Mill	None	On April 30th at 13:42 a group of 6 beluga whales was first observed from the vessel and land platforms. The beluga group was originally observed 7.5 km from the *Peregrine.* Seismic sources were not operating from the *Peregrine.* PSOs delayed calling ramp up ~1 hour due to the concern that the beluga group might approach the edge of the 160 dB zone. After the group was not observed for >30 minutes, ramp up was initiated and the *Peregrine* reached full volume (1,760 cu in). At 15:15, a group of 6 beluga whales, possibly the same group, was sighted by PSOs at 4.1 km from the *Peregrine*. Operations were shut down immediately (within a 1-shot period) when the sighting occurred. Operations were suspended for the remainder of the tide cycle.

Exposure Zone	Date	Project Area	Species	#	Initial Behavior Observed	Behavioral Reaction Observed	NMFS Weekly/Monthly Report Descriptions
DZ	9-May	S. Kenai	Harbor porpoise	2	Travel	None	On May 9th at 21:44 two harbor porpoise were observed 4 km from the *Peregrine*. The animals were observed traveling toward the source vessel, possibly approaching the EZ. Operations shut down immediately and ramp up was delayed for 30 minutes. The harbor porpoise were not observed again, and operations started with the ramp up procedure over 15 min after the harbor porpoise had no longer been seen.
EZ	11-May	S. Kenai	Harbor porpoise	1	Travel	None	On May 11th at 09:29 a single harbor porpoise was observed 1.5 km from the *Peregrine*. The source vessel was operating at full volume (1,760 cui). Operations were shut down immediately. The harbor porpoise was not observed again.
DZ	11-May	S. Kenai	Harbor seal	1	Travel	None	On May 11th at 15:42 a single harbor seal was observed 4.2 km from the *Peregrine* from the land observation team located at Kalifornsky Beach Road bluff site. The harbor seal was determined to be outside the EZ and operations continued.
EZ	15-May	S. Kenai	Harbor porpoise	1	Travel	None	On May 15th at 13:58 a single harbor porpoise was observed in the EZ by PSOs on the *Peregrine*. Operations were shut down immediately.
DZ	17-May	S. Kenai	Harbor porpoise	2	Travel	None	On May 17th at 19:26 two harbor porpoise were observed at 5.5 km from the *Peregrine* from the PSOs on the *Dreamcatcher*. Operations were not suspended.

Exposure Zone	Date	Project Area	Species	#	Initial Behavior Observed	Behavioral Reaction Observed	NMFS Weekly/Monthly Report Descriptions
DZ	24-May	S. Kenai	Harbor seal	1	Mill	None	On May 24th at 11:54 one harbor seal was observed at 6.9 km from the *Peregrine* from the PSOs on land. Operations were not suspended.
DZ	24-May	S. Kenai	Harbor seal	1	Mill	None	On May 24th at 12:49 one harbor seal was observed at 3.0 km from the *Peregrine* from the PSOs on land. Operations were not suspended.
DZ	24-May	S. Kenai	Harbor seal	1	Mill	None	On May 27th at 18:38 one harbor seal was observed at 5.3 km from the *Peregrine* from the PSOs on land. Operations were not suspended.
DZ	24-May	S. Kenai	Harbor seal	1	Mill	None	On May 27th at 19:06 one harbor seal was observed at 6.2 km from the *Peregrine* from the PSOs on land. Operations were not suspended.
DZ	12-Jun	S. Kenai	Harbor seal	1	Mill	None	On June 12th at 05:37 one harbor seal was observed from the *Dreamcatcher* platform. The harbor seal was 3.8 km from the *Artic Wolf*. The *Arctic Wolf* was operating at an array volume of 1610 cui. No mitigation measure was implemented. There were no behavioral changes or reactions observed.
DZ	23-Jun	S. Kenai	Harbor seal	1	Mill	Swim Away	On June 23rd at 23:01 one harbor seal was observed from the *Arctic Wolf* platform. The harbor seal was 3.8 km from the *Artic Wolf*. The *Arctic Wolf* was operating at an array volume of 1,760 cui. No mitigation measure was implemented. The harbor seal was observed and then it swam away.

Appendix G. Cook Inlet 2014 Seismic Survey Photo Log

Land Stations

Kalifornsky Beach Road Land Station: Theodolite seen in yellow and Big Eye binoculars in the forefront. Photo credit: Kelsey Stone

PSO Kelsey Stone at the South Coho Land Station. Photo credit: Kelsey Stone

PSO Meggie Moore on watch. Photo Credit: Roxann Merizan

PSO Matt O'Dell with the Big Eyes. Photo Credit: Kelsey Stone

PSOs on watch at the Kalifornsky Beach Road Land Station. Robyn Walker on the Theodolite, Vanessa James on the Big Eyes, and Roxann Merizan on the Fujinon Binoculars. Photo credit: Roxann Merizan

Kenai River Land Station, Photo Credit: Roxann Merizan

View of Mt. Illiamna from the Land Station on Kalifornski Beach Road. Photo Credit: Kelsey Stone

Sighting Photos

Humpback whale, Cook Inlet, 29 April 2014. Photo credit: Bridget Watts.

Mother (white) and calf (gray) Beluga whales swimming in the Cook Inlet in April 2014. Photo credit: Christina Goertz

Adult Belugas traveling in a group. Photo Credit: Rachel Huff-Aurora Interface Designs

Baby Beluga surfacing in the Cook Inlet. Photo credit: Christina Goertz

Belugas swimming in the Cook Inlet Photo Credit: Mark Cotter

Beluga swimming in the Cook Inlet Photo Credit: Mark Cotter

Aerial Photos

Beluga River feeding area. Photo Credit: Terra MH Hanks

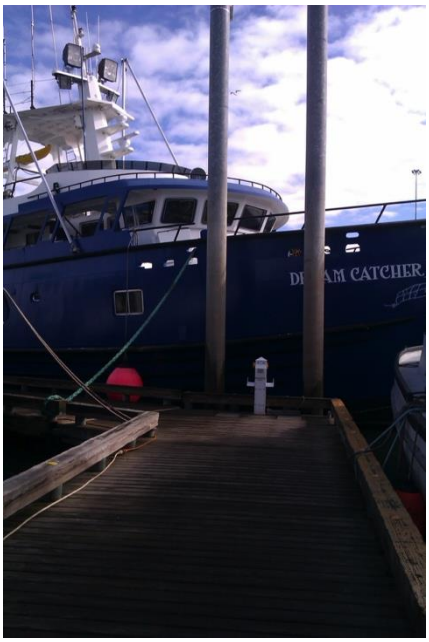
Circling over the river. Photo Credit: Terra MH Hanks

Aerial view looking south toward Turnagain Arm. Photo Credit: Terra MH Hanks

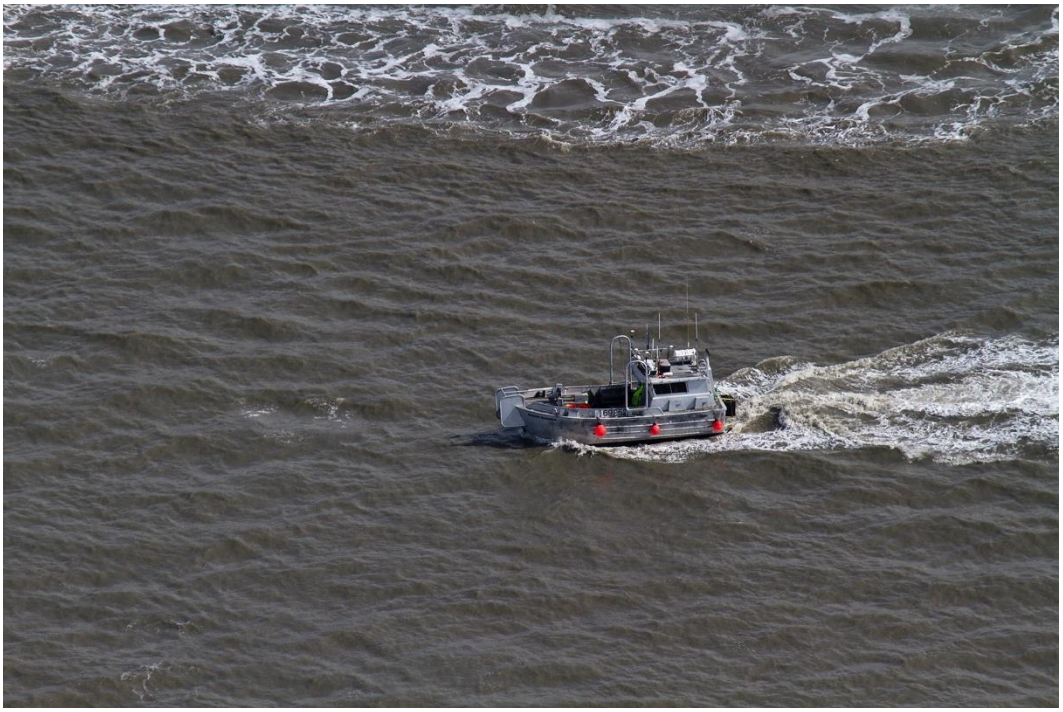
Vessels

Peregrine Falcon anchored in the Cook Inlet. Photo credits: Kristen Dominici

View from top deck of the Peregrine Falcon.



The Dreamcatcher at dock in Homer.



M/V Sleeprobber. Photo Credit: Mark Cotter

M/V Peregrine Falcon. Photo Credit: Mark Cotter

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