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BP Exploration (Alaska) Inc.
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900 E. Benson Boulevard
Anchorage, AK 99519-6612
USA

December 5, 2011

Ms. Candace Nachman
National Marine Fisheries Service
Office of Protected Resources
1315 East West Highway
Silver Springs, MD 20910-3226

RE: Request for Issuance of an Incidental Harassment Authorization for the Simpson Lagoon Ocean Bottom Cable (OBC) Seismic Survey 2012, Beaufort Sea, Alaska

Dear Ms. Nachman,

BP Exploration (Alaska), Inc. (BPXA), pursuant to 50 CFR Part 216.101-108 and Section 101 (a)(5)(D) of the Marine Mammal Protection Act (MMPA), 16 U.S.C. §1371 (a)(5), requests issuance of an Incidental Harassment Authorization (IHA) to allow non-lethal harassment of marine mammal incidental to the Simpson Lagoon OBC geophysical seismic operation to be conducted in 2012 in the Beaufort Sea, Alaska.

The enclosed application addresses specific items pursuant to 50 C.F.R. §216.104, "Submission of Requests", and §216.107, "Incidental Harassment Authorization for Arctic Waters." The planned operation activities described in the application will have a negligible impact on individual marine mammals or their populations found in the Beaufort Sea and no unmitigable adverse impact on the availability of marine mammals for subsistence purposes. Operational measures that will mitigate impacts to marine mammals and subsistence activities, as well as a description of the proposed monitoring for 2012, are also discussed.

If you have any questions about the enclosed application, please contact me at (907) 564-4325 or at janet.sheldon@bp.com.

Sincerely,

Janet Sheldon
Permitting Compliance Authority

Enclosure: IHA application dated December 5, 2012 cc: w/enclosure

Robert Suydam, North Slope Borough – Barrow, AK
Craig George, North Slope Borough – Barrow, AK
Harry Brower, Chairman Alaska Eskimo Whaling Commission – Barrow, AK
Jessica LeFevre, Alaska Eskimo Whaling Commission – Washington D.C.
Doug DeMaster, NOAA Fisheries – Seattle, WA
Brad Smith, NOAA Fisheries – Anchorage, AK
Arnold Brower, Jr. – ICAS

INCIDENTAL HARASSMENT AUTHORIZATION REQUEST FOR THE NON-LETHAL HARASSMENT OF WHALES AND SEALS DURING THE SIMPSON LAGOON OBC SEISMIC SURVEY, BEAUFORT SEA, ALASKA, 2012.

Submitted by

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December 5, 2011

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SUMMARY

BP Exploration (Alaska), Inc. (BPXA) plans to conduct a 3D ocean bottom cable (OBC) seismic survey in the Simpson Lagoon area of the Alaskan Beaufort Sea during the open water season of 2012 and requests an Incidental Harassment Authorization (IHA) allowing non-lethal harassment of marine mammals incidental to these activities. This application for an IHA is submitted pursuant to Section 101 (a)(5)(D) of the Marine Mammal Protection Act (MMPA), 16 U.S.C. § 1371 (a)(5). The proposed OBC seismic survey will use three source vessels to acquire data both within and outside the barrier islands. The airgun array towed behind the two main source vessels will consist of two sub-arrays, each with eight 40 cubic inch (cu in) airguns, totaling a 640 cu in discharge volume when all 16 airguns are operational. The mini source vessel will tow one sub-array of eight 40 cu in airguns for a total discharge volume of 320 cu in.

Of the eight cetacean species that can occur in the Beaufort Sea and that fall under the jurisdiction of the National Marine Fisheries Service (NMFS), the bowhead whale is the most likely to occur in the proposed Simpson Lagoon seismic survey area, followed by the beluga whale and gray whale. Of these three species only the bowhead whale is listed as "Endangered" under the Endangered Species Act (ESA). The other five cetacean species – narwhal, killer whale, harbor porpoise, minke whale and humpback whale – could occur in the Beaufort Sea, but each of these species is rare or extralimital and based on currently available data unlikely to be encountered. Of the four pinniped species under NMFS jurisdiction, the ringed seal is the most common species in the proposed survey area, followed by the bearded and spotted seal. Ribbon seals occur mainly in the western part of the Beaufort Sea and are therefore unlikely to be encountered in the Simpson Lagoon area. The Alaska stocks of bearded and ringed seals have been proposed by NMFS for listing as threatened under the ESA (NMFS 2010a, 2010b). The final decision will be announced in December 2011. BPXA is proposing a marine mammal monitoring and mitigation program to minimize potential impacts of the proposed activity on marine mammals and to document the nature and extent of any of such effects.

The items required to be addressed pursuant to 50 C.F.R. § 216.104, "Submission of Requests," are summarized below. This includes a description of the specific operations to be conducted, the marine mammals occurring in the survey area, proposed measures to mitigate against any potential injurious effects and a plan to monitor any behavioral effects on those marine mammals from the proposed OBC seismic survey operations.

1. DETAILED OVERVIEW OF OPERATIONS TO BE CONDUCTED

A detailed description of the specific activity or class of activities that can be expected to result in incidental taking of whales and seals.

BP Exploration (Alaska), Inc. (BPXA) proposes to conduct a 3D ocean bottom cable (OBC) seismic survey in the Simpson Lagoon area, Beaufort Sea, for an estimated 50 days of work during the open water period of approximately 1 July to 15 October 2012 (Figure 1.1). BPXA requests an Incidental Harassment Authorization (IHA) allowing non-lethal harassment of marine mammals incidental to this proposed OBC seismic survey (more detail on the type of incidental take authorization that is being requested is described in Section 5).

1.1. Purpose

The purpose of the proposed OBC seismic survey is to replace and augment existing datasets by providing better quality higher resolution seismic data to image the Milne Point Unit field. This data will improve BPXA's understanding of the reservoir, allowing more efficient reservoir management. The existing datasets include a 2001 summer OBC seismic survey over a portion of Simpson Lagoon and a 2007 Milne Point winter vibroseis survey (the latter was primarily onshore, with some receivers along the coast line).

1.2. Project Details

The proposed seismic survey utilize receivers (hydrophones and geophones) connected to a cable that will be deployed from a vessel to the seabed or will be inserted in the seabed in very shallow water areas near the shoreline. OBC seismic surveys are typically used to acquire seismic data in water that is too shallow for towed streamer operations or too deep to have grounded ice in winter. Data acquired through this type of survey will allow for the generation of a three-dimensional sub-surface image of the reservoir area. The generation of a three dimensional image requires the deployment of many parallel cables spaced close together over the area of interest. OBC seismic surveys require the use of multiple vessels for cable deployment and recovery, data recording, airgun operation, re-supply, and support. The planned 3D OBC seismic survey in Simpson Lagoon will be conducted by CGGVeritas.

The sections below describe in more detail the various components of the proposed OBC seismic survey, such as seismic source arrays, receivers and recording units, survey design, vessels and other equipment, and crew housing and transfer.

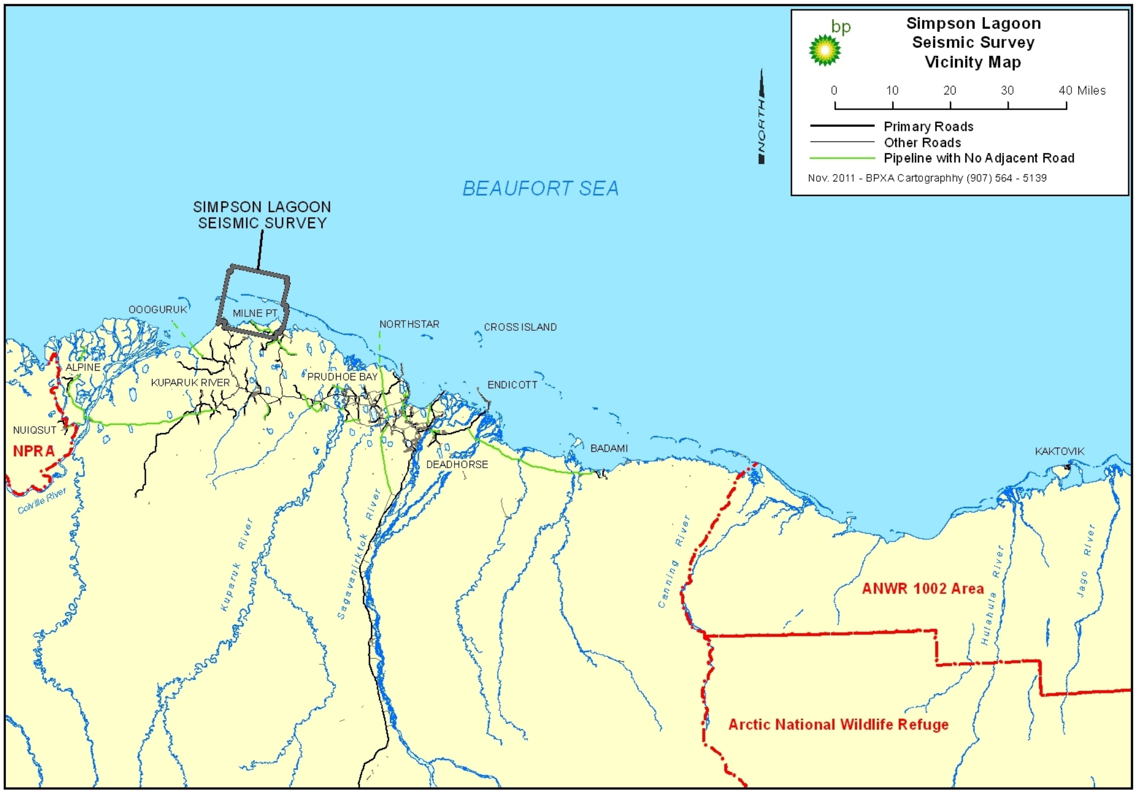

Figure 1.1. Overview of the Simpson Lagoon seismic survey area

Seismic Source Arrays

A total of three seismic source vessels (two main source vessels and one mini source vessel) will be used during the proposed survey. The sources will be arrays of sleeve airguns. Each main source vessel will carry an array that consists of two sub-arrays. Each sub-array contains eight 40 cu in airguns, totaling 16 guns per main source vessel with a total discharge volume of 2 × 320 cu in, or 640 cu in. This 640 cu in array has an estimated source level of ~223 dB re 1 µPa (rms). The mini source vessel will contain one array with eight 40 cu in airguns for a total discharge volume of 320 cu in. Estimated source level of this 320 cu in array is 212 dB re 1 µPa (rms). Table 1.1 summarizes the acoustic properties of the two airgun arrays.

The arrays of the main source vessels will be towed at a distance of ~30 feet (ft) from the stern at 6 ft depth, which is remotely adjustable if needed. The array of the mini source vessel will be towed at a distance of ~20 ft from the stern at 3 ft depth, also remotely adjustable when needed. The source vessels will travel along pre-determined lines with a speed varying from ~1 to 5 knots, mainly depending on the water depth. To limit the duration of the total survey, the source vessels will be operating in a flip-flop mode, with the operating source vessels alternating shots; this means that one vessel discharges airguns when the other vessel is recharging. Outside the barrier islands, the two main source vessels will be operating with expected shot intervals of 8 to 10 seconds, resulting in a shot every 4 to 5 seconds due to the flip-flop mode of operation. Inside the barrier islands all three vessels (the two main source vessels and the mini vessel) may be operating at the same time in this manner. The exact shot intervals will depend on the compressor capacity, which determines the time needed for the airguns to be recharged. Again, the advantage of source vessels alternating shots is that more data can be acquired in a shorter time. Seismic data acquisition is a 24 hour per day operation.

Table 1.1. Specification of the 640 cu in and 320 cu in airgun arrays (see JASCO's acoustic modeling report in Appendix A for more details)

Array Parameter	640 cu in array	320 cu in array
Number of guns	Sixteen 2000 psi sleeve airguns of 40 cu divided over two sub-arrays of eight guns.	Eight 2000 psi sleeve airguns of 40 cu in.
Zero to peak	12.5 bar-m (242 dB re 1µPa @1m)	4.26 bar-m (233 dB re 1µPa @1m)
Peak to peak	23.1 bar-m (247 dB re 1µPa @1 m)	7.92 bar-m (238 dB re 1µPa @1 m)
RMS pressure	1.44 bar-m (223 dB re 1µPa @1 m)	0.39 bar-m (212 dB re 1µPa @1 m)

Receivers and Recording Units

The survey area in Simpson Lagoon has water depths of 0 to 9 ft between the shore and barrier islands and 3 to 45 ft depths north of the barrier islands. Because different types of receivers will be used for different habitats, the survey area is categorized by the terms onshore, islands, surf-zone and offshore. Onshore is the area from the coastline inland. Islands are the barrier islands. Surf zone is the 0 to 6 ft water depths along the onshore coastline. Offshore is defined as depths of 3 ft or more. There is a zone between 3 and 6 ft which may be categorized both as surf zone and as offshore.

The receivers that will be deployed in water consist of multiple hydrophones and recorder units (Field Digitizing Units or FDUs) placed on Sercel ULS cables. Approximately 5,000 hydrophones will be connected to the ULS cable at a minimum of 82.5 ft intervals and secured to the ocean bottom cable. Surface markers and acoustic pingers will be attached to the cable at various intervals to ensure that the battery packs can be located and retrieved when needed and to determine exact positions for the hydrophones. This equipment will be deployed and retrieved with cable boats. The data received at each FDU will be transmitted through the cables to a recorder for further processing. This recorder will be installed on a boat-barge combination and positioned close to the area where data are being acquired. While recording, the boat-barge combination is stationary and expected to utilize a two or four point anchoring system.

In the surf-zone, receivers (hydrophones or geophones) will be bored or flushed up to 12 ft below the seabed. These receivers will transmit data through a cable (as described above) and have an attached line to facilitate retrieval after recording is completed.

Autonomous recorders (nodes) will be used onshore and on the islands. The node is located on the ground and its geophone will be inserted into the ground by hand with the use of a planting pole. Deployment of the autonomous receiver units will be done by a lay-out crew on the ground using helicopters for personnel and equipment transport and/or approved summer travel vehicles (onshore) and a support boat (for the islands). Data from nodes can be remotely retrieved from a distance (up to a kilometer). Retrieval of data may be from a boat or a helicopter. Equipment will be picked up after recording is complete.

Survey Design

The total area of the proposed seismic survey is approximately 110 mi^2, which includes onshore, surf-zone, barrier islands, and offshore (Figure 1.2). For the proposed survey, the receiver cables with hydrophones and recording units will be oriented in an east-west direction. A total of approximately 44 receiver lines will be deployed at the seafloor with 1100-1650 ft line spacing. Total receiver line length will be approximately 500 miles. The source vessel will travel perpendicular over the offshore receiver cables along lines oriented in a north-south direction. These lines will have a length of approximately 3.75 miles and a minimum spacing of 660 ft. The total length of all source lines is approximately 4000 miles, including line turns.

The position of each receiver deployed onshore, in the surf zone and on the barrier islands will be determined using GPS positioning units. Due to the variable bathymetry of the survey area, determining positions of receivers deployed in water may require more than one technique. A combination of Ocean Bottom Receiver Location (OBRL), GPS and acoustic pingers will be used. For OBRL, the source vessel fires a precisely positioned single energy source multiple times along either side of the receiver cables. Production data may also be used instead of dedicated OBRL acquisition. Multiple energy sources are used to triangulate a given receiver position. In addition, Sonardyne acoustical pingers will be located at predetermined intervals on the receiver lines. The pingers are located on the ULS cables and transmit a signal to a transponder mounted on a vessel. This allows for an interpolation of the receiver locations between the acoustical pingers on the ULS cable and also serves as a verification of the OBRL method. The Sonardyne pingers transmit at 19-36 kHz and have a source level of 188-193 dB re µPa at 1m. Because OBRL method is not accurate in shallow water (< 15 ft), the receiver locations at these depths will be recorded as "as laid" positions, which is the GPS location where the receivers are deployed.

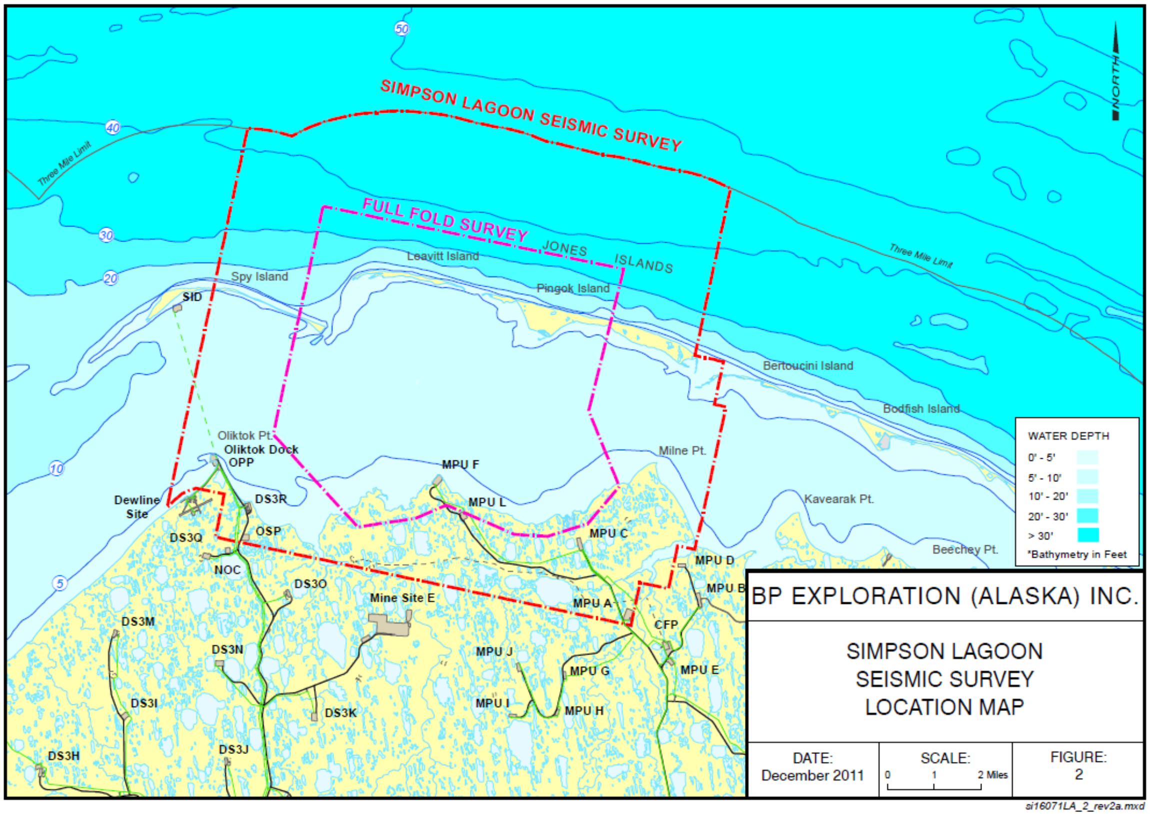

Figure 1.2. Simpson Lagoon seismic survey area. The pink dashed line represents the area where data needs to be acquired and the red dashed line shows the area covered by the receiver and source lines. Placement of the recorder barge may occur outside these lines. Also note that support vessels will transit between West Dock, Oliktok Point and the survey area.

Vessels and Other Equipment

The proposed Simpson Lagoon OBC seismic survey will involve 14 to 16 vessels as listed in Table 1.2 below. The contracting of vessels has not been fnalized to date. However, BPXA will contract vessels with parameters similar to those described in this table. If contracted vessels differ significantly from those described, BPXA will submit an amendment to address these changes where required.

To deploy and retrieve receivers in water depths less than those accessible by the cable boats (surf-zone), equipment such as airboats, buggies or an Arktos (amphibious craft) and/or Jon boats may be used. Helicopters and/or approved tundra travel vehicles will be used for deployment of receiver units onshore as well on the barrier islands.

Vessels and other equipment will be transported to the North Slope in late May/early June by trucks. Equipment will be staged at the CGGVeritas pad for preparation. Vessel preparation will include assembly of navigation and source equipment, cable deployment and retrieval systems and safety equipment. The duration of the preparation process will be about 35 days. Once assembled, vessels will be launched at either West Dock or Milne Point. Deployment, retrieval, navigation and source systems will then be tested near West Dock or in the project area prior to commencement of operations.

Table 1.2. Summary of number and type of vessels involved in the proposed Simpson Lagoon OBC seismic survey. The dimensions provided are approximate.

Vessel Type	Number	Dimensions	Main activity	Frequency
Source vessels: main	2	71 × 20 ft	Seismic data acquisition inside and outside barrier islands.	24-hour operation
Source vessel: mini	1	55 × 15 ft	Seismic data acquisition inside barrier islands.	24-hour operation
Recorder barge with tug boat	1	116.5 × 24 ft (barge) 23 × 15 ft (tug)	Seismic data recording	24-hour operation
Cable boats	5 - 6	42.6 × 13 ft	Deploy and retrieve receiver cables (with hydrophones/geophones).	24-hour operation
Crew transport vessels	2	44 × 14 ft	Transport crew and supplies to and from the working vessels	Intermittently, minimum every 8 hours
Shallow water crew and support boats	2 - 3	34 ft × 10.5 ft	Transport two to five people and small amounts of gear for the boats operating in the shallower parts of the survey area	Intermittently
HSSE vessel	1	38 × 15 ft	Support SSV measurements, HSSE compliance.	As required
TOTAL	14 to 16			

Crew housing and transfer

Seismic data acquisition is a 24-hour operation to allow data collection in the short time window available. The total number of people that will be involved is about 220, including crew on boats, camp personnel, mechanics, and management. There are no accommodations available on the source vessels or cable boats for the crew directly involved in the seismic operations, so crews will be changed out every 8 to 12 hours. Two vessels will be used for crew transfers. Most of the crew will be accommodated at CGGVeritas' seismic base camp which will be located at the Texaco Pad on Milne Point Road and some crew members might be accommodated in camps in Deadhorse or in other operating areas as needed.

The recorder barge/boat (M/V Alaganik and Hook Point) may accommodate up to 10 people. The barge portion is dedicated to recording and staging of cables, hydrophones and batteries and fuelling operations.

Refueling of vessels will be via other vessels at sea, and from land based sources located at West Dock and Milne Point Unit following approved US Coast Guard procedures. Sea states and the vessels function will be the determining factors on which method is used.

2. DATES, DURATION AND REGION OF ACTIVITY

The date(s) and duration of such activity and the specific geographical region where it will occur.

BPXA seeks incidental harassment authorization for the period 1 July to 15 October 2012. Anticipated duration of seismic data acquisition is approximately 50 days, depending on weather and other circumstances. Transportation of vessels to West Dock will occur by road in late May/early June. It is not anticipated that vessels will need to transit by sea; however, in case this does occur the transit will take place when ice conditions allow and in consideration of the spring beluga and bowhead hunt in the Chukchi Sea.

The project area encompasses 110 mi^2 in Simpson Lagoon, Beaufort Sea, Alaska. The approximate boundaries of the total surface area are between 70^o28’N and 70^o39’N and between 149^o24’W and 149^o55’W (Figure 1.2). About 46 mi^2 (41.8%) of the survey area is located inside the barrier islands in water depths of 0 to 9 ft, and 36 mi^2 (32.7%) outside the barrier islands in water depths of 3 to 45 ft. The remaining 28 mi^2 (25.5%) of the survey area is located on land (onshore and barrier island), which is solely being used for deployment of the receivers. Planned start date of seismic data acquisition offshore of the barrier islands is 1 July depending on the presence of ice. Open water seismic operations can only start when the project area is ice free (i.e. < 10% ice coverage), which in this area normally occurs around mid July (+/- 14 days). Limited layout of receiver cables might be possible on land and barrier islands before the ice has cleared. To limit potential impacts to the bowhead whale migration and the subsistence hunt, no airgun operations will take place in the area north of the barrier islands after 25 August. Surf zone geophone retrieval may continue for a brief period after airgun operations are complete.

3. SPECIES AND NUMBERS OF MARINE MAMMALS IN THE PROJECT AREA

The species and numbers of marine mammals likely to be found within the area of activity.

The marine mammal species that occur in the Beaufort Sea and that could be encountered in the Simpson Lagoon area are classified as follows:

- *Order Cetacea*
  - Toothed whales or Odontocetes: e.g., beluga, killer whale
  - Baleen whales or Mysticetes: e.g., gray whale, bowhead whale
- *Order Pinnipedia*
  - Pinnipeds: e.g., ringed, spotted, bearded and ribbon seals, Pacific walrus
- *Order Carnivora*
  - Fissipeds: e.g., polar bear

Cetaceans and pinnipeds (except walrus) are the subjects of this IHA Request to the National Marine Fisheries Service (NMFS). In the U.S., the walrus and polar bear are managed by the U.S. Fish & Wildlife Service (USFWS). An application for a letter of authorization (LOA) to allow incidental non-lethal harassment of Pacific walrus and polar bear during the proposed OBC seismic survey activities in Simpson Lagoon will be submitted separately to the USFWS.

The marine mammal species under NMFS jurisdiction that are known to, or may, occur in the Beaufort Sea include eight cetacean species and four species of pinniped (Table 3.1). Two cetacean species, the bowhead and humpback whales, are listed as endangered under the Endangered Species Act (ESA). The bowhead whale is the most common species in the Beaufort Sea, whereas humpback whales are considered extralimital and therefore unlikely to be encountered in the Simpson Lagoon area. Of the six non-ESA listed cetaceans, the gray whale and beluga whale are the most commonly occurring species in the Beaufort Sea. The narwhal, killer whale, harbor porpoise, and minke whale are rare or extralimital to the Beaufort Sea and therefore unlikely to be encountered in the Simpson Lagoon area. These species are included in Table 3.1 in light gray font and their distribution is briefly discussed in Section 4.3.

The ringed, bearded and spotted seals are the most commonly occurring pinniped species in the Beaufort Sea. Ribbon seals occur mainly in the western part of the Beaufort Sea and are therefore unlikely to be encountered in the Simpson Lagoon. The Alaska stocks of bearded and ringed seals have been proposed by NMFS for listing as threatened under the ESA (NMFS 2010a, 2010b). The final decision will be announced in December 2011.

Table 3.1. Habitat, abundance, and conservation status of marine mammals under NMFS jurisdiction that may or are likely to occur in the Beaufort Sea during the open-water season. Species that are rare or extralimital are included in gray font.

Species	Abundance	Habitat	ESA[1]	IUCN[2]	CITES[3]
		Odontocetes			
Beluga whale (*Delphinapterus leucas*) Beaufort Sea Stock Eastern Chukchi Sea Stock	 39,258[4] 3,710[5]	Offshore, coastal, ice edges	Not listed	NT	II
Narwhal (*Monodon monoceros*)	Rare/Extralimital in Beaufort Sea	Offshore, ice edge	Not listed	NT	II
Killer whale (*Orcinus orca*)	Rare/Extralimital in Beaufort Sea	Variable habitats	Not listed	DD	II
Harbor Porpoise (*Phocoena Phocoena*)	Rare/Extralimital in Beaufort Sea	Coastal, inland waters, shallow offshore waters	Not listed	LC	II
		Mysticetes			
Bowhead whale (*Balaena mysticetus*) Bering-Chukchi-Beaufort Stock	11,836[6]	Pack ice and coastal	Endangered	LC	I
Gray whale (*Eschrichtius robustus*) N-Bering and S-Chukchi Eastern Pacific Population	 488[7] 20,110[8]	Coastal, lagoons	Not listed	LC	I
Minke whale (*Balaenoptera acutorostrata*)	Rare/Extralimital in Beaufort Sea	Shelf, coastal	Not listed	LC	I
Humpback whale (*Megaptera novaeangliae*)	Rare/Extralimital in Beaufort Sea	Shelf, coastal	Endangered	LC	I
		Pinnipeds			
Bearded seal (*Erignathus barbatus*) Alaska Population Eastern Chukchi Sea Population	 250,000 - 300,000[9] 4,863[10]	Pack ice, open water	In review for listing	LC	-
Spotted seal (*Phoca largha*) Alaska Population Eastern and Central Bering Sea Population	 ~59,214[11] 101,568[12]	Pack ice, open water, coastal haulouts	Not listed	DD	-
Ringed seal (*Phoca hispida*) Bering/Chukchi Sea Stock Beaufort Sea Stock	 230,673[13] 326,500[14]	Landfast and pack ice, open water	In review for listing	LC	-
Ribbon seal (*Histriophoca fasciata*)	Uncommon in central Beaufort Sea	Pack ice, open water	Not listed	DD	-

[1] U.S. Endangered Species Act.

[2] IUCN 2011. IUCN Red List of Threatened Species. Version 2011.1. <www.iucnredlist.org>. Codes for IUCN classifications ver 3.1: EN = Endangered; NT = Near Threatened; LC = Least Concern; DD = Data Deficient. Category descriptions can be found at http://www.iucnredlist.org/apps/redlist/static/categories_criteria_3_1#categories.

[3] Convention on International Trade in Endangered Species of Wild Fauna and Flora (UNEP-WCMC 2004).

[4] IWC 2000, Allen and Angliss 2011.

[5] Allen and Angliss 2011.

[6] 2004 Population estimate from photo-identification data (Koski et al. 2008a).

[7] Southern Chukchi Sea and northern Bering Sea (Clark and Moore 2002).

[8] North Pacific gray whale population (Rugh 2003 *in* Keller and Gerber 2004); see also Rugh et al. (2005).

[9] Bering-Chukchi Sea population (Allen and Angliss 2011).

[10] Eastern Chukchi Sea population (NMML, unpublished data).

[11] Alaskan population (Allen and Angliss 2011).

[12] Eastern and Central Bering Sea (Boveng et al. 2009).

[13] Average Bering/Chukchi Sea population (Bengtson et al. 2005).

[14] Alaskan Beaufort Sea population estimate (Amstrup 1995).

4. STATUS AND (SEASONAL) DISTRIBUTION OF AFFECTED SPECIES OR STOCKS OF MARINE MAMMALS

A description of the status, distribution, and seasonal distribution (when applicable) of the species or stocks of marine mammals likely to be affected by such activities

This section contains detailed information on the population status of the marine mammal species that are known to occur in the Beaufort Sea and that might be affected by the proposed OBC seismic survey in the Simpson Lagoon area. It also provides more details on the temporal and spatial distribution and abundance taking into account the most recent data available. The bowhead whale (*Balaena mysticetus*) is currently the only marine mammal species under NMFS jurisdiction that is listed under the ESA and likely to occur in the project area. The decision to list the Arctic stocks of ringed and bearded seals as threatened under the ESA is under review. A brief summary on the status, abundance and distribution of species that are extralimital or rare to the Beaufort species is provided in a separate section.

4.1. Cetaceans

Beluga Whale (Delphinapterus leucas)

The beluga whale is an arctic and subarctic species with a circumpolar distribution. The beluga whale occurs mainly in seasonally ice-covered seas between 50°N and 80°N (Reeves et al. 2002) and is closely associated with open leads and polynyas (Hazard 1988). There are five stocks of beluga whales in Alaska: the Cook Inlet, Bristol Bay, eastern Bering Sea, eastern Chukchi Sea, and Beaufort Sea stocks (O'Corry-Crowe et al. 1997). Animals of the Beaufort Sea stock and eastern Chukchi Sea stock could potentially occur in the project area. The most recent population estimate for the Beaufort Sea stock is 39,258 individuals and the eastern Chukchi Sea stock is estimated at 3,710 animals (Allen and Angliss 2010). The population estimate of the

Beaufort Sea stock is based on 1992 data (DeMaster 1995, Allen and Angliss 2010) and the size estimate of the eastern Chukchi Sea stock arises from survey effort in 1989-1991 (Allen and Angliss 2010). Both stocks are believed to be stable or, in case of the Beaufort Sea stock, slightly increasing (Allen and Angliss 2010).

In spring, the Beaufort and Chukchi Sea stocks of beluga whales migrate through coastal open leads from their winter grounds in the Bering Sea to the Arctic to reach their respective summer grounds in the Beaufort and Chukchi seas. Most animals of the Beaufort Sea stock migrate to the Mackenzie River estuary in the Canadian Beaufort Sea where they arrive in April or May, with some animals arriving as early as March or as late as July (Braham et al. 1977, Ljungblad et al. 1984, Richardson et al. 1995). They typically stay there during July and August to molt, feed, and calve. Later in the summer they spread out, foraging in offshore waters of the eastern Beaufort Sea, Amundsen Gulf and other northern waters (Davis and Evans 1982, Harwood et al. 1996, Richard et al. 2001). Belugas from the Chukchi Sea stock stay in coastal areas or shallow lagoons early in the summer, such as the Kasegaluk Lagoon. Later in the summer (after mid-July) they move offshore to forage in the ice-packed deeper waters along and beyond the continental shelf (Finley 1982, Suydam et al. 2005). Five of 23 beluga whales fitted with satellite tags in Kasegaluk Lagoon (captured in late June and early July 1998-2002) were tracked north into the Arctic Ocean venturing into 90% pack ice at 79-80°N (Suydam et al. 2005), suggesting that a significant proportion of the population may be far-ranging, even leaving the Chukchi Sea region, during the mid- to late-summer period. In the fall, the Chukchi and Beaufort Sea stocks both return to their wintering grounds in the Bering Sea following a deepwater route along the continental shelf break or routes farther offshore (Allen and Angliss 2010).

Beluga whales are often seen migrating in groups of 100 to 600 animals (Braham and Krogman 1977), probably consisting of smaller permanent social units, such as nursing groups or family units (Brodie 1989). Beluga whales feed on a variety of fish and invertebrates, their diet varying by season and location (Burns and Seaman 1985, Hazard 1988). In summer, beluga whales feed on a variety of schooling and anadromous fish, particularly Arctic cod. Most feeding is done over the continental shelf and in nearshore estuaries and river-mouths.

In the central and eastern Beaufort Sea beluga whales mainly migrate in deep offshore waters along the ice edge more than 62 miles north of the Alaskan coast. Aerial and vessel-based surveys associated with seismic programs in the central Alaskan Beaufort Sea from 1996-2001 observed only a few beluga whales migrating along or near the coast (LGL and Greeneridge 1996, Miller et al. 1998, 1999), although aerial surveys as part of seismic survey monitoring and mitigation plans did record some animals there in July 2008 (Christie et al. 2010). Aerial observations in August-September 2008, conducted as part of a monitoring program for an (non-BPXA) OBC seismic survey off Oliktok Point in the Beaufort Sea reported seven beluga whale sightings (consisting of 15 individuals). These animals were observed offshore at a distance of 56 to 68 miles from shore, with few sightings made close to shore (< 19 miles). No beluga whales were seen from the seismic source vessels (Hauser et al. 2008). No beluga whales were sighted by observers on seismic survey vessels in the central Alaskan Beaufort Sea north of

Prudhoe Bay and the Colville River delta during the summer of 2007 (Funk et al. 2008). Beluga whales were, however, observed on two days during aerial surveys flown offshore of the barrier islands from 22 August through 8 October 2007. A total of 31 sightings of 61 animals were recorded on 22 August and 11 September. One sighting occurred just offshore of the barrier islands near Simpson Lagoon, while all other sightings were about 50 miles offshore of the barrier island, near the 100 m (328 ft) isobath (Funk et al. 2008). Survey data from Harrison Bay collected during aerial surveys in 2010 documented 32 beluga whales, most >40 miles from shore (Brandon et al. 2011). Data collected in the Beaufort Sea by the Bowhead Whale Aerial Survey Program (BWASP) from 2000 to 2009 also show a predominantly offshore distribution of beluga whales (>56 miles offshore) with occasional nearshore sightings (Clarke et al. 2010). From Northstar Island, belugas have been sighted occasionally relatively close to shore. During a 2008 OBC seismic survey in Foggy Island Bay (just east of Prudhoe Bay), 3 sightings of 8 individuals were observed inside the barrier islands in the summer season (Aerts et al. 2008).

Based on the above mentioned aerial and vessel-based marine mammal data, beluga whales are expected to be migrating mainly offshore. However, some individuals can be expected to travel closer to shore within or in close proximity to the proposed survey area in Simpson Lagoon.

Bowhead Whale (Balaena mysticetus)

Bowhead whales only occur in the northern hemisphere at high latitudes and have a somewhat circumpolar distribution (Reeves 1980). They are found in the Arctic (Bering, Chukchi, and Beaufort seas), the Canadian Arctic and West Greenland (Baffin Bay, Davis Strait, and Hudson Bay), the Okhotsk Sea (eastern Russia), and the Northeast Atlantic from Spitzbergen westward to eastern Greenland. Five stocks are recognized for management purposes. Of the five stocks of bowhead whales recognized by the International Whaling Commission (IWC), the Western Arctic stock or Bering-Chukchi-Beaufort (BCB) stock seasonally inhabits the Beaufort Sea and is most likely to be found in the planned survey area. The BCB stock has the largest population of the five stocks, accounting for about 90% of the species' world population. These whales winter in the Bering Sea and migrate through the Bering Strait, Chukchi Sea and Alaskan Beaufort Sea to their summer feeding habitat in the Canadian Beaufort Sea. Spring migration through the Chukchi and the western Beaufort Sea occurs through offshore ice leads, generally from March through mid-June (Braham et al. 1984, Moore and Reeves 1993). In the fall, they return through the Beaufort Sea to their wintering grounds in the central and western Bering Sea (Moore and Reeves 1993). Satellite tracking data indicate that some bowhead whales continue migrating west past Barrow and through the Chukchi Sea to Russian waters before turning south toward the Bering Sea (Quakenbush 2007, Quakenbush et al. 2010).

Estimates of bowhead whales in the Bering, Chukchi, and Beaufort seas, before they were over harvested by commercial whaling, were between 10,400-23,000 whales. Commercial whaling decreased the population size to approximately 3,000 whales (Woodby and Botkin 1993). Until the early 1990s, the population was believed to be increasing at a rate of ~ 3.2% per year (Zeh et al. 1996) despite annual subsistence harvests of 14–74 bowheads from 1973 to 1997 (Suydam et al. 1995). A census in 2001 yielded an estimated annual population growth rate of 3.4% (95% CI 1.7–5%) from 1978 to 2001 and a population size (in 2001) of ~10,470 animals (George et al. 2004, revised to 10,545 by Zeh and Punt [2005]). A population estimate from photo identification data collected in 2004 indicated 11,800 animals (Koski et al. 2008a), which further supports the estimated 3.4% population growth rate. Assuming a continuing annual population growth of 3.4%, the 2010 bowhead population may number around 14,200 animals. The increase in population estimates between the late 1970s to the early 1990s is believed to be a result of actual bowhead whale population growth as well as improvements made to census techniques.

Although recovering well following its decline, the bowhead whale is currently still listed as endangered under the ESA, depleted by the MMPA (Allen and Angliss 2010), and an Alaska Species of Concern with the Alaska Department of Fish and Game (ADF&G). The Alaska Eskimo Whaling Commission (AEWC) has co-managed this stock with the U.S. government since the 1980s.

The BCB population migrates north using offshore ice leads in the Chukchi Sea and western Beaufort Sea from March through mid-June (Braham et al. 1984, Moore and Reeves 1993), although small numbers may remain in the Bering and Chukchi seas during summer (Rugh et al. 2003, Sekiguchi 2007, Moore et al. 2010).

Some bowheads arrive in the coastal areas of the eastern Canadian Beaufort Sea and Amundsen Gulf in late May and June, but most remain in the offshore pack ice of the Beaufort Sea until mid summer. After feeding in the Canadian Beaufort Sea and Amundsen Gulf, bowheads return west in the fall. From late August through mid- to late-October, bowheads return through the Alaskan Beaufort Sea heading to their wintering grounds in the central and western Bering Sea (Moore and Reeves 1993). Although most animals migrate through the central Alaskan Beaufort Sea in September and October, bowheads have been seen or heard offshore Prudhoe Bay during the last week of August (Treacy 1993, LGL and Greenridge 1996, Greene 1997, Green et al. 1999, Blackwell et al. 2004, 2008, Greene et al. 2007, Goetz et al. 2008). Westbound bowheads typically reach Kaktovik and Cross Island in early September and the Barrow area in mid-September and remain there until late October (e.g., Brower 1996).

Late summer and autumn aerial surveys have been conducted in the Alaskan Beaufort Sea since 1979 (see Ljungblad et al. 1986, 1987, Moore et al. 1989, Treacy 1990-1998, 2000, 2002a,b, Monnett and Treacy 2005, Treacy et al. 2006, Clarke et al. 2011). Data demonstrate that bowhead whales tend to migrate west in deeper water (farther offshore) during years with higher-than-average ice coverage than in years with less ice. Sighting rates are also lower in heavy ice years. During the fall migration, most bowheads migrate west in water ranging from 50 to 656 feet deep (Miller et al. 2002), however few whales are ever seen shoreward of the barrier islands in the Alaskan Beaufort Sea. The main migration corridor is located over the continental shelf, typically within 34 miles of shore during years with light to moderate ice conditions (Treacy et al. 2006).

During vessel-based surveys conducted as part of a seismic monitoring program between Thetis Island and Leavitt Islands during August-September 2008 (Hauser et al. 2008) no bowhead whales were identified. Fifteen aerial surveys flown from 25 August to 27 September north of the barrier islands observed 55 bowhead whales in 40 groups (Hauser et al. 2008) with peak sightings occurring 15.5-18.6 miles from shore. Christie et al. (2010) reported that in 2006 most bowhead whales were observed >25 miles from shore, while in 2007 and 2008 there were seen closer to the barrier islands. Aerial surveys conducted in 2010 (Brandon et al. 2011) recorded 78 bowhead whales in the vicinity of Harrison Bay, west of the proposed survey area, with sighting rates highest in September and early October.

Bowheads may be encountered during the planned activity. The latter part of the planned survey will overlap with the fall migration of bowhead whales in September and October. It is likely that small numbers of bowhead whales will occur within the survey area, with larger numbers occurring offshore to the north.

*Gray Whale (*Eschrichtius robustus*)*

Gray whales originally inhabited both the North Atlantic and North Pacific oceans. The Atlantic population is believed to have become extinct by the early 1700s, likely from over harvesting. There are currently two populations of gray whales in the North Pacific Ocean: the eastern North Pacific population which lives along the west coast of North-America and the western North Pacific population, is believed to occur along the coast of eastern Asia (Rice et al. 1984, Swartz et al. 2006) and summers near Sakhalin Island, Russia.

Though populations have fluctuated greatly, the eastern Pacific gray whale population has recovered significantly from commercial whaling under protection via the MMPA (and the ESA until 1994). In 1997, Rugh et al. (2005) estimated the population at 29,758 ±3,122, and in winter 2001-2002 the estimate was 18,178 ±1,780. The population estimate increased during winter 2006–2007 to 20,110 ±1,766 (Rugh et al. 2008). The eastern Pacific stock is not considered by NMFS to be endangered or to be a strategic stock.

The eastern North Pacific population annually migrates from warm wintering ground lagoons in coastal Baja California and Mexico to summer foraging areas in the Bering and Chukchi Seas off northern Alaska and Russia (Jones et al. 1984; Swartz et al. 2006, Lagerquist et al. 2011), primarily between Cape Lisburne and Point Barrow, most often in shallow coastal habitat (Moore et al. 2000b). Not all eastern gray whales follow this migration pattern. A small subset of the eastern population feeds in coastal water off of British Columbia, Washington, and Oregon (Reeves and Mitchell 1988; Calambokidis et. al. 2002, 2010). In addition, gray whale calls have been recorded throughout the winter in the Beaufort Sea near Barrow, Alaska, suggesting that some gray whales remain in arctic waters during this season (Stafford et al. 2007).

The western North Pacific population is presently believed to range from wintering grounds in the South China Sea to feeding grounds in the Sea of Okhotsk and along the south-eastern coast of the Kamchatka Peninsula. It should be noted that the wintering range for this population remains unconfirmed. Data from a 13 year old male that was satellite tagged in September 2010 suggests that not all whales migrate south along the Asia coast in the winter. This tagged whale travelled east from Sakhalin Island to the Bering Sea shelf break and then southeast across the Gulf of Alaska and Northeast Pacific Basin to join the eastern gray whale migration route near Washington State (Mate et al. 2011).

Gray whales are often found clustered near shore at Point Hope and between Icy Cape and Point Barrow, as well as in offshore waters northwest of Point Barrow at Hanna Shoal and southwest of Point Hope in autumn. Few gray whales have historically been recorded in the Beaufort Sea east of Point Barrow. Hunters at Cross Island took a single gray whale in 1933 (Maher 1960). Only one gray whale was sighted in the central Alaskan Beaufort Sea during extensive aerial surveys from 1979 to 1997. However, in September 1998, small numbers of gray whales were sighted on several occasions in the central Alaskan Beaufort Sea (Miller et al. 1999, Treacy 2000). A single gray whale was also seen on 1 August 2001 near the Northstar production island (Williams and Coltrane 2002). Several gray whale sightings were reported during both vessel-based and aerial surveys in the Beaufort Sea in 2006 and 2007 (Jankowski et al. 2008, Lyons et al. 2009). A few gray whales have also been observed in the Canadian Beaufort Sea (Rugh and Fraker 1981, LGL Ltd, unpubl. data) indicating that small numbers have been passing through the Alaskan Beaufort in some years. Given the infrequent occurrence of gray whales in the Beaufort Sea in summer, it is expected that few to no gray whales will occur in the vicinity of the planned project.

4.2. Pinnipeds

*Bearded Seal (*Erignathus barbatus*)*

Bearded seals have a circumpolar distribution and are strongly ice-associated. In Alaskan waters, bearded seals occur over the continental shelf waters of the Bering, Chukchi, and Beaufort seas (Burns 1981), from nearshore waters out at least as far as the shelf break (Allen and Angliss 2010). Surveys along the Alaskan coast indicate that bearded seals prefer areas of 70% to 90% sea ice coverage (Allen and Angliss 2010). They generally inhabit areas of shallow water (less than 656 feet [200m]) that are seasonally ice covered (Cameron et al. 2009, Allen and Angliss 2010).

Bearded seals migrate seasonally with the advance and retreat of sea-ice and water depth (Kelly 1988). As the ice recedes in the spring, bearded seals overwintering in the Bering Sea migrate through the Bering Strait (mid-April to June), and summer either along the margin of the multi-year ice in the Chukchi Sea or in nearshore areas of the central and western Beaufort Sea. Some bearded seals will overwinter in the Chukchi and Beaufort seas, but conditions are likely not as favorable.

Bearded seals breed in the spring. Pupping takes place on top of the ice from late-March through May, primarily in the Bering and Chukchi seas, although some pupping takes place on moving pack ice in the Beaufort Sea. These seals do not form herds, although loose aggregations of animals may occur. The Alaska stock of bearded seals is believed to be greater than 155,000 (Beringia DPS, NMFS 2010a) and may be as large as 250,000-300,000 (Popov 1976, Burns 1981, MMS 1996) but there is no reliable estimate of bearded seal abundance in the Beaufort Sea or Chukchi Sea (Allen and Angliss 2010, Cameron et al. 2010). The Alaska stock of bearded seals, part of the Beringia distinct population segment, has been proposed by NMFS for listing as threatened under the ESA (NMFS 2010a).

Bearded seals have been commonly observed in the central Alaskan Beaufort Sea. Surveys associated with seismic programs in 2006, 2007, 2008 and 2010 reported sightings of several tens of bearded seals during vessel-based and aerial surveys (Funk et al. 2008, Hauser et al. 2008, Savarese et al. 2010, Brandon et al. 2011, Reiser et al. 2011), as did barge-based vessel surveys conducted from 2005 to 2007 by Green et al. (2005, 2006, 2007). Bearded seals are commonly sighted during the aerials surveys conducted in the Beaufort Sea (Treacy 2002a, 2002b, Moulton et al. 2003, Clarke et al. 2011).

Based on observation data, bearded seals are likely to be encountered during the proposed activity but the numbers are expected to be small.

Spotted Seal (Phoca largha)

The spotted seal is found from the Beaufort Sea to the Sea of Japan and is most numerous in the Bering and Chukchi seas (Quakenbush 1988) although small numbers do range into the Beaufort Sea during summer (Rugh et al. 1997, Lowry et al. 1998). The population of spotted seals worldwide has been estimated between 370,000 and 420,000 (Bigg 1981) with the Bering Sea population, including Russian animals, estimated at 200,000-250,000 (Bigg 1981). A reliable estimate of the entire Alaskan stock is currently not known (Allen and Angliss 2010), but the estimate is most likely between several thousand and several tens of thousands (Rugh et al. 1997).

Pupping occurs in the Bering Sea wintering areas in early spring (March and April), followed by mating and molting in May and June (Quakenbush 1988). The seals are strongly ice-associated during this time. During the summer, spotted seals are found in Alaska from Bristol Bay through western Alaska to the Chukchi and Beaufort seas where they haul out on land for at least part of the time. Spotted seals are commonly seen in bays, lagoons and estuaries, but also range far offshore as far north as 69-72°N; during summer they are rarely seen on pack ice unless the ice is close to shore. In October, spotted seals begin their migration south into the Bering Sea (Lowry et al. 1998) where the animals overwinter.

Satellite transmitters placed on four spotted seals in the Kasegaluk Lagoon resulted in estimates that only 6.8% of seals were hauled out (Lowry et al. 1998). Based on an actual minimum count of 4,145 hauled out seals, Allen and Angliss (2010) estimated the Alaskan population at 59,214 animals. Because of the concern about the future of ice seals due to receding ice conditions and associated potential habitat loss, NMFS conducted a status review of the spotted seal. Preliminary analyses from 2007 and 2008 survey data in the central and eastern Bering Sea provided a provisional abundance estimate of 101,568 (SE = 17,869) spotted seals in that area (Boveng et al. 2009). Based on this status review NMFS determined not to list spotted seals under the ESA, because they are currently not in danger of extinction or likely to become endangered in the foreseeable future (NMFS 2009).

Spotted seals have been observed frequently, although in low numbers in recent years, in the central Alaskan Beaufort Sea. Haulout sites in the Beaufort Sea include Oarlock Island, Pisasuk River, and the Colville River Delta, which is near the proposed project area. Historically, the Colville River Delta and nearby Sagavanirktok River supported as many as 400-600 spotted seals, but in recent times fewer than 20 seals have been seen at any one site (Johnson et al. 1999). From 2005-2007, Green et al. (2005, 2006, 2007) monitored marine mammals from barges travelling between Prudhoe Bay and Cape Simpson. Overall, they observed between 23 and 54 spotted seals annually. Savarese et al. (2010) also reported between 59 and 125 spotted seals annually during surveys in the central Beaufort Sea between 2006-2008. In 2010, Reiser et al. (2011) reported most of their spotted seal observations in July and August while other seal species were more commonly observed in September and October.

The proposed activity may encounter a few spotted seals due to the proximity of haulout sites used by a number of animals during the summer.

Ringed Seal (Phoca hispida)

Ringed seals have a circumpolar distribution (King 1983) and are year round residents in the Beaufort, Bering and Chukchi seas (King 1983, Allen and Angliss 2010). Ringed seals are closely associated with ice and prefer large floes (>157 ft [>48 m] in diameter) and can often be found in areas with ice coverage >90% (Allen and Angliss 2010). They appear to prefer to overwinter and breed on nearshore stable landfast ice, but they are sometimes found at low densities in offshore pack ice. Hauling out on disintegrating landfast ice in May and June, the ringed seals then follow the receding ice edge north (Allen and Angliss 2010). They maintain breathing holes throughout the winter in ice up to 6 ft (1.8m) thick and dig multiple haul-out shelters and nursery lairs beneath the snow (Kelly 1988). During March and April, female seals build snow lairs along pressure ridges or under snowdrifts on landfast or drifting icepack, where they give birth to a single pup which is then nursed for 5-8 weeks (Smith 1973, Hammill et al. 1991, Lydersen and Hammill 1993).

There is currently no complete population estimate available for the entire Alaskan stock (Allen and Angliss 2010). Historic ringed seal population estimates in the Bering-Chukchi-Beaufort area ranged from 1-1.5 million (Frost 1985) to 3.3-3.6 million (Frost et al. 1988). Frost and Lowry (1999) estimated 80,000 ringed seals in the Beaufort Sea during summer and 40,000 during winter, indicating that half of the population moves into the Chukchi and Bering seas in winter. The Alaska stock of ringed seals is not currently listed as endangered, and is not classified as a strategic stock by NMFS. However, there is increasing concern about the future of the ringed seal due to receding ice conditions and potential habitat loss. NMFS conducted a status review for the ringed seal (Kelly et al. 2010a), and has proposed to list the Arctic stock of ringed seals as threatened under the ESA due to threats from global warming. A final decision is expected to be made in December 2011.

Frost and Lowry (1999) conducted surveys in May and found that the density of ringed seals was greater to the east of Flaxman Island than to the west. Based on survey data for 1996-1999, ringed seal density in fast ice areas between Oliktok Point and Flaxman Island ranged from 0.48 to 0.77 seals per km^2 (Frost et al. 2002). Similarly, Moulton et al. (2002) founded densities ranged from 0.39 to 0.63 seals per km^2 near the Northstar development area prior to construction.

During the open-water season, ringed seals are widely dispersed as single animals or in small groups and they are known to move into coastal areas (Smith 1987, Harwood and Stirling 1992, Moulton and Lawson 2002, Green et al. 2007).

Ringed seals have routinely been observed during previous seismic surveys in this region (e.g., Funk et al. 2008, Hauser et al. 2008, Savarese et al. 2010, Brandon et al. 2011, Reiser et al. 2011), during monitoring from Northstar Island (e.g., Aerts and Richardson 2009, 2010) and during aerial surveys flown for bowhead whales (Clarke et al. 2011). They are typically the most abundant pinniped species seen in the Beaufort Sea. Based on the data available, ringed seals are likely to be the most abundant marine mammal species encountered in the area of the proposed activities.

4.3. Uncommon or Extralimital Species

Minke whales, humpback whales, killer whales, narwhal, harbor porpoises, and ribbon seals could occur in the Beaufort Sea but are either uncommon or extralimital (Table 3.1).

The minke whale is relatively common in the Bering and Chukchi seas and their range might be expanding into the northern Chukchi Sea (Ireland et al. 2007, Haley et al. 2010, Brueggeman et al. 2009, 2010) but they are not considered likely to occur in the Beaufort Sea. No minke whales have been reported during the BWASP (Clarke et al. 2011) from 2006-2008 and no earlier sightings have been reported in the Beaufort Sea.

Humpback whales have not generally been found in the Arctic Ocean, with the exception of the Barents Sea. The first confirmed sighting of a humpback whale in the Beaufort Sea took place in August 2007 (Hashagen et al. 2009), when a cow and calf were observed 54 miles east of Point Barrow. No additional sightings have been documented.

Killer whales are known to inhabit almost all coastal waters of Alaska, extending from southeast Alaska through the Aleutian Islands to the Bering and Chukchi seas (Allen and Angliss 2010). Killer whales have been seen infrequently in the Beaufort Sea, but little is known about these whales (Leatherwood et al. 1986, Allen and Angliss 2010). George et al. (1994) reported that killer whales are seen at Point Barrow in low numbers each year. No killer whales have been reported during the BWASP surveys conducted from 2006-2008 (Clarke et al. 2011). Occasional unconfirmed killer whale sightings have been reported by oil industry staff based at Northstar Island and at the Endicott Main Production Island.

Narwhal are common in the waters of northern Canada, west Greenland, and in the European Arctic, but rarely occur in the Beaufort Sea (COSEWIC 2004). Only a handful of sightings have occurred in Alaskan waters (Allen and Angliss 2010). George and Suydam (unpublished data) summarized eight observations of 11-12 individuals by Alaska Native hunters in the Chukchi and Beaufort seas between 1989 and 2008. No narwhal have been reported during the BWASP surveys conducted in the Beaufort Sea or during seismic survey program monitoring (Funk et al. 2008, Hauser et al. 2008).

Harbour porpoise occur from Point Barrow along the western Alaskan coast, along the Aleutians and throughout southeast Alaska (Allen and Angliss 2010) but are considered extralimital in the Beaufort Sea. However, a small number of sightings have occurred in recent years (Hauser et al. 2008, Lyons et al. 2009), including some in the vicinity of the proposed survey area.

Ribbon seals are found in the North Pacific Ocean and parts of the Arctic Ocean, most often along the pack ice (Allen and Angliss 2010). Ribbon seals have been sighted in very low numbers in the northeastern Chukchi Sea (Haley et al. 2010). No ribbon seals have been reported as part of the BWASP surveys conducted in the Beaufort Sea or during seismic survey program monitoring (Funk et al. 2008, Hauser et al. 2008), although three animals were reported during vessel-based activities near Prudhoe Bay in 2008 (Savarese et al. 2009, 2010).

5. TYPE OF INCIDENTAL HARASSMENT AUTHORIZATION REQUESTED

The type of incidental taking authorization that is being requested (i.e., takes by harassment only, takes by harassment, injury and/or death), and the method of incidental taking.

BPXA seeks authorization for non-lethal incidental "level B harassment" of marine mammals pursuant to Section 101(a)(5)(D) of the MMPA during its proposed OBC seismic survey in Simpson Lagoon, Beaufort Sea, for the period 1 July to 15 October 2012. "Level B harassment" is defined under the MMPA as "*any act that has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption to behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding or sheltering*".

Disturbance of whales and seals from the proposed seismic activities described in Section 1 of this application can occur due to:

- Exposure to pulsed sounds from vessel sonar systems, pingers, and airguns used during the seismic survey;
- Exposure to sounds from helicopter traffic flying to and from the barrier islands to deploy and retrieve receivers; and

- Physical presence of vessels in the area, i.e., collision risk or close approach between marine mammals and vessels.

The response of whales and seals to pulsed sounds depends on many factors as described in Section 7 of this application. The loudest noise sources will emanate from the use of airguns during active seismic data collection. Disturbance reactions, such as avoidance, may occur among some whales and seals in the proximity to the seismic vessel when the vessel is actively discharging its airguns. No serious injury to whales and seals is expected, for example due to collisions with vessels, given the nature of the activity in combination with the planned mitigation measures (see Section 11). The use of vessel sonar systems and pingers are not likely to have any additional impact on whales and seals, given the relatively high operating frequency, short pulse duration, low duty cycle, and brief (if any) behavioral response. No lethal injuries are expected. Other noise sources, such as the sounds of vessel and helicopter traffic, may elicit some avoidance reactions from whales and seals.

In summary, BPXA seeks authorization of incidental non-lethal harassment of whales and seals from pulsed sounds generated during the permitted seismic survey activities, as well as the physical presence of vessels in the area. Sounds produced during vessel transits and helicopter traffic to and from the seismic survey location are similar to that of conventional vessel and helicopter traffic and are not considered to be subject of this IHA application.

6. NUMBER OF MARINE MAMMALS THAT MAY BE HARASSED

By age, sex, and reproductive condition (if possible), the number of marine mammals (by species) that may be taken by each type of taking identified in [Section V], and the number of times such takings by each type of taking are likely to occur.

This section describes the methods used to estimate the numbers of marine mammals that might be affected during the proposed OBC seismic survey activities in Simpson Lagoon. Section 7 provides a summary of potential impacts from airgun sounds on marine mammals and shows that exposure to airgun sounds can lead to injury of marine mammals in close proximity to the source, such as a temporary reduction in hearing sensitivity or permanent hearing damage (defined as level A harassment under the MMPA). Sounds generated by airguns can also elicit behavioral responses in marine mammals (defined as level B harassment under the MMPA). NMFS uses a threshold of 190 dB re 1 µPa (rms) for all pinnipeds and 180 dB for all cetaceans under their jurisdiction for the onset of “level A harassment” from pulsed sounds. The threshold for “Level B harassment” from pulsed sounds is 160 dB re 1 µPa (rms) for all marine mammals (NMFS 2005).

The estimated number of whales and seals potentially affected by airgun sounds are based on their expected densities in the survey area in combination with the estimated area ensonified with pulsed sound levels of 160 dB re 1µPa (rms) or more. Species most likely to be encountered in the survey area in relatively high numbers are ringed and bearded seals (see Section 4).

Bowhead whales are expected offshore of the barrier islands, during their westward fall migration. Other cetacean species, such as gray and beluga whales could also occur in the area, but not regularly and likely in low numbers. Requests for incidental harassment authorization of marine mammal species that are rare or extralimital to the Beaufort Sea are also included in Table 6.4 below, to cover any incidental occurrences.

Section 6.1 describes the approach used to estimate marine mammal densities representative for the proposed survey area and the sources of information used for these estimated densities. Section 6.2 summarizes the modeled distances to received sound levels from the two airgun arrays, derived from acoustic models. The estimated numbers of marine mammals potentially affected is summarized in Section 6.3.

6.1. Marine Mammal Density Estimates

The proposed OBC seismic survey in Simpson Lagoon covers an area of 36 mi^2 just outside the barrier islands to a water depth of 50 ft, and an area of 46 mi^2 inside the barrier islands in water depths of less than 10 ft. Outside the barrier islands seismic data acquisition will be halted 25 August, during the westward bowhead whale fall migration. The duration of the seismic data acquisition in the Simpson Lagoon area is estimated to be approximately 50 days, based on a continuous 24-hour operation and taking into account unpredictable delays.

Because most cetacean species show a distinct seasonal distribution, density estimates for the central Beaufort Sea have been derived for the summer period (covering July and August) and the fall period (covering September and October). Animal densities encountered in the Beaufort Sea during both of these time periods will further depend on the presence of ice. However, if ice cover within or close to the seismic survey area is more than approx. 10% seismic survey activities may not start or be halted. Cetacean and pinniped densities related to ice conditions are therefore not included in this IHA application. Pinniped species in the Beaufort Sea do not show a distinct seasonal distribution during the period July-early October and as such density estimates derived for seal species are used for both the summer and fall periods.

In addition to seasonal variation in densities, spatial differentiation is an important factor for marine mammal densities, both in latitudinal and longitudinal gradient. Taking into account the size and location of the proposed seismic survey area and the associated area of influence, only the nearshore zone (defined as the area between the shoreline and the 50 m [164 ft] bathymetry line) of the Beaufort Sea was considered to be relevant for the calculation of densities.

Density estimates are based on best available scientific data. In cases where the best available data were collected in regions, habitats, or seasons that differ from the proposed survey activities, information from monitoring results collected in similar habitats, regions or seasons was used. Some sources from which densities were used include correction factors to account for perception and availability bias in the reported densities. Perception bias is associated with diminishing probability of sighting with increasing lateral distance from the trackline, where an animal is present at the surface but could be missed. Availability bias refers to the fact that the animal might be present but is not available at the surface. The uncorrected number of marine mammals observed is therefore always lower than the actual numbers present. Unfortunately, for most marine mammals not enough information is available to calculate these two correction factors. The density estimates provided in this IHA request are therefore based on uncorrected data, unless mentioned otherwise.

Because the available density data is not always representative for the area of interest, and correction factors were not always known, there is some uncertainty in the data and assumptions used in the density calculations. To provide allowance for these uncertainties, maximum density estimates have been provided in addition to average density estimates The marine mammal densities presented are believed to be close to, and in most cases higher than, the densities that are expected to be encountered during the proposed survey.

Density of Cetaceans in the Beaufort Sea

Beluga Whale

Summer beluga density estimates for the Alaskan Beaufort Sea are derived from aerial survey data over the period 1982-1986 as analyzed by Moore et al. (2000b). During the summer season, beluga whales were observed mostly in continental slope habitat (water depths of 201-2,000 m [660-6562 ft]) and infrequently in inner shelf habitat (< 50 m [164 ft]). Most applicable to the proposed OBC seismic survey are the data collected in water depths of less than 164 ft. Along 7,447 mi (11,985 km) of on-transect effort in July-August there were a total of nine beluga sightings (Moore et al. 2000). No correction was applied to this data for the purpose of this IHA request for two reasons: (1) all nine sightings were observed offshore of the 164 ft (50 m) bathymetry line and the proposed survey, including the contour of the 160 dB sound level, occurs in shallower water depths, and (2) the majority of beluga sightings occurred farther to the east and there were no sightings at the longitude of Simpson Lagoon Bay. A density of 0.0008 whales/km^2 was used as the average summer density for beluga whales. The maximum density was derived by multiplying the average density with a factor of two (Table 6.1).

Fall densities for beluga whales were calculated using data derived from BWASP aerial surveys collected in 2006-2008 (Clarke et al. 2011). Generally, beluga whales selected water on the outer shelf and slope with moderate to heavy ice during the westward migration, however, ice cover in the period 2006-2008 was relatively low compared to historical years and beluga whales were often observed in ice free waters. Based on aerial survey data (Moore et al. 2000, Clarke et al. 2011) few beluga whales are expected to be encountered in the central part of the Beaufort Sea, especially shoreward of the barrier islands.

The fall beluga whale density was calculated by using the total transect effort and number of belugas observed during fall of 2006, 2007, and 2008 (Clarke et al. 2011). A value of 2.841 to correct for animals missed, and a value of 0.58 to correct for animals not available at the surface from Harwood et al. (1996) were applied to derive corrected density estimates. Transect effort in the fall of 2006 was 12,393 km during which a total of 525 belugas observed. A corrected density of 0.1038 whales/km^2 was derived from this data. In fall 2007, a total of 117 belugas were sighted along 6,294 km of transect effort, from which a corrected density of 0.0455 whales/km^2 was calculated. The density for 2008 was the lowest with 15 belugas along 10,856 km of transect effort (corrected density of 0.0034 whales/km^2). The average value over these three years was 0.0545 whales/km^2. This was calculated by dividing the total number of belugas sighted with the total 2006-2008 transect effort and applying the correction factors. The 2006 fall density was used as the maximum value. Because most sightings were observed offshore of the 50 m bathymetry line and the proposed survey takes place in water depths of less than 15 m (of which a majority inside the barrier islands), the densities used for the purpose of this IHA request were assumed to be 25% of the average and maximum densities provided here (Table 6.1).

Bowhead Whale

Bowheads in the eastern Alaskan and Canadian Beaufort Sea occur in offshore habitats during the summer. Starting late August-early September whales are leaving their feeding grounds and migrate westward in shallower habitats during years with moderate and light ice-cover and in deeper waters in years with heavy ice-cover. During the summer period (July-August) relatively few bowhead whales are expected to be present in the nearshore zone of the central Beaufort Sea. Bowhead sightings become more common there when whales start their westward migration in August, with peak sighting rates occurring in September.

The bowhead whale summer density estimates were derived from 2008 aerial survey data in Camden Bay (Christie et al. 2010) and the 2010 aerial survey in Harrison Bay (Brandon et al. 2011) conducted as part of a marine mammal monitoring program for seismic and shallow hazard surveys. Because these data sets cover the summer season (July-August) it was considered to be the most representative information available. The 2008 Camden Bay survey area covered water depths between 20-200 m. The average density over the period 6 July-18 August was estimated to be 0.009 whales/km^2, and included correction factors from Thomas et al. (2002). This density was based on data collected on the three days that bowhead whales were sighted (7, 9, and 12 July), during periods without operational airguns. The 2010 Harrison Bay aerial survey covered the area just offshore of the barrier islands to 100 m water depth. The average density over the period 16 July-13 August was 0.004 whales/km^2, including correction factors from Thomas et al. (2002). This density was based on data collected before seismic operations started during which one bowhead was observed on 3 August. For the purpose of this IHA request, the average summer density was derived from these two values (0.0065 whales/km^2) and the maximum bowhead density for the proposed survey area was derived by multiplying the average density by 4 (= 0.0260 whales/km^2) to account for variability.

The bowhead whale fall density estimates used in this IHA request are derived from the BWASP aerial surveys, which contain the best available and most current information of bowhead whale distribution and abundance in the Beaufort Sea. These surveys started in 1979 and have been repeated annually, resulting in a large multi-year dataset. Clarke and Ferguson (2010) present an update of this aerial survey effort, summarizing data from the period 2000-2009, and comparing those with results from data prior to 2000. Since the Simpson Lagoon OBC seismic project takes place around 148^{o} longitude in waters of less than 50 ft (15 m), densities of bowhead whales provided by Clarke and Ferguson (2010) for the eastern Beaufort Sea (defined as east of 154^{o} longitude) in the 0-20 m depth zone were considered to be most representative of the proposed survey area. Clarke and Ferguson (2010) reported 96 animals during 9,933 km of on transect aerial survey effort in September and 42 animals during 6,143 km of on transect effort in October. Correction factors from Thomas et al. (2002) were applied to these numbers; this is a value of 2 to correct for animals available at the surface but not detected and a value of 0.07 for animals present but not available at the surface. This resulted in a density of 0.1381 whales/km^2 for September and 0.0977 whales/km^2 for October. The combined September-October value (0.1226 whales/km^2) is used as the average density and the September value as the maximum density.

Other cetacean species

No densities have been estimated for gray whales and for cetacean species that are rare or extralimital to the Beaufort Sea (humpback whale, minke whale, killer whale, harbor porpoise, narwhal; see Table 3.1), because sightings of this animals have been very infrequent. Gray whales may be encountered in small numbers throughout the summer and fall, especially in the nearshore areas. Small numbers of harbor porpoises may be encountered as well. During an aerial survey offshore of Oliktok Point in 2008, just west of the proposed survey area, two harbor porpoises were sighted offshore of the barrier islands, one on 25 August and the other on 10 September (Hauser et al. 2008). The first confirmed sighting of a humpback whale with calf was documented on 1 August 2007, about 54 mile (87 km) east of Point Barrow (Hashagen et al. 2009), so an occasional sighting could occur. For the purpose of this IHA request, arbitrary numbers have been included in the table for requested “take” authorization to cover potential sightings of any of these species during the proposed survey.

Density of Pinnipeds in the Beaufort Sea

Pinnipeds in the polar regions are mostly associated with sea ice and most census methods count pinnipeds when they are hauled out on the ice. To account for the proportion of animals present but not hauled out (availability bias) or seals present on the ice but missed (detection bias), a correction factor should be applied to the “raw” counts. This correction factor is dependent on the behavior of each species. To estimate what proportion of ringed seals were generally visible resting on the sea ice, radio tags were placed on seals during spring 1999-2003 (Kelly et al. 2006). The probability that seals were visible, derived from the satellite data, was applied to seal abundance data from past aerial surveys and indicated that the proportion of seals visible varied from less than 0.40 to more than 0.75 between survey years. The environmental factors that are important in explaining the availability of seals to be counted were found to be time of day, date, wind speed, air temperature, and days from snow melt

(Kelly et al. 2006). Besides the uncertainty in the correction factor, using counts of basking seals from spring surveys to predict seal abundance in the open-water period is further complicated by the fact that seal movements differ substantially between these two seasons (Kelly et al. 2010b). Data from nine ringed seals that were tracked from one subnivean period (early winter through mid-May or early June) to the next showed that ringed seals covered large distances during the open water foraging period (Kelly et al. 2010b). Ringed seals tagged in 2011 close to Barrow also show long distance travel during the open water season (e-mail updates from Jason Herreman 16 November 2011).

To estimate densities for ringed, bearded and spotted seals, data were used from three surveys conducted as part of shallow water OBC seismic surveys in the Beaufort Sea (Harris et al. 2001, Aerts et al. 2008, Hauser et al. 2008). Habitat and survey specifics are very similar to the proposed survey, therefore these data were considered to be the more representative than basking seal densities from spring aerial survey data (e.g., Moulton et al. 2002, Frost et al. 2002, 2004).

No distinction is made in density of pinnipeds between summer and autumn season. Also, no correction factors have been applied to the seal densities reported here. Instead, a multiplier was applied to the estimated densities to account for variability in seal abundance.

All seal species

Ringed seals are the most common seal species in the Beaufort Sea, followed by the bearded seal. Spotted seals also occur, specifically in the nearshore zone, but are not as frequently observed as the other two species. During the 1996 OBC survey, 92% of all seal species identified were ringed seals, 7% bearded seals and 1% spotted seals (Harris et al. 2001). This 1996 survey occurred in two habitats, one about 19 mile east of Prudhoe Bay near the McClure Islands, mainly inshore of the barrier islands in water depths of 10 to 26 ft and the other 6 to 30 miles northwest of Prudhoe Bay, about 0 to 8 mile offshore of the barrier islands in water depths of 10 to 56 ft (Harris et al. 2001). Because it is often difficult to identify seals to species, a large proportion of seal sightings were unidentified in all three surveys. The total seal sighting rate was therefore used to calculate densities for each species, using the ratio of 92%, 7% and 1% for ringed, bearded and spotted seals as mentioned above.

During the 1996 OBC survey (Harris et al. 2001) the sighting rate for all seals during periods when airguns were not operating was 0.63 seals/hour. The sighting rate during non-seismic periods was 0.046 seals/hour for the survey in Foggy Island Bay, just east of Prudhoe Bay (Aerts et al. 2008). The OBC survey that took place at Oliktok Point, adjacent to the proposed survey in Simpson Lagoon, recorded 0.0671 seals/hour when airguns were not operating (Hauser et al. 2008). The survey effort in kilometers or miles is only reported for the survey at Oliktok Point.

The total source line miles that will be travelled during the proposed OBC seismic survey is approximately 4,000 miles (6,440 km). The average vessel speed during the survey will be ~3 knots (or 3.4 miles/hour), calculated based on a 40 ft distance traveled during the 8-second shot interval. Applying the average vessel speed of 3.4 miles/hour, it will take about 1176 hours to complete data acquisition along these source lines, which is equivalent to about 49 days. The total number of seals expected to be observed in the area is 741 (based on 0.63 seals/hour), 54 (based on 0.046 seals/hour), and 79 (based on 0.067 seals/hour). The average of these three values is 291 seals, and the maximum 741 seals.

Ringed seals

The average density for ringed seals is expected to be 0.0420 seals/km^2, based on a ratio of 92% and a total of 6,440 km [(291 × 0.92)/6,440)]. The maximum density is estimated as 0.1058 seals/km^2. To account for variability in seal abundance the average and maximum densities were multiplied by a factor 4.

Bearded Seal

The average density for bearded seals is expected to be 0.0031 seals/km^2, based on a ratio of 7% and a total of 6,440 km [(291 × 0.07)/6,440)]. The maximum density is estimated as 0.0081 seals/km^2. To account for variability in seal abundance the average and maximum density was multiplied by a factor 4.

Spotted seals

The average density for ringed seals is expected to be 0.0005 seals/km^2, based on a ratio of 1% and a total of 6,440 km [(291 × 0.01)/6,440)]. The maximum density is estimated as 0.0012 seals/km^2. To account for variability in seal abundance the average and maximum density was multiplied by 4.

Table 6.1. Expected densities (average and maximum) of cetaceans and pinnipeds in the Simpson Lagoon survey area calculated for the summer (July-August) and autumn (September-October) seasons. Densities are provided in number per km^2. No densities were estimated for extralimital species.

Species	Summer densities (#/km^2)		Autumn densities (#/km^2)	
	Average	Maximum	Average	Maximum
Bowhead whale	0.0065	0.0130	0.1226	0.2762
Beluga whale	0.0008	0.0016	0.0136	0.0259
Ringed seal	0.1680	0.4232	0.1680	0.4232
Bearded seal	0.0124	0.0324	0.0124	0.0324
Spotted seal	0.0020	0.0048	0.0020	0.0048

6.2. Modeled Safety and Disturbance Criteria

An acoustic propagation model, i.e., JASCO's Marine Operations Noise Model (MONM), was used to estimate the distances to received sound levels of 190, 180, 170, 160, and 120 dB re 1µPa (rms) for pulsed sounds from the 640 cu in and 320 cu in airgun arrays. Modeling methodology and results are described in detail in the report "Acoustic Noise Modeling of BP's 2012 Seismic Program in Simpson Lagoon (Harrison Bay, AK)" (Warner and Hipsey 2011; Appendix A). Table 6.2 summarizes the distances from the source to specific received sound levels, taken from the acoustic modeling report. Distances to received levels from the smallest gun in the array (40 cu in) were modeled separately using the same methodology and are included in the table, however, these results are not included in the report of Appendix A.

Table 6.2. Estimated distances to specified received rms SPL sound levels from airgun arrays with a total discharge volume of 640 cu in and 320 cu in (Warner et al. 2011; Appendix A) and for the smallest gun in the array (40 cu in).

Received levels dB re 1 µPa (rms) [a]	Distance in meters (inside barrier island)			Distance in meters (outside barrier island)	
	640 cu in*	320 cu in*	40 cu in**	640 cu in*	40 cu in**
190	~310	~160	~16	~120	<50
180	~750	~480	~59	~950	<50
170	~1,200	~930	~300	~2,500	~120
160	~1,800	~1,500	~700	~5,500	~810
120	~6,400	~5,700	~3,700	~44,000	~16,000

** values are based on a 2 m tow depth for the 640 cu in array and a 1 m tow depth for the 320 cu in array*
*** values for the 40 cu in airgun are based on 2 m tow depth.*

The distances to received sound levels of 160 dB re 1 µPa (rms) of the 640 cu in airgun array were used to calculate the numbers of marine mammals potentially harassed by the activities. The distances to received levels of 180 dB and 190 dB re 1 µPa (rms) are mainly relevant as safety radii to avoid level A harassment of marine mammals through implementation of shut down and power down measures (see Section 11 for a summary of the mitigation measures).

6.3. Number of marine mammals potentially affected

NMFS uses a threshold of 160 dB re 1 µPa (rms) for all marine mammals under their jurisdiction for the onset of "level B harassment" from pulsed sounds (NMFS 2005, 2010c). The radii associated with received sound levels of 160 dB re 1 µPa (rms) or higher are therefore used to calculate the number of potential marine mammal "exposures" to airgun sounds. The potential number of each species that might be exposed to received pulsed sound levels of ≥160 dB re 1 µPa (rms) is calculated by multiplying the expected species density as provided in Table 6.1 with the anticipated area to be ensonified to that level during airgun operations. Bowhead and beluga whales are migrating through the area, so every encounter likely involves a new individual. Although seal species are also known to cover large distances, they are expected to linger longer within a certain area, and so one individual might be exposed multiple times.

The area expected to be ensonified was determined by entering the seismic survey lines into a MapInfo Geographic Information System (GIS). GIS was then used to identify the relevant areas by "drawing" the applicable 160-dB buffer of the 640 cu in array (Table 6.2) around each seismic source line and calculate the total area within the buffers. This was done for the survey area outside the barrier islands and inside the barrier islands separately. This method avoids the large overlap of buffer zones from each seismic source line, and hence an overestimation of the potential number of marine mammals exposed. The area ensonified with pulsed sound levels of ≥160 dB re1 µPa (rms) from airgun operations outside the barrier islands is estimated as 197.5 mi^2 (512 km^2) and from airgun operations inside the barrier islands 105 mi^2 (272 km^2).

Summer density estimates of marine mammals will be applied to all (100%) survey effort outside the barrier islands and to 60% survey effort inside the barrier islands. Fall densities are not applied to the outside barrier island survey effort, since no survey effort is planned after 25 August. This is shown as a gray area in Table 6.3A. Fall densities are applied to 100% survey effort inside the barrier island activity, because some of the source lines will be rerun in order to image the full fold area adequately.

Table 6.3 provides the number of marine mammals potentially exposed to pulsed sound levels of ≥160 dB re 1 µPa (rms) during the proposed seismic survey for data acquisition outside and inside the barrier islands. Table 6.4 summarizes this data and specifies the number for which authorization is requested.

Number of Cetaceans Potentially Exposed to ≥160 dB

During autumn some migrating bowheads have been found to react to a noise threshold closer to 130 dB re 1 µPa (rms; Miller et al. 1999; Richardson et al. 1999). Migrating bowhead whales might therefore show avoidance reactions before being exposed to sound levels of 160 dB re 1 µPa (rms) or higher. The numbers potentially impacted at thresholds of ≥160 dB re 1 µPa (rms), however, are calculated as if no avoidance behavior takes place. Our estimated average and maximum numbers of bowhead whales exposed to sound levels of 160 dB or more, as rounded numbers, are in Table 6.3. For the data acquisition outside the barrier islands only the summer densities were used.

Average and maximum estimates of the number of beluga whales potentially exposed are also summarized in Table 6.3. Species such as gray whale, narwhal, killer whale and harbor porpoise are not expected to be encountered but might be present in very low numbers; the maximum expected numbers exposed for these species are provided in Table 6.3 and are based on arbitrary estimates.

Number of Pinnipeds Potentially Exposed

Pinnipeds are not likely to react to seismic sounds unless the received levels are 170 dB re 1 µPa (rms), and many of those exposed to 170 dB will still not react overtly (Harris et al. 2001; Moulton and Lawson 2002; Miller et al. 2005). Ringed seals account for the majority of marine mammals expected to be encountered during the proposed seismic survey and thus more likely to be exposed to airgun sounds with received levels of ≥160 dB. The average (and maximum) estimates of the number of ringed seals exposed to these received levels for activities inside and outside the barrier island are summarized in Table 6.3.

The other two species that could be encountered are the bearded seal and spotted seal. The likelihood of encounters, however, is much lower than for ringed seals with average and maximum numbers potentially exposed to ≥160 as shown in Table 6.3.

Table 6.3. Average (avg) and maximum (max) estimated number of cetaceans and pinnipeds that might be exposed to sound levels of 160 dB re 1µPa (rms) or more during the Simpson Lagoon shallow seismic survey outside (A) and inside (B) the barrier islands. Numbers for gray whales and extralimital species are not included in this table. Gray area means that there is no data acquisition outside the barrier islands in the fall.

(A)	Outside Barrier Islands Number of Individuals Exposed to ≥160 dB					
Species	Summer		Fall			
	Avg	Max	Avg	Max	Total avg	Total max
Bowhead whale	3	13			3	13
Beluga whale	0	1			0	1
Ringed seal	60	307			60	307
Bearded seal	9	24			9	24
Spotted seal	1	3			1	3

(B)	Inside Barrier Islands Number of Individuals Exposed to ≥160 dB					
Species	Summer		Fall			
	Avg	Max	Avg	Max	Total	Total
Bowhead whale	1	4	33	75	34	79
Beluga whale	0	0	4	7	4	7
Ringed seal	19	98	32	163	51	261
Bearded seal	3	8	5	13	7	20
Spotted seal	0	1	1	2	1	3

6.4. Summary

The total estimated number of cetaceans and pinnipeds potentially exposed to sound levels that can trigger behavioral responses are relatively low (Table 6.4). The maximum number of bowhead whales, listed as endangered under the ESA, potentially exposed to sound levels of 160 dB re 1µPa (rms) or more is estimated at ~93. Assuming a population size of 15,232 animals in 2012, based on the population estimate of ~10,545 animals (Zeh and Punt 2005) and an annual growth rate of 3.4%, this number is about 0.6% of the population. Chance encounters with small numbers of other cetacean species are possible, but not likely for the nearshore zone of the survey and the associated area of influence. Belugas are known to show aggregate behavior and can occur in large numbers in nearshore zones. For the unlikely event that a group of belugas appears in the Simpson Lagoon area during the seismic survey a number of 50 is added to the requested authorization. These estimated exposures do not take into account the mitigation measures that will be implemented, such as marine mammal observers watching for animals, shutdowns or power downs of the airguns when marine mammals are seen within defined ranges, and ramp up of airguns. These measures will further reduce the number of exposures and expected short-term reactions, and minimize any effects on hearing sensitivity.

Table 6.4. Summary of the total number of marine mammals potentially exposed to received sound levels of ≥160 dB during BP's proposed seismic survey. The number of animals for which authorization is requested is specified in a separate column.

Species	Number of Individuals Exposed to ≥160 dB		Requested Authorization
	Avg	Max	
Bowhead whale	38	93	93
Beluga whale	4	8	8(50)*
Gray whale	0	3	3
Killer whale	0	3	3
Harbor porpoise	0	3	3
Humpback whale	0	1	1
Minke whale	0	1	1
Ringed seal	112	567	567
Bearded seal	16	44	44
Spotted seal	2	6	24**
Ribbon seal	0	3	3

* *A number of 50 is added to the requested authorization for the unlikely event that a group of belugas appears in the Simpson Lagoon area during the seismic survey*

*** The maximum number is multiplied by 4 to obtain the requested authorization in case more spotted seals are observed than based on the assumed 1% ratio of occurrence (see text).*

The maximum number of ringed seals potentially exposed is estimated at 567, which is about 0.2% of the estimated population size of the Beaufort Sea stock (Table 3.1). Bearded and spotted seals could also be present and potentially exposed to sound levels of 160 dB or more, but in relatively low numbers that represent less than 0.05% of their estimated population sizes. It is probable that at this received level only a small percentage of these seals would actually be disturbed. If disturbance to seals occurs it is expected to be a short-term response without any negative consequences for the individuals or their populations.

7. ANTICIPATED IMPACT ON SPECIES OR STOCKS

The anticipated impact of the activity upon the species or stock of marine mammals.

This section summarizes the potential impacts on marine mammals of airgun operations and pinger systems. It also includes information known from other species than those that might occur in the area.

7.1. Potential effects of airgun sounds

Airgun sounds can have several different effects on marine mammal species, such as temporary or permanent hearing impairment tolerance, behavioral disturbance, or non-auditory physical effects (Richardson et al. 1995). In some cases airgun sounds can mask the natural sounds important to marine mammals, or marine mammals show tolerance to introduced sounds. In this section these effects are briefly summarized.

Tolerance

Pulsed sounds from airguns are detectable in the water at large distances. However, marine mammals that are present at a few kilometers from operating seismic vessels often show no apparent response, even though the pulsed sounds must be readily audible to the animals based on measured received levels and the hearing sensitivity known for that mammal group. In these cases the animal likely tolerates the sounds in its environment. Pinnipeds and small odontocetes seem generally more tolerant to exposures of airgun pulses than mysticetes.

Masking

Underwater sound has the potential to interfere with the communication of a marine mammal species or can affect their ability to detect environmental sounds. This can occur when the frequency of the introduced sound is close to that used by the marine mammals and if the anthropogenic sound source is present for a significant fraction of the time (Richardson et al. 1995). However, masking effects of pulsed sounds on marine mammal calls and other natural sounds are expected to be limited, although there are very few specific data available. Some whales are known to continue calling in the presence of seismic pulses (e.g., Richardson et al. 1986, McDonald et al. 1995, Greene et al. 1999, Nieukirk et al. 2004), shown in studies from northern Norway and the Gulf of Mexico that demonstrated continued sperm whale calling in the presence of seismic pulses (Madsen et al. 2002, Tyack et al. 2003). There has, however, also been evidence that sperm whales cease calling when exposed to pulses from a very distant seismic ship (Bowles et al. 1994). Bowhead whale calls are frequently detected in the presence of seismic pulses, although the number of calls detected may sometimes be reduced (Richardson et al. 1986, Greene et al. 1999), possibly because animals moved away from the sound source or ceased calling (Blackwell et al. 2011). In contrast to studies showing reduced calling, Di Lorio and Clarke (2010) found evidence of increased calling by blue whales during activities that used a sparker (a lower-energy seismic source).

Masking effects of seismic pulses are expected to be negligible during the planned project given the low number of cetaceans expected to be exposed, the intermittent nature of seismic pulses, and the fact that ringed seals (most likely to be present in the area) are not vocal during this period. However, reverberation and multi-path arrival could, at least in theory, lead to some masking.

Disturbance Reactions

Disturbance includes a variety of effects, including subtle changes in behavioral parameters, (such as breathing rate, travel speed, dive time, etc.), more conspicuous changes in activities (for example disruption to feeding or migration), and displacement. The NMFS considers short-term subtle behavioral responses that that are within the animal’s normal range and that do not have any biological significance, do not rise to a level requiring a small take authorization (NMFS 2001, p. 9293). Biologically significant in this case means “in a manner that might have deleterious effects to the well-being of individual marine mammals or their populations” as defined by the National Resource Council (NRC 2005).

Reactions to sound depend on the species that is exposed, the state of maturity of the animal, its experience, current activity, reproductive state, and many other factors including environmental influences that affect sound propagation (Richardson et al. 1995, Gordon et al. 2004). If a marine mammal reacts to an underwater sound by briefly changing its behavior or moving a small distance, the impacts of the change are unlikely to be significant to the individual, let alone the stock or the species as a whole. However, if a sound source displaces marine mammals from an important feeding or breeding area for a prolonged period, impacts on the animals, or even the population, could be significant. The sound criteria used to estimate how many marine mammals might be disturbed to some biologically-important degree by a seismic program are based on studies of several species that have reported on behavioral observations. Detailed studies have been conducted on humpback, gray, and bowhead whales, and on ringed seals. Less detailed data are available for some other species of mysticetes, sperm whales, and small odontocetes and for many other species information on sound level exposure and resulting disturbance is not available at all.

Mysticetes

Baleen whales generally avoid areas with operating airguns, but avoidance radii are highly variable. Baleen whales exposed to strong sound pulses from airguns often react by deviating from their normal migration route and/or interrupting their feeding and moving away, but they also often do not show obvious reactions to pulses from large arrays of airguns at distances beyond a few kilometers, even though the airgun pulses remain well above ambient noise levels out to much longer distances. In the case of migrating gray and bowhead whales, the observed changes in behavior appeared to be of little or no biological consequence to the animals. They simply avoid the sound source by displacing their migration route to varying degrees, but within the natural boundaries of the migration corridors.

Studies of gray, bowhead, and humpback whales have determined that received levels of pulses in the 160–170 dB re 1 µPa rms range seem to cause obvious avoidance behavior. In many areas, seismic pulses from large arrays of airguns diminish to those levels at distances ranging from 2.7 to 9 miles (4.5 to 14.5 km) from the source. For the much smaller airgun array of this seismic survey the distances to received levels in the 160–170 dB re 1 µPa rms range are 0.6 to 3.4 miles (1.1 to 5.5 km) depending on the location and airgun array used (see Table 6.2). Baleen whales within those distances may show avoidance or other strong disturbance reactions to the airgun array, but few baleen whales are expected to occur in the Simpson Lagoon seismic survey area.

Subtle behavioral changes sometimes become evident at lower received levels. Recent studies have shown that some species of baleen whales, particularly bowhead and humpback whales can show strong avoidance at received levels lower than 160–170 dB re 1 µPa rms. Weir (2008) found that encounter rates and mean distance with humpback whales did not differ significantly according to airgun operational status during a 10-month seismic survey offshore Angola. Bowhead whales migrating west across the Alaskan Beaufort Sea in autumn are unusually responsive, with avoidance occurring out to distances of 12 to 18 miles (20 to 30 km) from a medium-sized airgun source (Miller et al. 1999, Richardson et al. 1999) where received levels were measured to be ~120-130 dB re 1 µPa rms. The call detection rate of bowhead whales migrating through areas with airgun activity was found to be dropping significantly at sound exposure levels of more than 120 dB re $1\mu Pa \cdot s^{-2}$ as summed over 15 minutes (Blackwell et al. 2011). More recent research on bowhead whales (Miller et al. 2005, Koski et al. 2008b) corroborates earlier evidence that, during the summer feeding season, bowheads are not as sensitive to seismic sources. In summer, bowheads typically begin to show avoidance reactions at a received level of about 160–170 dB re 1 µPa rms (Richardson et al. 1986, Ljungblad et al. 1988, Miller et al. 1999). Koski et al. (2008b) reported that feeding bowheads tolerated received levels of seismic sounds that approached ~160 dB re 1 µPa rms and that some tolerated even higher levels; one group of three whales tolerated received levels of ~180 dB re 1 µPa rms.

Malme et al. (1986, 1988) studied the responses of feeding eastern gray whales to pulses from a single 100 cu in airgun off St. Lawrence Island in the northern Bering Sea. Based on small sample sizes they estimated that 50% of feeding gray whales ceased feeding at an average received pressure level of 173 dB re 1 µPa (rms) and that at received levels of 163 dB 10% of feeding whales interrupted feeding. Those findings were generally consistent with the results of experiments conducted on larger numbers of gray whales that were migrating along the California coast, and on observations of the distribution of feeding Western Pacific gray whales off Sakhalin Island, Russia during a seismic survey (Yazvenko et al. 2007).

The Simpson Lagoon seismic project will be conducted during the summer and fall, when bowhead whales are commonly involved in migration. As part of the planned mitigation measures, BPXA will plan to complete those portions of the survey area outside of the barrier islands prior to 25 August 2012. All seismic activities after this date will take place inshore of the barrier islands where encounters with bowhead whales are less likely and the barrier islands will reduce acoustic propagation of the seismic sound source. Given the shallow water depths in the nearshore zone and with seismic airguns of relatively small discharge volumes, the distance of received levels that might elicit avoidance behavior will likely not (or will barely) reach the main migration corridor. Any localized, temporary displacement of migrating animals, if it occurs, is expected to be within the natural boundaries of the migratory corridor.

Whether the exposure to pulsed sounds and the possible short-term behavioral responses lead to more long term effects such as reproductive rate or distribution and habitat use in subsequent days or years is not very well known. Migratory gray whales continued to migrate annually along the west coast of North America despite intermittent seismic exploration and much ship traffic in that area for decades (Appendix A in Malme et al. 1984). Similarly, seismic explorations in the summer and autumn range of migrating bowhead whales did not alter their annual migration pattern to and from the eastern Beaufort Sea (Richardson et al. 1987). Populations of both gray whales and bowhead whales grew substantially during this time, so based on currently available knowledge brief exposures to sound pulses from the proposed airgun source are highly unlikely to result in long-term effects.

Odontocetes

Based on the relatively limited information available about the potential impacts from airgun sounds on odontocetes (compared to the more extensive studies conducted on baleen whales), it can be concluded that reactions of toothed whales to large arrays of airguns are variable and generally seems to be confined to a smaller radius than has been observed for mysticetes. There are a few studies that report on responses of various odontocetes to seismic surveys pulsed sounds, such as the sperm whale study in the Gulf of Mexico (Tyack et al. 2003, Jochens et al. 2006, Miller et al. 2009) and the increasing amount of information about based on monitoring studies conducted during seismic surveys (e.g., Stone 2003, Smultea et al. 2004, Moulton and Miller 2005). Miller et al. (2009) conducted at-sea experiments where reactions of sperm whales were monitored through the use of controlled sound exposure experiments from large airgun arrays consisting of 20-guns and 31-guns. Of 8 sperm whales observed, none changed their behavior when exposed to either a ramp-up at 4-8 miles (7-13 km) or full array exposures at 0.6-

8 miles (1-13 km). As noted above with humpback whales, Weir (2008) found that encounter rates and mean distance with sperm whales did not differ significantly according to airgun operational status during a 10-month seismic survey offshore Angola. Weir (2008) also reported that Atlantic spotted dolphins did occur at significantly greater distances from the active array compared to periods when the guns were off, although there was no evidence of prolonged or large-scale displacement.

Most delphinids show some limited avoidance of seismic vessels operating large airgun systems, though seismic operators and marine mammal observers sometimes see dolphins and other small toothed whales relatively close to operating airguns. Some dolphins seem to be attracted to seismic vessels and floats and some have been observed to bow-ride with the waves of seismic vessels even when large arrays of airguns are firing. Nonetheless, there have been indications that small toothed whales sometimes move away, or maintain a somewhat greater distance from the vessel, when a large array of airguns is operating than when it is silent (e.g., Goold 1996a,b,c, Calambokidis and Osmek 1998, Stone 2003). An example are the lower sighting rates of beluga whales within 6.2-12 miles (10-20 km) of an active seismic vessel recorded during aerial surveys and vessel-based observations conducted as part of seismic operations in the southeastern Beaufort Sea. These results suggest that some belugas might be avoiding seismic operations at distances of up to 12 miles (20 km) (Miller et al. 2005).

Captive bottlenose dolphins and beluga whales exhibit changes in behavior when exposed to strong pulsed sounds similar in duration to those typically used in seismic surveys (Finneran et al. 2002, 2005), although the animals tolerated high received levels of sound (pk–pk level >200 dB re 1 μPa) before exhibiting aversive behaviors. With the presently-planned source, such levels would be limited to distances less than 200 m of the 640 cu in and 320 cu in arrays, both outside and inside the barrier islands and encounters with beluga whales are not likely to occur within these distances.

Pinnipeds

Pinnipeds are generally even less responsive to airgun sounds than cetaceans and are not likely to show a strong avoidance reaction to the airgun sources that will be used during the proposed survey. Visual monitoring from seismic vessels has shown only slight avoidance or other changes in behavior in pinnipeds, if any responses occurred at all. Ringed seals do not frequently avoid the area within a few hundred meters of operating airgun arrays (Harris et al. 2001, Moulton and Lawson 2002, Miller et al. 2005). However, telemetry work suggests that avoidance and other behavioral reactions by harbor and grey seals to small airgun sources may at times be stronger than evident to date from visual studies of pinniped reactions to airguns (Thompson et al. 1998). Even if reactions of the seal species occurring in the proposed study area are as strong as those in the telemetry study, reactions are expected to be confined to relatively small distances and durations, with no long-term effects on pinniped individuals or populations.

Hearing Impairment and Other Physical Effects

Temporary or permanent hearing impairment is a possibility when marine mammals are exposed to very strong sounds. Close proximity to airgun pulses has the potential for hearing impairment in marine mammals, but there has been no specific documentation of this because it is difficult to assess in animals in the wild. Current NMFS policy regarding exposure of marine mammals to high-level sounds is that cetaceans and pinnipeds should not be exposed to impulsive sounds ≥180 and ≥190 dB re 1 µPa (rms), respectively (NMFS 2000). Those criteria have been used in defining the safety (shutdown) radii planned for the proposed seismic survey, but were established without actual data on the minimum received levels of sounds necessary to cause temporary auditory impairment in marine mammals.

NMFS is developing new noise exposure criteria for marine mammals that account for the now-available scientific data on TTS and other relevant factors in marine and terrestrial mammals (NMFS 2005). Science-based noise exposure criteria have also been proposed based on an extensive review and syntheses of available data on the effect of noise on marine mammals (Southall et al., 2007), which concludes the current 180 dB and 190 dB are conservative.

Several aspects of the planned monitoring and mitigation measures for this project are designed to detect marine mammals occurring in close proximity to airguns to avoid exposing them to sound pulses that might, at least in theory, cause hearing impairment. In addition, many cetaceans are likely to show some avoidance of the area with high received levels of airgun sounds and as such reduce or (most likely) avoid any possibility of hearing impairment.

Non-auditory physical effects (e.g., stress, neurological effects, bubble formation, and other types of organ or tissue damage) might also occur in marine mammals exposed to strong underwater pulsed sounds. It is possible that some marine mammal species (i.e., beaked whales) may be especially susceptible to injury and/or stranding when exposed to strong pulsed sounds. However, as discussed below, there is no definitive evidence that any of these effects occur even for marine mammals in close proximity to large arrays of airguns and beaked whales do not occur in the project area. It is unlikely that any effects of these types would occur during the present project given the brief duration of exposure of any given mammal, and the planned monitoring and mitigation measures (see below). The following subsections provide more detail about the possibilities of TTS, permanent threshold shift (PTS), and non-auditory physical effects.

Temporary Threshold Shift (TTS)

TTS is the mildest form of hearing impairment that can occur as a result of exposure to a strong sound (Kryter 1985). An animal experiencing TTS has a higher hearing threshold and can hear a specific sound only if it rises above that treshold. At least in terrestrial mammals, TTS can last from minutes or hours to (in cases of strong TTS) days. Hearing sensitivity in both terrestrial and marine mammals recovers rapidly after exposure to the sound ends if the sound exposure is at or just above the TTS treshold. There are few data that discuss to what sound levels and durations a marine mammal needs to be exposed to in order to elicit mild TTS. None of the published data concern TTS elicited by exposure to multiple pulses of sound.

The TTS threshold for toothed whales exposed to single short pulses appears to be to a function of the energy content of the pulse (Finneran et al. 2002, 2005). Given the available data, the received level of a single seismic pulse might need to be ~210 dB re 1 µPa rms (~221–226 dB pk–pk) in order to produce brief, mild TTS. Exposure to several seismic pulses at received levels near 200–205 dB (rms) might result in slight TTS in a small odontocete, assuming the TTS threshold is a function of the total received pulse energy. Seismic pulses with received levels of 200–205 dB or more are usually restricted to a radius of no more than 656 ft (200 m) around a seismic vessel operating a large airgun array. The 200-205 dB radius of the smaller airgun array in the proposed survey will be no more than 328 ft (100 m).

The levels or properties of sound that are required to induce TTS in baleen whales is unknown. During the proposed survey the baleen whale most likely to occur in the project are westward migrating bowhead whales. Given the relatively small size of the array, the area of operations during the migration period, the expectation that most bowhead whales are passing through the area in a short time frame, and the tendency of bowhead whales to avoid approaching airguns (or vessels), it is unlikely that they will be exposed to sound levels high enough for TTS to occur.

In pinnipeds, TTS thresholds associated with exposure to brief pulses (single or multiple) of underwater sound have not been measured. Initial evidence from prolonged exposures suggested that some pinnipeds may incur TTS at somewhat lower received levels than do small odontocetes exposed for similar durations (Kastak et al. 1999, 2005, Ketten et al. 2001, cf. Au et al. 2000). However, for the harbor seal (which is closely related to the ringed seal), TTS onset apparently occurred at somewhat lower received energy levels than for odontocetes (Kastak and Schusterman 1998).

In this project, approximately half of the planned seismic survey will take place in very shallow waters nearshore of the barrier islands. The propagation of the sounds generated is expected to be very limited offshore of the islands, where most of the baleen whales are expected to occur; in addition, plans call for the completion of the offshore portion of the project seaward of the barrier islands prior to 25 August 2012, before the majority of migrating whales are expected to be present. There is a possibility that a small number of seals (which often show little or no avoidance of approaching seismic vessels) could occur close to the airguns and that they might incur slight TTS if no mitigation action (shutdown) were taken.

The safety radii that will be used are based on the 180 and 190 dB (rms) levels for cetaceans and pinnipeds, respectively, according to the criteria established by the NMFS before TTS measurements for marine mammals started to become available. Data that are now available imply that TTS is unlikely to occur unless bow-riding odontocetes are exposed to airgun pulses much stronger than 180 dB re 1 µPa rms (Southall et al., 2007). Since no bow-riding species are expected in the study area during the proposed seismic survey, and mitigation measures will be implemented based on the rather conservative 180 dB and 190 dB criteria, it is unlikely that such exposures will occur.

Permanent Threshold Shift (PTS)

With PTS there is a physical damage to the sound receptors in the ear. In some cases PTS can lead to total or partial deafness, whereas in other cases the animal might have an impaired ability to hear sounds in specific frequency ranges.

There is no specific evidence that exposure to pulses of airgun sound can cause PTS in any marine mammal, even with large airgun arrays. However, since marine mammals close to an airgun might incur TTS, there is the theoretical possibility that PTS might occur in individuals very close to airguns. Single or occasional occurrences of mild TTS are not indicative of permanent auditory damage in terrestrial mammals. Relationships between TTS and PTS thresholds have not been studied in marine mammals, but are assumed to be similar to those in humans and other terrestrial mammals. PTS might occur at a received sound level at least several decibels above the sound levels inducing mild TTS if the animal were exposed to the strong sound pulses with very rapid rise time.

In the proposed project, marine mammals are unlikely to be exposed to received levels of seismic pulses strong enough to cause more than slight TTS and given the higher level of sound necessary to cause PTS, it is even less likely that PTS could occur. In fact, even the levels reasonably close to the airgun array may not be sufficient to induce PTS, especially because a mammal would not be exposed to more than one strong pulse unless it swam reasonably close to the airgun array for a period longer than the inter-pulse interval. Baleen whales, and apparently belugas, generally avoid the immediate area around operating seismic vessels. The planned monitoring and mitigation measures, including visual monitoring, power downs, and shutdowns of the airguns when mammals are seen within the designated safety radii, will minimize the limited probability of exposure of marine mammals to sounds strong enough to induce PTS.

Non-auditory Physiological Effects

Non-auditory physiological effects or injuries that theoretically might occur in marine mammals exposed to strong underwater sound include stress, neurological effects, bubble formation, and other types of organ or tissue damage. However, studies examining such effects are very limited. If any such effects do occur, they probably would be limited to unusual situations when animals might be exposed at close range for unusually long periods. It is doubtful that any single marine mammal would be exposed to strong seismic sounds for a sufficiently long time period that significant physiological stress would develop. That is especially so in the case of the proposed project where the airgun configuration focuses most energy downward and the source vessels are moving with speeds of 3 to 5 knots.

Little is known about the potential for airgun sounds to cause auditory impairment or other physical effects in marine mammals and the limited data available do not allow for meaningful quantitative predictions of the numbers (if any) of marine mammals that might be affected in those ways. Marine mammals that show behavioral avoidance of seismic vessels, including most baleen whales, some odontocetes (including belugas), and some pinnipeds, are especially unlikely to incur auditory impairment or other physical effects. Also, the planned monitoring and mitigation measures include shutdowns of the airguns should animals enter designated "safety radii", which will further reduce any such effects that might otherwise occur.

Stranding and Mortality

Marine mammals can be killed or severely injured when they happen to be in close proximity to underwater detonations of high explosives. Airgun pulses are much less energetic and have slower rise times, and there is no information available showing that airgun sounds can cause serious injury, death, or strandings. The shallow water environment, small airgun arrays and planned monitoring and mitigation measures of the proposed survey are not expected to result in mortality of marine mammal species.

7.2. Potential effects of pinger signals

A pinger system (Sonardyne Acoustical Pingers) and acoustic releases/transponders will be used during seismic operations to position the receivers and locate and retrieve the batteries. Sounds transmitted by these pingers are characterized by very short pulses. The Sonardyne pinger has a source level ranging from ~188-193 dB re 1 µPa at 1 m in a frequency range of 19-36 kHz and the transponder has source levels ~192 dB re 1 µPa at 1 m in a frequency range of 7-15 kHz. Pulses are emitted on command from the operator aboard the source vessel.

Masking

The pinger produces sounds within the frequency range that could be detected by some seals (functional underwater hearing estimated at 75 Hz to 75 kHz), baleen whales (hearing sensitivity from few tens of Hz to ~10kHz), and beluga whales (peak sensitivity at ~10-15 kHz) (Southall et al. 2007). However, marine mammal communications will not be masked appreciably by the pinger signals because of the relatively low power output, low duty cycle, and brief period when an individual mammal is likely to be within the area where they could potentially be exposed.

Behavioral Responses

Marine mammal behavioral reactions to pulsed sound sources such as airguns are discussed above, and responses to pinger sounds are likely similar if received at the same levels. However, the pulsed signals from the pinger are much weaker than those from the airgun and will propagate over shorter distances. Therefore, behavioral responses are not expected unless marine mammals are very close to the source. The maximum reaction that might be expected would be a startle reaction or other short-term response. NMFS (2001) has concluded that short-term behavioral reactions that that are within the animal's normal range and that do not have any biological significance, do not rise to a level requiring a small "take" authorization.

Hearing Impairment and Other Physical Effects

Source levels of the pinger are much lower than those of the airguns, which are discussed above. It is unlikely that the pinger produces pulse levels strong enough to cause temporary hearing impairment or (especially) physical injuries even in an animal that is (briefly) in a position near the source.

8. ANTICIPATED IMPACT ON SUBSISTENCE

The anticipated impact of the activity on the availability of the species or stocks of marine mammals for subsistence uses.

Subsistence hunting and fishing are essential for Alaska residents to maintain social organization and household economics, particularly in rural coastal villages (Wolfe and Walker 1987). Resources obtained through subsistence hunting and fishing are highly valued commodities fundamental to the customs and traditions of the Inupiat culture, including artistic expression, religion and family life. Subsistence harvesting provides important sources of nutrition in almost all Arctic rural communities and is a vital part of their livelihood.

BPXA does not expect that the proposed project activities will adversely affect subsistence hunting. Mitigation measures will be implemented to minimize or completely avoid any adverse effects on the availability of subsistence resources. Additionally, avoidance guidelines and mitigation measures are developed in a formal agreement with the AEWC, individual community Whaling Captain's Associations, BPXA and other Industry Participants in the form of the Conflict Avoidance Agreement (CAA).

8.1. Subsistence Resources

Marine mammals are legally hunted in Alaskan waters by coastal Alaska Natives and represent between 60% and 80% of their total subsistence harvest. The species regularly harvested by subsistence hunters in and around the Beaufort Sea are bowhead and beluga whales, ringed, spotted, and bearded seals, and polar bears. The latter is not discussed in this section, as polar bears do not fall under the jurisdiction of NMFS. The importance of each of the subsistence species varies among the communities and is mainly based on availability and season.

The communities closest to the project area are, from west to east, the villages of Barrow, Nuiqsut, and Kaktovik. Barrow is located about 180 miles west from the survey area. It is the largest community on the Alaska's Beaufort Sea coast with a population of 4,351 in 2004 (DCED 2005). Important marine subsistence resources for Barrow include bowhead and beluga whales, ice seals, polar bears, and walrus. Nuiqsut is located near the mouth of the Colville River, about 35 miles southwest of the project area and had a population of 430 in 2004 (DCED 2005). Most important marine subsistence resource for Nuiqsut is the bowhead whale, and to a lesser extent beluga whales, polar bears and seals. Nuiqsut hunters use Cross Island as a base to hunt for bowhead whales during the fall migration and have historically hunted bowhead whales as far east as Flaxman Island. Kaktovik is located on Barter Island, about 150 miles east of the project area and had a population of 284 in 2004 (DCED 2005). Major marine subsistence resources include bowhead and beluga whales, seals, and polar bears. Approximately 50% of Kaktovik households participate in fall whaling (Fuller and George 1999).

Bowhead Whale

The bowhead whale is a critical subsistence and cultural resource for the North Slope communities of Barrow, Nuiqsut and Kaktovik (Table 8.1). The level of allowable harvest is determined under a quota system in compliance with the International Whaling Commission (IWC 1980; Gambell 1982). The quota is based on the nutritional and cultural needs of Alaskan Natives as well as on estimates of the size and growth of the Bering-Chukchi-Beaufort seas stock of bowhead whales (Donovan 1982; Braund 1992). In 2007, a five-year block quota ended and a new five-year block quota started in 2008 (http://www.iwcoffice.org/meetings/meeting 2007.htm). The quota is regulated through an agreement between NMFS and the Alaska Eskimo Whaling Commission (AEWC). The AEWC allots the number of bowhead whales that each community is permitted to harvest. Contemporary whaling in Kaktovik dates from 1964 and in Nuiqsut from 1973 (EDAW/AECOM 2007; Galginaitis and Koski 2002). The number of boats used or owned in 2011 by the subsistence whaling crew of the villages of Kaktovik, Nuiqsut, and Barrow was 8, 12, and 40, respectively. These numbers presumably change from year to year.

Bowhead harvesting in Barrow occurs both during the spring (April-May) and fall (September-October) when the whales migrate relatively close to shore (ADNR 2009). During spring bowheads migrate through open ice leads close to shore. The hunt takes place from the ice using umiaks (bearded seal skin boats). During the fall, whaling is shore-based and boats may travel up to 30 miles a day (EDAW/AECOM 2007). Although in Barrow historically most whales were taken during spring whaling, the efficiency of the spring harvest tends to be lower than the autumn harvest due to ice and weather conditions as well as struck whales escaping under the ice (Suydam et al. 2010). In the past few years the bowhead fall hunt has become increasingly important. Between 1993-2010, Barrow landed an average of 22 bowhead whales per year (Table 8.1).

Nuiqsut and Kaktovik hunters harvest bowhead whales only during the fall. The bowhead spring migration in the Beaufort Sea occurs too far from shore for hunting because ice leads do not open up nearshore (ADNR 2009). In Nuiqsut, whaling takes place from early September through mid-to-late September as the whales migrate west (EDAW/AECOM 2007). Three to five whaling crews base themselves at Cross Island, a barrier island approximately 35 miles east of the Simpson Lagoon survey area. Nuiqsut whalers harvest an average of 3 bowheads each year (Table 8.1).

Whaling from Kaktovik also occurs in the fall, primarily from late August through late September or early October (EDAW/AECOM 2007). Kaktovik whalers hunt from the Okpilak and Hulahula rivers east to Tapkaurak Point (ADNR 2009). Whaling activities are staged from the community rather than remote camps; most whaling takes place within 12 miles of the community (ADNR 2009). Kaktovik whalers harvest an average of 3 bowhead whales each year (Table 8.1).

Table 8.1. Bowhead landings[1] during the period 1993-2010 at Barrow, Nuiqsut, and Kaktovik. Barrow numbers provide total (autumn) landings.

Year	Barrow	Nuiqsut	Kaktovik
1993	23(7)	3	3
1994	16(1)	0	3
1995	20(11)	4	4
1996	24(19)	2	1
1997	31(21)	3	4
1998	25(16)	4	3
1999	24(6)	3	3
2000	18(13)	4	3
2001	26(7)	3	4
2002	20(17)	4	3
2003	16(6)	4	3
2004	21(14)	3	3
2005	29	1	3
2006	22	4	3
2007	20	3	3
2008	21	4	3
2009	19	2	3
2010	22	4	3

[1] From Burns et al. (1993), various issues of IWC Reports, AEWC, J.C. George (NSB Department of Wildlife Management) and EDAW/AECOM 2007.

Beluga Whale

The harvest of beluga whales is managed cooperatively through an agreement between NMFS and the Alaska Beluga Whale Committee (ABWC). From 2002-2006, 5-43 beluga whales were harvested annually from the Beaufort Sea stock (Allen and Angliss 2010), with a mean annual take of 25.4 animals. Few beluga whales are harvested by either Nuiqsut or Kaktovik.

Pinnipeds

Seals represent an important subsistence resource for the North Slope communities. Harvest of bearded seals usually takes place during the spring and summer open water season from Barrow (EDAW/AECOM 2007) with only a few animals taken by hunters from Kaktovik or Nuiqsut. Seals are also taken during the ice-covered season, with peak hunting occurring in February (ADNR 2009). In 2003, Barrow-based hunters harvested 776 bearded seals, 413 ringed seals and 12 spotted seals (ADNR 2009). Nuiqsut hunters harvest seals in an area from Cape Halkett to Foggy

Island Bay. For the period 2000-2001, Nuiqsut hunters harvested one bearded seal and 25 ringed seals (ADNR 2009). Kaktovik hunters also hunt seals year-round. In 2002-2003, hunters harvested 8 bearded seals and 17 ringed seals.

Walrus are not generally available to hunters in Nuiqsut and Kaktovik. From 1989-2008, only two walrus were harvested from Kaktovik and none from Nuiqsut (USFWS 2009). Walrus are harvested more frequently from Barrow where recent harvests have ranged from 4 walrus in 1994 to 51 in 2003 (ADNR 2009).

8.2. Anticipated Impact

The proposed seismic survey will take place between July and September. The project area is located approximately 35 miles northeast from Nuiqsut, 35 miles west from Cross Island, 150 miles west from Kaktovik and 180 miles east from Barrow. Potential impact from the planned activities is expected mainly from sounds generated by the vessel and during active airgun deployment. Due to the timing of the project and the distance from the surrounding communities, it is anticipated to have no effects on spring harvesting and little or no effects on the occasional summer harvest of beluga whale, subsistence seal hunts (ringed and spotted seals are primarily harvested in winter while bearded seals are hunted during July-September in the Beaufort Sea), or the fall bowhead hunt. The community of Nuiqsut may begin fall whaling activities in late August to early September from Cross Island (east of the survey area), and their efforts are typically focused on whales approaching Cross Island so that any harvest would occur before whales approached the survey area. As part of the planned mitigation measures, BPXA will complete those portions of the survey area outside of the barrier islands prior to 25 August 25. All seismic activities after this date will take place inshore of the barrier islands.

BPXA will participate in a Conflict Avoidance Agreement (CAA) to meet the requirements for a Plan of Cooperation of 50 CFR 216.104 Article 12 of the MMPA. The CAA will identify what measures have been or will be taken to minimize adverse impacts of the planned activities on subsistence harvesting (see Section 12 for more details). BPXA will meet with the AEWC and communities' Whaling Captains' Associations as part of the CAA development, to establish avoidance guidelines and other mitigation measures to be followed where the proposed activities may have an impact on subsistence.

9. ANTICIPATED IMPACT ON HABITAT

The anticipated impact of the activity upon the habitat of the marine mammal populations, and the likelihood of restoration of the affected habitat.

The proposed OBC seismic survey is not expected to result in any permanent impact on habitats used by marine mammals or to the food sources they use. The proposed survey will be of limited spatial and temporal extent and any effects are expected to be localized and short-term, and based on data from other OBC seismic surveys, those effects would be limited to behavioral changes in individual animals.

The primary potential impact associated with the proposed activity will be elevated sound levels and their associated direct effects on marine mammals rather than any specific impact to habitat (see discussion in Section 6 and 7). As described in Section 7, avoidance reactions by cetaceans and pinnipeds, if they occur, will be of short duration and limited to a relatively small area around the source vessel.

With respect to the prey species of pinnipeds and some cetaceans, the airguns used in the proposed surveys are relatively small compared to standard energy sources for large marine seismic surveys. The characteristics of the seismic pulses from airguns is such that the zone of potential injury to fish and invertebrates is limited to within a few meters of the seismic source (Buchanan et al. 2004). Adult fish near seismic operations are likely to avoid the immediate vicinity of the sound source and thus avoid injury. The only designated Essential Fish Habitat (EFH) species that may occur in the vicinity of the planned project activities are adult salmon, and their presence in the Beaufort Sea is limited, although possibly increasing (George et al. 2007, Bacon et al. 2009, Fechhelm et al. 2009, Moss et al. 2009, North Slope Borough 2009). While there is limited data on the impacts of airguns on the food sources of cetaceans and pinnipeds, there is no information to suggest that any potential impacts will affect marine mammal populations.

10.ANTICIPATED IMPACT OF LOSS OR MODIFICATION OF HABITAT ON MARINE MAMMALS

The anticipated impact of the loss or modification of the habitat on the marine mammal populations involved.

Due to the limited area and duration of the proposed seismic program, no loss or modification of habitat that would produce long-term impacts to marine mammals is expected to occur. See also Section 9 above on the anticipated impact on habitat essential to marine mammal species in the Beaufort Sea.

11. MITIGATION MEASURES

The availability and feasibility (economic and technological) of equipment, methods, and manner of conducting such activity or other means of effecting the least practicable adverse impact upon the affected species or stocks, their habitat, and on their availability for subsistence uses, paying particular attention to rookeries, mating grounds, and areas of similar significance.

The introduction of pulsed sounds generated by airguns is the main source of potential impacts on marine mammal species and is the focus of this request. As discussed in Section 7, exposure to airgun sounds in close proximity to the source may result in different effects to marine mammals, such as behavioral changes, TTS or PTS. Sounds generated by airguns can also elicit behavioral responses in marine mammals. The mitigation measures described in this section, implemented to reduce any potential impact on marine mammals, are based on a combination of requirements set forth by BOEM[1], BSEE[1], and NMFS. The mitigation measures can be divided into two main groups: 1) General mitigation measures that apply to all vessels and helicopters involved in the survey; and 2) Specific mitigation measures that apply to source vessels operating airguns. The primary purpose of these specific measures is to detect marine mammals within, or about to enter designated safety zones and to initiate immediate shutdown or power down of the airgun(s).

11.1. General mitigation measures

These general mitigation measures apply to all vessels that are part of the Simpson Lagoon seismic survey, including crew transfer vessels. The three source vessels will operate under an additional set of specific mitigation measures during airgun operations as summarized in Section 11.2.

- Vessel operators shall avoid concentrations or groups of whales and vessels shall not be operated in a way that separates members of a group. In proximity of feeding whales or aggregations, vessel speed shall be less than 10 knots.
- When within 900 feet (300 m) of whales vessel operators shall take every effort and precaution to avoid harassment of these animals by:
    - reducing speed and steering around (groups of) whales if circumstances allow, but never cutting off a whale's travel path;
    - avoiding multiple changes in direction and speed.

[1] On 1 October 2011, the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE), formerly the Minerals Management Service (MMS), was replaced by BOEM (Bureau of Ocean Energy Management) and BSEE (Bureau of Safety and Environmental Enforcement) as part of a major reorganization.

- Vessel operators shall check the waters immediately adjacent to a vessel to ensure that no marine mammals will be injured when the vessel's propellers (or screws) are engaged.
- To minimize collision risk with marine mammals, vessels shall not be operated at speeds that would make collisions with whales likely. When weather conditions require, such as when visibility drops, vessels shall adjust speed accordingly to avoid the likelihood of injury to whales.
- Sightings of dead marine mammals will be reported immediately to the BPXA HSSE Representative. The BPXA HSSE Representative is responsible for ensuring reporting of the sightings according to the guidelines provided by NMFS.
- In the event that any aircraft (such as helicopters) are used to support the planned survey, the mitigation measures below will apply:
  - Under no circumstances, other than an emergency, shall aircraft be operated at an altitude lower than 1,000 feet above sea level (ASL) when within 0.3 mile (0.5 km) of groups of whales.
  - Helicopters shall not hover or circle above or within 0.3 mile (0.5 km) of groups of whales.

11.2. Seismic Survey Mitigation Measures

Specific mitigation measures will be adopted during airgun operations according to NMFS guidelines, provided that doing so will not compromise operational safety requirements. The mitigation measures outlined below have been established by NMFS to prevent marine mammals from exposures to received levels of 190 dB dB re 1µPa (rms) for pinnipeds and 180 dB re 1µPa (rms) for cetaceans.

Marine mammal observers (MMOs) on board of the source vessels play a key role in monitoring the 190 and 180 dB safety zones and implementation of the mitigation measures. Their primary role is to monitor marine mammals near the seismic source vessel during all daylight airgun operations and during any nighttime start-up of the airguns. Pre-season distances to received sound levels of 190 and 180 dB, produced by the proposed airgun arrays, have been estimated using an acoustic model (Appendix A). MMOs will use these pre-season distances to monitor the safety zones until the radii have been verified during sound source verification measurements, after which the safety zone will be decreased or increased in keeping with field measurements (see Section 13). When marine mammals are observed within, or about to enter, designated safety zones, MMOs have the authority to call for immediate power down (or shutdown) of airgun operations as required by the situation. A summary of the procedures associated with each mitigation measure is provided below. The criteria are consistent with guidance by NMFS.

Ramp Up Procedure

Ramp up procedures of an airgun array involves a step-wise increase in the number of operating airguns until the required discharge volume is achieved. The purpose of a ramp up (sometimes also referred to as soft start) is to provide marine mammals in the vicinity of the activity the opportunity to leave the area and thus avoid any potential injury or impairment of their hearing abilities.

NMFS normally requires that, once ramp up commences, the rate of ramp up be no more than 6 dB per 5 min period. A common procedure is to double the number of operating airguns at 5-min intervals, starting with the smallest gun in the array. BPXA intends to double the number of airguns operating at 5 minute intervals during ramp up. For the 640 cu in airgun array of the Simpson Lagoon seismic survey this is estimated to take 20 minutes, and for the 320 cu in array 15 minutes. During ramp up, the safety zone for the full airgun array will be observed.

The ramp up procedures will be applied as follows:

1. A ramp up, following a cold start, can be applied if the safety zone has been free of marine mammals for a consecutive 30-minute period. The entire safety zone must have been visible during these 30 minutes. If the entire safety zone is not visible, then ramp up from a cold start cannot begin.
2. Ramp up procedures from a cold start will be delayed if a marine mammal is sighted within the safety zone during the 30-minute period prior to the ramp up. The delay will last until the marine mammal(s) has been observed to leave the safety zone or until the animal(s) is not sighted for at least 15 or 30 minutes. The 15 minutes applies to small toothed whales and pinnipeds, while a 30 minute observation period applies to baleen whales and large toothed whales.
3. A ramp up, following a shutdown, can be applied if the marine mammal(s) for which the shutdown occurred has been observed to leave the safety zone or until the animal(s) is not sighted for at least 15 minutes (small toothed whales and pinnipeds) or 30 minutes (baleen whales and large toothed whales). This assumes there was a continuous observation effort prior to the shutdown and the entire safety zone is visible.
4. If, for any reason, electrical power to the airgun array has been discontinued for a period of 10 minutes or more, ramp-up procedures need to be implemented. Only if the MMO watch has been suspended, a 30-minute clearance of the safety zone is required prior to commencing ramp-up. Discontinuation of airgun activity for less than 10 minutes does not require a ramp-up.
5. The seismic operator and MMOs will maintain records of the times when ramp-ups start and when the airgun arrays reach full power.

Power Down Procedures

A power down is the immediate reduction in the number of operating airguns such that the radii of the 190 dB and 180 dB (rms) zones are decreased to the extent that an observed marine mammal is not in the applicable safety zone of the full array. During a power down, one airgun (or some other number of airguns less than the full airgun array) continues firing. The continued operation of one airgun is 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.

1. The array will be immediately powered down whenever a marine mammal is sighted approaching close to or within the applicable safety zone of the full array, but is outside the applicable safety zone of the single mitigation airgun.
2. Likewise, if a mammal is already within the safety zone when first detected, the airguns will be powered down immediately.
3. If a marine mammal is sighted within or about to enter the applicable safety zone of the single mitigation airgun, it too will be shutdown.
4. Following a power down, ramp up to the full airgun array will not resume until the marine mammal has cleared the safety zone. The animal will be considered to have cleared the safety zone if it is visually observed to have left the safety zone of the full array, or has not been seen within the zone for 15 minutes (pinnipeds or small toothed whales) or 30 minutes (baleen whales or large toothed whales).

Shutdown Procedures

The operating airgun(s) will be shutdown completely if a marine mammal approaches or enters the 190 or 180 dB (rms) safety radius of the smallest airgun.

Airgun activity will not resume until the marine mammal has cleared the safety radius of the full array. The animal will be considered to have cleared the safety radius as described above under ramp up procedures.

Poor visibility conditions

BPXA plans to conduct 24-hour operations. MMOs will not be on duty during ongoing seismic operations during darkness, given the very limited effectiveness of visual observation at night (there will be no periods of darkness in the survey area until mid-August). The proposed provisions associated with operations at night or in periods of poor visibility include the following:

- If during foggy conditions, heavy snow or rain, or darkness (which may be encountered starting in late August), the full 180 dB safety zone is not visible, the airguns cannot commence a ramp-up procedure from a full shut-down.

- If one or more airguns have been operational before nightfall or before the onset of poor visibility conditions, they can remain operational throughout the night or poor visibility conditions. In this case ramp-up procedures can be initiated, even though the safety zone may not be visible, on the assumption that marine mammals will be alerted by the sounds from the single airgun and have moved away.

BPXA is aware that available techniques to effectively detect marine mammals during limited visibility conditions (darkness, fog, snow, and rain) are in need of development and has in recent years supported research and field trials intended to improve methods of detecting marine mammals under these conditions. BP intends to continue research and field trials to improve methods of detecting marine mammals during periods of low visibility.

12.PLAN OF COOPERATION

Where the proposed activity would take place in or near a traditional Arctic subsistence hunting area and/or may affect the availability of a species or stock of marine mammal for Arctic subsistence uses, the applicant must submit either a plan of cooperation or information that identifies what measures have been taken and/or will be taken to minimize any adverse effects on the availability of marine mammals for subsistence uses.

As in previous years, BPXA intends to participate in the Conflict Avoidance Agreement (CAA) with the Alaska Eskimo Whaling Commission (AEWC) and communities' Whaling Captains' Associations for the proposed 2012 Simpson Lagoon OBC seismic survey. BPXA will work with representatives of these communities and organizations to develop avoidance guidelines and mitigation measures to minimize potential adverse impacts on subsistence activities. Meetings currently planned to take place prior to the survey include:

December 12-13, 2011: Meeting with the AEWC and Whaling Captains' Associations during the AEWC Quarterly meeting in Anchorage

January 5, 2012: NMFS peer review meeting of IHA application in Seattle by independent expert panel.

February 16-17, 2012: CAA discussions with AEWC and Whaling Captains' Associations during the AEWC Annual Convention in Barrow.

March 5-9, 2012: As in previous years, BPXA plans to participate in the "open water stakeholder review meeting" to be convened by NMFS in Anchorage. Representatives of the AEWC, NSB, and native communities are expected to participate.

Subsequent meetings with whaling captains, other community representatives, the AEWC, NSB, and any other stakeholders will be held as necessary to negotiate the terms of the CAA and to coordinate the planned seismic survey operation with subsistence hunting activity.

The CAA will cover the phases of BPXA's seismic survey planned to occur from July through September. The purpose will be to identify measures that will be taken to minimize any adverse effects on the availability of marine mammals for subsistence uses and to ensure good communication between BPXA, native communities along the coast, and subsistence hunters at sea.

13. MONITORING AND REPORTING PLAN

The suggested means of accomplishing the necessary monitoring and reporting that will result in increased knowledge of the species, the level of taking or impacts on populations of marine mammals that are expected to be present while conducting activities and suggested means of minimizing burdens by coordinating such reporting requirements with other schemes already applicable to persons conducting such activity. Monitoring plans should include a description of the survey techniques that would be used to determine the movement and activity of marine mammals near the activity site(s) including migration and other habitat uses, such as feeding.

BPXA proposes to implement marine mammal and acoustic monitoring during the Simpson Lagoon OBC seismic survey activities, which will allow implementation of the proposed mitigation measures, will satisfy the anticipated monitoring requirements of the NMFS IHA and USFWS LOA, and will meet any monitoring requirements agreed to as part of the CAA. BPXA's proposed Monitoring Plan is described below. BPXA understands that this Monitoring Plan will be subject to review by NMFS and others, and that refinements will be required following discussions with NMFS and others.

The monitoring work described here has been planned as a self-contained project independent of any other related monitoring projects that may be occurring simultaneously in the same region. Provided that an acceptable methodology and business relationship can be worked out in advance, BPXA is prepared to work with others in its efforts to manage, understand, and fully communicate information about environmental impacts related to its activities.

13.1. Vessel-Based Marine Mammal Monitoring

There will be two vessel-based monitoring programs during the Simpson Lagoon OBC seismic survey. One program involves the presence of marine mammal observers (MMOs) on the seismic source vessels during the entire seismic survey period. The other vessel-based program involves two MMOs on a monitoring vessel outside the barrier islands after 25 August.

Visual Monitoring from Source Vessels

Two marine mammal observers will be present on each seismic source vessel. Of these two MMOs, one will be on watch at all times during daylight hours to monitor the 190 and 180 dB safety zones for the presence of marine mammals during airgun operations. During the fall bowhead whale migration season the 160 dB disturbance zone will also be monitored for the presence of groups of 12 or more baleen whales. The 120 dB disturbance zone for bowhead cow/calf pairs will be monitored from another vessel (see section "Visual Monitoring Outside the Barrier Islands"). The main objectives of the vessel-based marine mammal monitoring program from the source vessels are as follows:

1. To implement mitigation measures during seismic operations (e.g. course alteration, airgun power-down, shut-down and ramp-up);
2. To record all marine mammal data needed to estimate the number of marine mammals potentially affected, which must be reported to NMFS within 90 days after the survey;
3. To compare the distance and distribution of marine mammals relative to the source vessel at times with and without seismic activity;
4. To obtain data on the behavior and movement patterns of marine mammals observed and compare those at times with and without seismic activity.

The potential to successfully achieve objectives 3 and 4 is subject to the number of animals observed during the survey period.

Marine Mammal Observer Protocol

BPXA intends to work with experienced MMOs that have had previous experience working on seismic survey vessels, which will be especially important for the lead MMO on the source vessels. At least one Alaska Native resident, who is knowledgeable about Arctic marine mammals and the subsistence hunt, is expected to be included as one of the team members aboard the vessels. Before the start of the seismic survey the crew of the seismic source vessels will be briefed on the function of the MMOs, their monitoring protocol, and mitigation measures to be implemented. They will also be aware of the monitoring objectives of the dedicated monitoring vessel, and how their observations can affect the operations.

On all source vessels, at least one observer will monitor for marine mammals at any time during daylight hours (there will be no periods of total darkness until mid-August). MMOs will be on duty in shifts of a maximum of 4 hours at a time, although the exact shift schedule will be established by the lead MMO in consultation with the other MMOs.

The three source vessels will offer suitable platforms for marine mammal observations. Observations will be made from locations where MMOs have the best view around the vessel. During daytime, the MMO(s) will scan the area around the vessel systematically with reticle binoculars (e.g., 7×50 Fujinon) and with the naked eye. Laser range-finding binoculars (Leica LRF 1200 laser rangefinder or equivalent) will be available to assist with distance estimation, using other vessels in the area as targets. Laser range finding binoculars are generally not useful in measuring distances to animals directly.

Communication Procedures

When marine mammals in the water are detected within or about to enter the designated safety zones, the airgun(s) power-down or shut-down procedures will be implemented immediately. To assure prompt implementation of power-downs and shut-downs, multiple channels of communication between the MMOs and the airgun technicians will be established. During the power-down and shut-down, the MMO(s) will continue to maintain watch to determine when the animal(s) are outside the safety radius. Airgun operations can be resumed with a ramp-up procedure (depending on the extent of the power down) if the observers have visually confirmed that the animal(s) moved outside the safety zone, or if the animal(s) were not observed within the safety zone for 15 minutes (pinnipeds and small toothed whales) or for 30 minutes (for baleen whales and large toothed whales). Direct communication with the airgun operator will be maintained throughout these procedures.

Data Recording

All marine mammal observations and any airgun power-down, shut-down and ramp-up will be recorded in a standardized format. Data will be entered into a custom database using a notebook computer. The accuracy of the data entry will be verified by computerized validity data checks as the data are entered and by subsequent manual checking of the database after each day. These procedures will allow initial summaries of data to be prepared during and shortly after the field program, and will facilitate transfer of the data to statistical, graphical, or other programs for further processing and archiving.

Visual Monitoring Outside the Barrier Islands

The main purpose of the MMOs on the monitoring vessel that will operate outside the barrier islands is to monitor the 120 dB disturbance zone during daylight hours for the presence of four or more bowhead cow/calf pairs. The predicted distances to received levels of 120 dB are 6.4 km for the 640 cu in array and 5.7 km for the 320 cu in array. The distance to the 160 dB disturbance zone is small enough (1.8 km for the 640 cu in and 1.5 km for the 320 cu in array) to be covered by the MMOs on the source vessels. Of the two MMOs on the monitoring vessel, one will be on watch at all times during daylight hours to monitor the disturbance zones and to communicate any sightings of four bowhead cow/calf pairs to the MMOs on the source vessels. The shift schedule and observer protocol will be similar as that of the MMOs on the source vessels.

Channels of communication between the lead MMOs on the source vessels and the dedicated monitoring vessel will also be established. If four or more bowhead cow/calf pairs are observed within or entering the 120 dB disturbance zone the lead MMO on monitoring vessel will immediately contact the lead MMO on the source vessel, who will ensure prompt implementation of airgun power downs or shutdowns . The lead MMO of the monitoring vessel will continue monitoring the 120 dB zone and notify the MMO on the source vessel when the cow/calf pairs have left the safety zone or when they haven't been observed within the safety zone for 30 minutes. Under these conditions ramp-up can be initiated.

These vessel based surveys outside the barrier island will be conducted up to 3 days per week, weather depending. Anticipated start date is 25 August and these surveys will be continuing until the end of the data acquisition period. During this period data acquisition will take place only inside the barrier islands. The vessel will follow transect lines within the 120 dB zone that are designed in such a way that the area ensonified by 120 dB or more will be covered. The exact start and end point will depend on the area to be covered by the source vessels during that particular day.

13.2. Acoustic Monitoring

The acoustic monitoring program will have two objectives: (1) to verify the modeled distances to the safety and disturbance zones from the 640 cu in and 320 cu in airgun arrays and to provide corrected distances to the MMOs, if necessary; and (2) to measure vessel sounds (i.e., received levels referenced to 1 m from the sound source) of each representative vessel of the seismic fleet, to obtain information on the sounds produced by these vessels.

Verification and establishment of safety and disturbance zones

Acoustic measurements to calculate received sound levels as a function of distance from the airgun sound source will be conducted within 72 hours of initiation of the seismic survey. These measurements will be conducted according to a standard protocol for the 640 cu in array, the 320 cu in array and the 40 cu in gun, both inside and outside the barrier islands.

The results of these acoustic measurements will be used to re-define, if needed, the distances to received levels of 190, 180, 160 and 120 dB. The distances of the received levels as a function of the different sound sources (varying discharge volumes) will be used to guide power-down and ramp-up procedures. A preliminary report describing the methodology and results of the verification for at least the 190 dB and 180 dB (rms) safety zones will be submitted to NMFS within 14 days of completion of the measurements.

Measurements of Vessel Sounds

BPXA intends to measure vessel sounds of each representative vessel. The exact scope of the source level measurements (back-calculated as received levels at 1 m from the source) will follow a pre-defined protocol to eliminate the complex interplay of factors that underlie such measurements, such as bathymetry, vessel activity, location, season, etc. Where possible and practical the monitoring protocol will be developed in alignment with other existing vessel source level measurements.

13.3. Reporting

A report on the preliminary results of the sound source verification measurements, including the measured 190, 180, 160, and 120 dB (rms) radii of the airgun sources, will be submitted within 14 days after collection of those measurements at the start of the field season. This report will specify the distances of the safety zones that were adopted for the survey.

A report on BPXA's activities and on the relevant monitoring and mitigation results will be submitted to NMFS within 90 days after the end of the seismic survey. The report will describe the operations that were conducted, the measured sound levels, and the cetaceans and pinnipeds that were detected near the operations. The report will be submitted to NMFS, providing full documentation of methods, results, and interpretation pertaining to all acoustic and vessel-based marine mammal monitoring. The 90-day report will summarize the dates and locations of seismic operations, and all whale and seal sightings (dates, times, locations, activities, associated seismic survey activities, etc.). Marine mammal sightings will be reported at species level to the extent possible. Especially during unfavorable environmental conditions (e.g. low visibility, high sea states) and at larger distances, species level identification will not always be possible. The number and circumstances of ramp-up, power-down, shut-down, and other mitigation actions will also be reported. The 90-day report will include estimates of the amount and nature of potential impact to cetaceans and pinnipeds encountered during the survey.

14. COORDINATING RESEARCH TO REDUCE AND EVALUATE INCIDENTAL HARASSEMENT

Suggested means of learning of, encouraging, and coordinating research opportunities, plans, and activities relating to reducing such incidental taking and evaluating its effects.

Provided that an acceptable methodology and business relationship can be worked out in advance, BPXA will work with any number of external entities, including other energy companies, agencies, universities, and NGOs, in its efforts to manage, understand, and fully communicate information about environmental impacts related to the seismic activities.

BPXA remains committed to an improved understanding of cumulative effects. In the past, BP has been an active participant in the National Academy's cumulative effects study. In addition, BP has sponsored an expert working group through the University of California tasked with development of a method or methods for better understanding cumulative effects associated with underwater sound. Experts from the North Slope Borough, the National Marine Fisheries Service, the Marine Mammal Commission, and a number of other organizations have participated in this working group. The North Slope Borough has contributed funding and logistical support to the working group. As of late 2011, the working group has begun testing the method that was developed using 2008 data from the Beaufort Sea. As part of this test, BPXA has supported extensive acoustic and simulation modeling. BPXA hopes to see the results of the working group published in 2012 or 2013. A summary of the current status of the project is available from BPXA.

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APPENDIX A

Acoustic Modeling Report JASCO Applied Sciences

Acoustic Noise Modeling of BP's 2012 Seismic Program in Simpson Lagoon (Harrison Bay, AK)

Submitted to:
OASIS Environmental Inc.

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Contents

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Figures

1. Introduction

This acoustic modeling study has been performed to estimate underwater sound levels produced by airgun arrays for BP's proposed 2012 shallow water seismic survey in Simpson Lagoon (Harrison Bay, AK). Sound from this type of sources has the potential to affect nearby marine mammals. The Marine Mammal Protection Act (MMPA), as amended through 1997, prohibits the harassment of marine mammals and has defined two levels of harassment:

1. Level A harassment – has the potential to injure a marine mammal or marine mammal stock in the wild; and,
2. Level B harassment – 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 but which does not have the potential to injure a marine mammal or marine mammal stock in the wild.

The NMFS has set the following regulatory threshold limits for exposure of marine mammals to impulsive noise:

1. Level A: 190 and 180 dB re µPa rms for pinnipeds and cetaceans, respectively
2. Level B: 160 dB re µPa rms for pinnipeds and cetaceans

Incidental, unintentional level A and level B harassments need to be permitted under an Incidental Harassment Authorization (IHA). BP intends to apply for an IHA for their shallow water Simpson Lagoon seismic survey, for which the number of potential exposures to sounds needs to be estimated for species that might occur in the area. . The number of acoustic exposures for each species is calculated by multiplying the area ensonified above the threshold levels by the spatial density of that species.

The acoustic modeling work presented in this document provides estimates of the ensonified areas and maximum distances from the source to received sound level thresholds. These areas and maximum distances were estimated for BP's proposed 640 and 320 in^3 airgun arrays operating in two characteristic depth environments within BP's survey area: the shallow waters inside the barrier islands with water depths less than about 3 m, and the deeper waters outside the barrier islands ranging from about 5 to 15 m depth. Figure 1 shows the survey area and the source locations for the model scenarios.

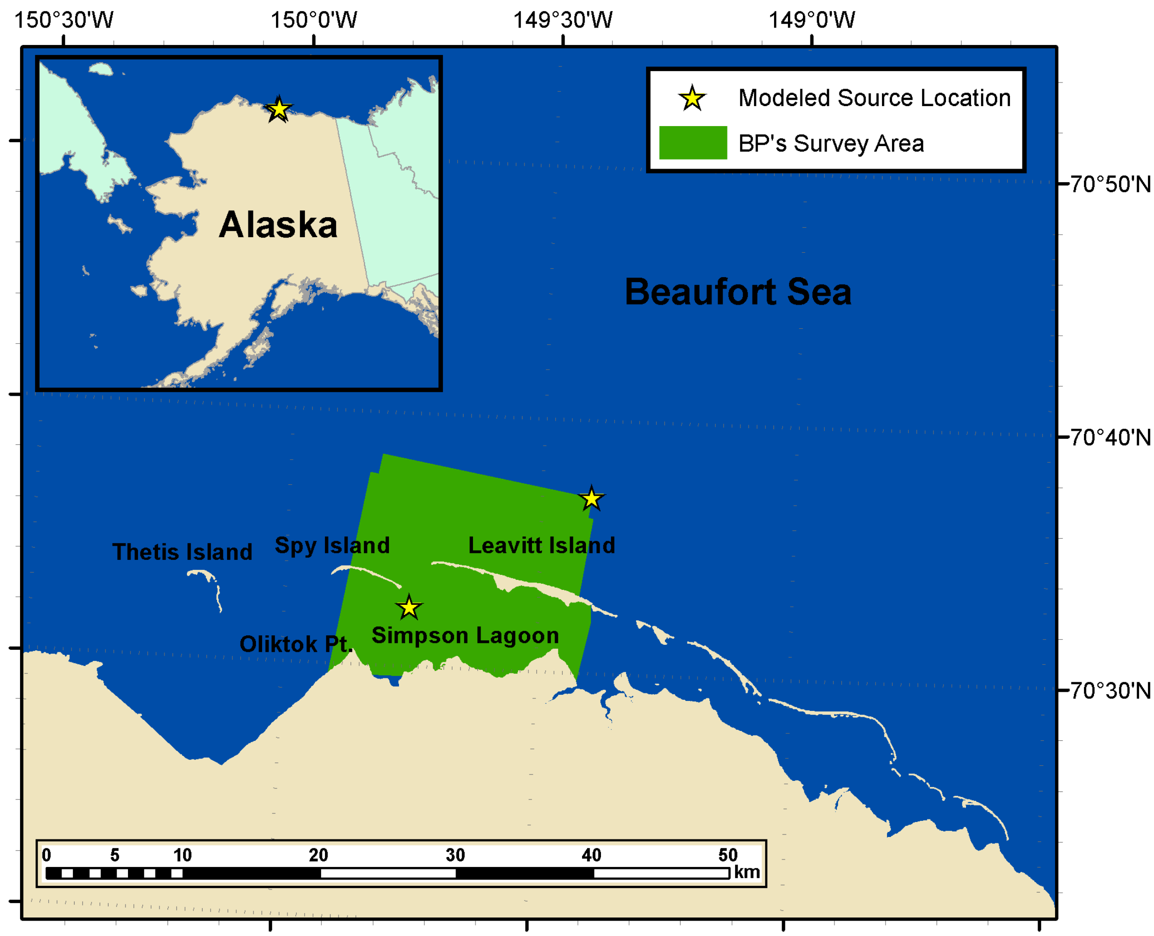

Figure 1: Map of BP's seismic survey area and the two source locations of the model scenarios.

2. Methods

2.1. Acoustic Metrics

Underwater sound amplitude is measured in decibels (dB) relative to a fixed reference pressure of 1 µPa. Several sound level metrics are commonly used to evaluate the loudness or effects of impulsive noise. The primary sound level metrics of importance here are 90% rms sound pressure level (rms SPL) and sound exposure level (SEL).

The 90% rms SPL (dB re 1 µPa, ANSI symbol L_{p90}) is the root-mean-square pressure level over the time window T_{90}:

$$L_p = 10\log_{10}\left(\frac{1}{T_{90}}\int_{T_{90}} p^2(t)dt\right) \quad \text{Equation 1}$$

where T_{90} is the time interval containing the central 90% (from 5% to 95% of the total) of the cumulative square pressure of the pulse. Because the window length, T_{90}, is used as a divisor, pulses that are more spread out in time have a lower rms SPL for the same total acoustic energy.

The SEL (dB re 1 µPa^2·s, ANSI symbol L_E) is the time integral of the square pressure over the fixed time window containing the entire pulse, *T:*

$$L_E = 10\log_{10}\left(\int_T p^2(t)dt\right) \qquad \text{Equation 2}$$

SEL has units of dB re 1 µPa·√s or equivalently dB re 1 µPa^2·s. It is a measure related to sound energy (or exposure) rather than sound pressure, although it is not measured in energy units.

Because the 90% rms SPL and SEL are both computed from the integral of square pressure, these metrics are related numerically by a simple expression, which depends only on the duration of the 90% integration time window T_{90}:

$$\mathrm{L_p} = \mathrm{L_E} - 10\log(T_{90}) - 0.458$$

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where the 0.458 dB factor accounts for the rms SPL containing 90% of the total energy from the per-pulse SEL (Malme *et al.*, 1986; Greene, 1997; McCauley *et al.*, 1998).

2.2. Source Level Model (AASM)

The directional source level pattern of each airgun array was predicted with JASCO's Airgun Array Source Model (AASM, MacGillivray, 2006). This model is based on the physics of the oscillation and radiation of airgun bubbles as described by Ziolkowski (1970). The model solves the set of parallel differential equations that govern bubble oscillations. AASM also accounts for non-linear pressure interactions between airguns, port throttling, bubble damping, and GI-gun behavior, as discussed by Dragoset (1984), Laws *et al.* (1990), and Landro (1992). AASM includes four empirical parameters that are tuned so that the model output matches observed airgun behavior; these parameters were optimized to best fit a large library of empirical airgun data using a "simulated annealing" global optimization algorithm. These airgun data were measurements of the signatures of Bolt 600/B guns ranging in volume from 5 to 185 in^3 (Racca and Scrimger, 1986).

AASM produces a set of "notional" signatures for each array element based on the array layout and the volume, tow depth and firing pressure of each airgun. These notional signatures are the pressure waveforms of the individual airguns at a standard reference distance of 1 m, and they account for the interactions with the other airguns in the array. The signatures are output for direct use by full-wave sound propagation models; they are also summed with the appropriate phase delays to obtain the far-field source signature of the entire array in different directions. This far-field array signature is filtered into 1/3-octave pass-bands to compute the source levels of the array as a function of frequency band and azimuthal angle in the horizontal plane.

The interactions between individual elements of the array create directionality in the overall acoustic emission levels. Generally, this directionality is prominent mainly at frequencies in the mid-range of several tens to several hundred Hz. At lower frequencies, whose acoustic wavelengths are much larger than the inter-airgun separation distances, directivity is weak, while at higher frequencies the pattern of lobes becomes too finely spaced to be resolved and the effective directivity essentially disappears.

2.3. Acoustic Source Levels

Two airgun arrays have been proposed for BP's seismic survey. The larger array has a total volume of 640 in^3 and consists of two strings towed at 2 m depth, which is remotely adjustable if needed. Each string has eight 40 in^3 airguns. The plan view layout of the 640 in^3 array is shown in Figure 2. The smaller array has a total volume of 320 in^3 and consists of one string of the 640 in^3 array towed at 1 m depth, also remotely adjustable if needed. All airguns will have a firing pressure of 2000 psi.

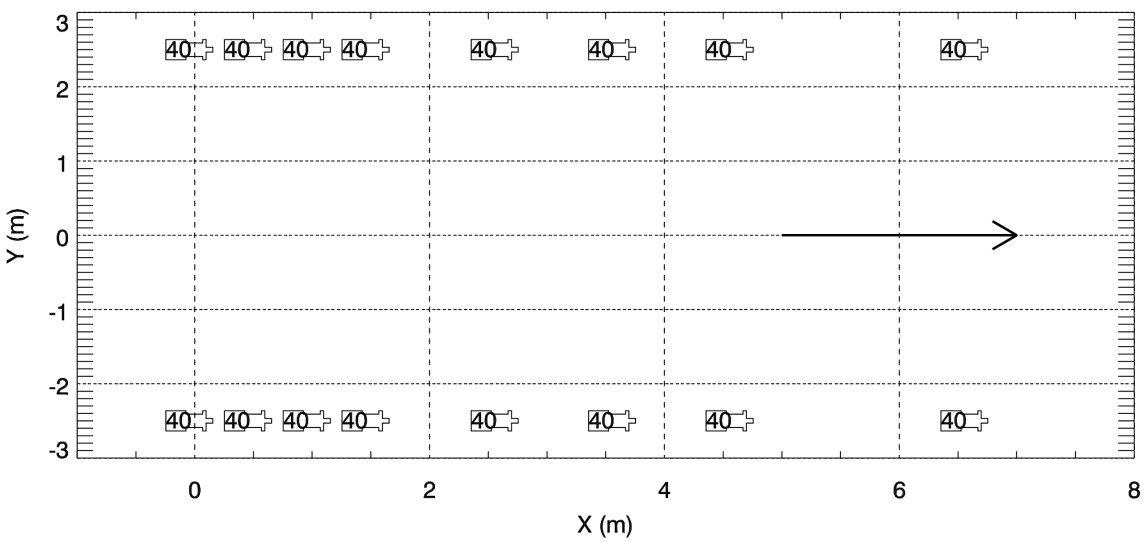

Figure 2: Plan view of the 640 in^3 airgun array. The array is towed at 2 m depth. Tow direction is to the right. The 320 in^3 array consists of one string of the 640 in^3 array towed at 1 m depth.

AASM was run to compute the sources signatures and 1/3-octave band levels in the horizontal directions. Broadside and endfire overpressure signatures and corresponding power spectrum levels for each source are shown in Figures 3 and 4. Horizontal 1/3-octave band directionality plots for each source are shown in Figures 5 and 6. The directionality for each array becomes significant at frequencies greater than 125 Hz. Consequently, the directionality of the resulting sound field not only depends on the environment, but on the tow direction. All the acoustic modelling results presented in this study are for the nominal tow depths indicated above; a larger operational depth than specified would likely result in an increase of the ensonified footprint.

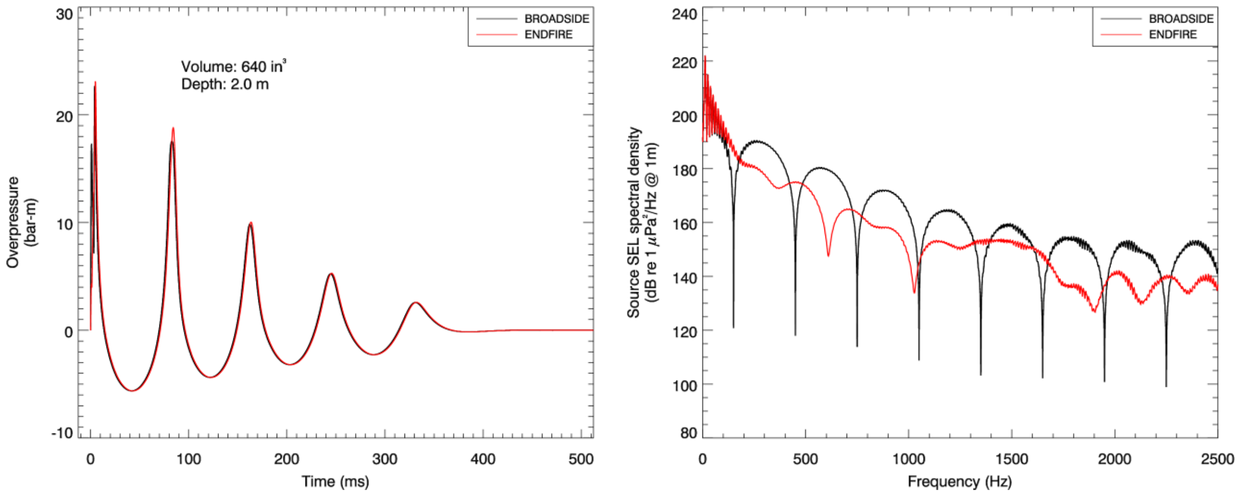

Figure 3: Predicted overpressure signatures (left) and power spectra (right) for the 640 in^3 airgun array in the broadside and endfire directions. Surface ghosts (effects of the pulse reflection at the water surface) are not included in these signatures.

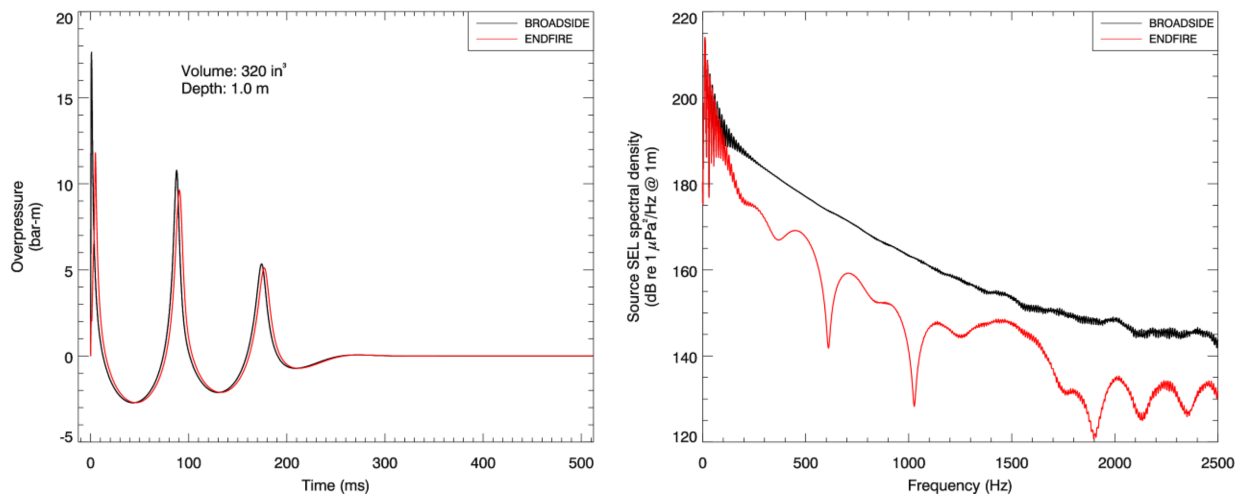

Figure 4: Predicted overpressure signatures (left) and power spectra (right) for the 320 in^3 airgun in the broadside and endfire directions. Surface ghosts (effects of the pulse reflection at the water surface) are not included in these signatures.

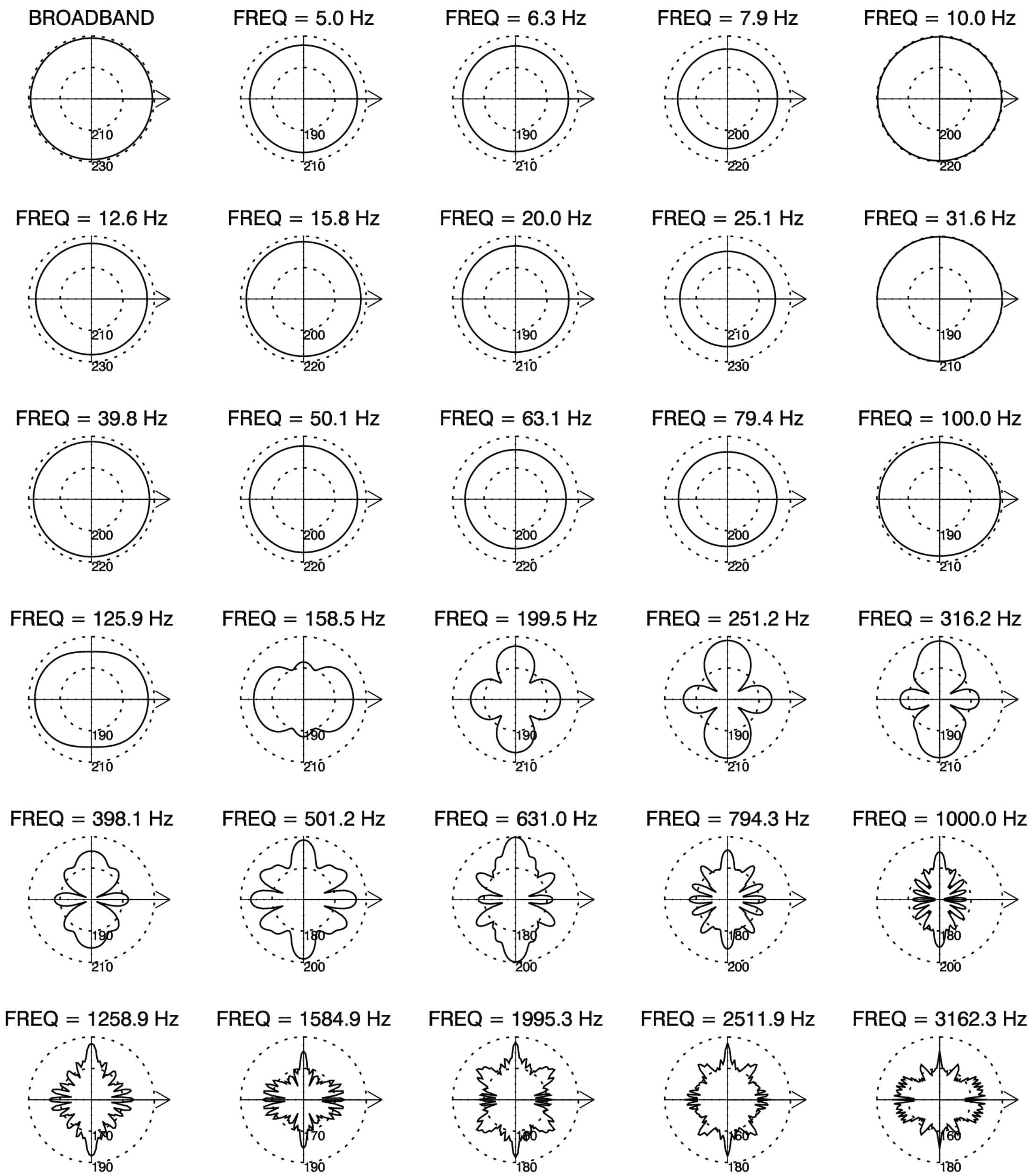

Figure 5: 640 in^3 array directionality of predicted source levels (dB re 1 μPa2·s at 1 m) in 1/3-octave bands. Third-octave band center frequencies are indicated above each plot.

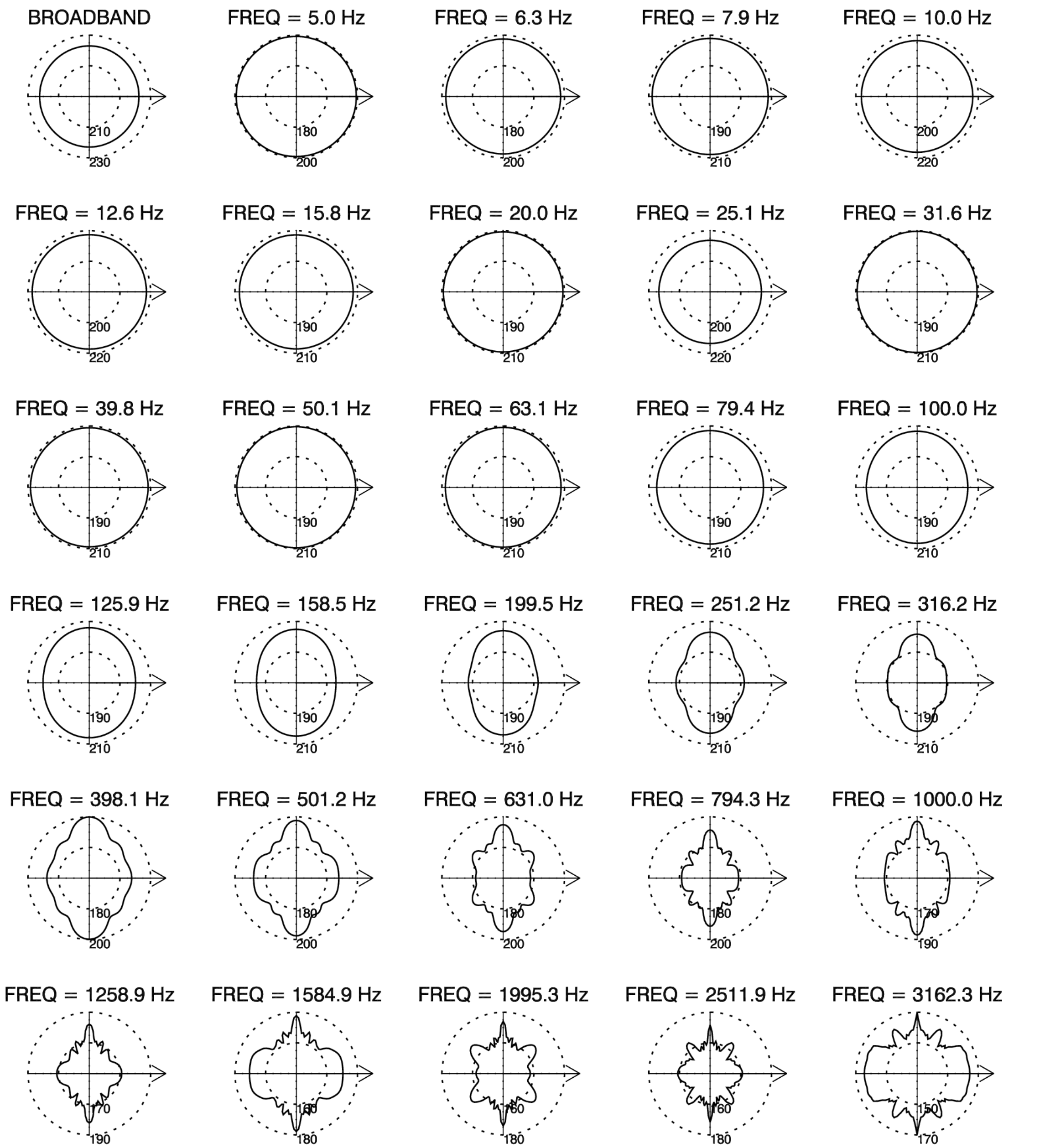

Figure 6: 320 in^3 array directionality of predicted source levels (dB re 1 $\mu Pa^2 \cdot s$ at 1 m) in 1/3-octave bands. Third-octave band center frequencies are indicated above each plot.

2.4. Sound Propagation Models

2.4.1. Marine Operations Noise Model

Acoustic footprints for seismic survey operations around Simpson Lagoon were modeled using JASCO Applied Sciences' proprietary Marine Operations Noise Model (MONM). MONM generates accurate estimates of the ensonfication of an underwater environment by specified sound sources using a sophisticated numerical acoustic propagation algorithm. This algorithm fully accounts for the spectral distribution of the source and the physics of sound propagation in the water column and underlying geological substrates.

The propagation modeling algorithm in MONM is based on the U.S. Naval Research Laboratory's split-step Padé parabolic equation (PE) range-dependent acoustic model RAM (Collins, 1993). RAM has been extensively benchmarked for accuracy and is widely employed in the underwater acoustics community. The split-step Padé solution is not only valid for very wide vertical propagation angles (> 60 degrees in most cases) but it also fully accounts for the geoacoustic properties of the sub-bottom and the discontinuity of these properties at the interface (Jensen *et al*., 2000, Ch. 6). Furthermore, JASCO has augmented RAM to account for losses due to the elastic (that is, shear-wave) properties of the sub-bottom using the complex density equivalent fluid approximation (Zhang and Tindle, 1995). The combination of the wide-angled PE and the accurate handling of the sub-bottom geoacoustic properties mean that JASCO's approach is completely applicable in shallow water environments.

MONM computes acoustic fields in 3-D by modeling transmission loss along evenly distributed radial traverses covering a 360 º swath from the source (so-called N×2-D modeling). The model makes use of several parameters of the propagation environment including bathymetry, sound speed profiles in water and geoacoustic profiles. Underwater sound propagation is strongly influenced by the geoacoustic properties of the seabed, which include the material density, seismic compressional-wave (P-wave) and shear-wave (S-wave) speeds, and the seismic wave-attenuation of seabed materials. MONM takes each of these into account when calculating propagation loss. Frequency dependence of sound propagation is treated by computing acoustic transmission loss in 1/3-octave bands up to several kHz. Sound pressure levels in each band are computed by applying frequency-dependent transmission losses to the corresponding 1/3-octave band source levels. Broadband results are then obtained by summing the levels across all bands. This approach has been validated against benchmarks and experimental data (Hannay and Racca, 2005) and has proven to be highly accurate for predicting noise levels in the vicinity of industrial operations associated with geophysical survey activities.

2.4.2. FWRAM Far-field Waveform Synthesis Model

For computing *rms* SPLs from seismic survey operations, far-field pressure waveforms were modeled along single-range depth transects using JASCO's FWRAM time-domain PE model. FWRAM computes synthetic pressure waveforms versus range and depth for range-varying marine acoustic environments using the parabolic equation approach to solving the acoustic wave equation. This software uses the same underlying algorithmic engine as MONM for computing acoustic propagation along 2-D range-depth transects, and the same environmental inputs (bathymetry, water sound speed profiles, and seabed geoacoustics). FWRAM computes pressure waveforms via Fourier synthesis of the modeled acoustic transfer function in closely spaced frequency bands. Like MONM, FWRAM accounts for range-varying properties of the acoustic environment and is therefore capable of computing *rms* SPL at long ranges. FWRAM, being a time-domain model, is well suited to computing time-averaged *rms* SPL values for impulsive sources.

2.5. Acoustic Environment

2.5.1. Bathymetry

JASCO's acoustic models utilize high-resolution grids of bathymetry data to define water depths inside a region of interest. Bathymetric data from a nautical chart and a bathymetry dataset were combined and gridded for this study. The nautical chart (NOAA, 1996) contained high-resolution depth soundings. The soundings were manually digitized for areas near the Alaskan coast and the barrier islands. Outside the barrier islands, the University of Alaska's Geographic Information Network of Alaska (GINA) dataset was used. GINA data consist of a combination of topology and bathymetry information from three publicly available gridded datasets, re-sampled and merged into uniformly registered latitude/longitude grids at 30 arc second resolution (Lindquist *et al.,* 2004). The latitude/longitude point bathymetry data were converted into UTM coordinates and interpolated onto a regular Cartesian grid at 20 and 50 meters resolution for the model scenarios inside and outside the barrier islands, respectively. Generally, the water depth inside the barrier islands is less than 3 m. Outside the barrier islands, the water depth is greater than 5 m and increases in the offshore direction.

2.5.2. Underwater sound speed

Temperature and salinity are the most important factors that determine the speed of sound in water. The sound speed profiles for the expected months of seismic surveying, July, August, and September, were obtained from the World Ocean Atlas 2009 dataset (Locarnini *et al*., 2010 and Antonov *et al*., 2010). A slight upward-refracting profile exists for July, whereas August and September have almost uniform sound speed profiles though different in mean value. The gradient of the sound speed profile has a greater influence on the refraction of sound than the exact sound speed, so sound propagation will be very similar in August and September. The profile from August was used in the modeling because it will apply during the majority of seismic survey operations. The sound speed profiles shown were computed directly from temperature and salinity values using standard formulae (Coppens, 1981).

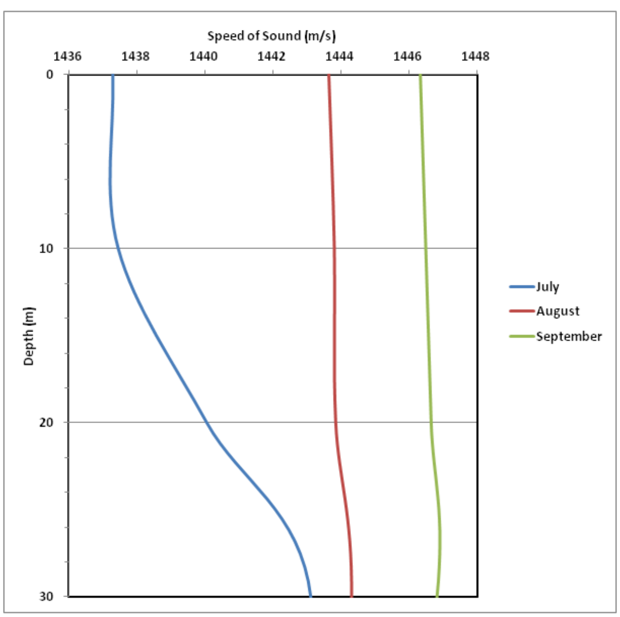

Figure 7: Sound speed profiles for July, August, and September at the seismic survey site obtained from the World Ocean Atlas 2009 dataset. The August profile was used in the propagation models.

2.5.3. Seabed geoacoustics

The five geoacoustic properties used by MONM and FWRAM for modeling sound propagation in sub-bottom sediments are as follows:

1. Relative density: The density of the bottom materials relative to the density of water.
2. Compressional-wave sound speed: The phase speed of longitudinal body waves (P-waves) in the bottom materials (units of m/s).
3. Compressional attenation: The rate of attenuation (units of dB per wavelength) of longitudinal body waves in the bottom materials.
4. Shear-wave sound speed: The phase speed of transverse body waves (S-waves) in the bottom materials (units of m/s).
5. Shear attenuation: The rate of attenuation (units of dB per wavelength) of transverse body waves in the bottom materials.

Profiles of density, compressional-wave speed, and compressional attenuation may be defined to arbitrary depths in the sub-bottom. The complex-density fluid approximation used by MONM does account for bottom loss due to shear-wave conversion at the seabed interface. In this approximation, shear-wave properties of the sediments are only modeled at the water-seabed interface. Shear-wave properties of the deeper layers, which do not significantly influence sound propagation in the water column, are not considered by the complex-density approximation.

The geoacoustic profile, describing the elasto-acoustic properties of the seabed sediments, was initially based on a generic three-layer model of increasing compressional speed with depth. To obtain a better estimate of the geoacoustic parameters in BP's survey area, FWRAM was used to ground-truth the geoacoustic profile. Two FWRAM runs were conducted for the 880 in^3 airgun array used in Eni/PGS's seismic survey operating inside and outside of Spy and Leavitt Islands. The geoacoustic parameters were then adjusted so that the modeled levels matched the Hauser *et al*. 2008 measurements. The geoacoustic parameters describing the resulting ground-truthed profile are listed in Table 1.

Table 1: Ground-truthed seabed geoacoustic profile at BP's seismic survey area.

Depth (mbsf)	Soil Description	Relative Density (water=1)	Compressional Sound Speed (m/s)	Compressional Attenuation (dB/λ)	Shear Sound Speed (m/s)	Shear Attenuation (dB/λ)
0	Sand and silty sand	1.6	1500	0.05		
20	Clay, silt, sand, gravel	2.0	1700	0.5	250	4.0
80	Coarse to gravely sand	2.2	2050	0.5		

2.6. SEL Modeling

MONM was used to directly compute the SEL produced by the 640 and 320 in^3 arrays near BP's survey area. Acoustic fields were computed on a three-dimensional spatial grid, resolved into 1/3-octave frequency bands. For subsequent presentation and interpretation, sound levels from

MONM were rendered as two-dimensional contour maps that showed the acoustic footprint maximized over the depth dimension.

The modeling procedure for the SEL calculation was as follows:

1. MONM was used to compute three-dimensional fields (in range, azimuth and depth) of transmission loss for each airgun array source location in 29 1/3-octave frequency bands centered from 5 to 3150 Hz.
2. SEL fields, in the same 1/3-octave bands, were computed by combining directional airgun array source levels (Section 2.3) with transmission loss.
3. The 1/3-octave band SEL fields for each array were resampled onto a 50 m cartesian grid (easting, northing) at every depth. A 500 m radial-smoothing kernel was applied to the SEL fields at ranges greater than 1 km prior to gridding.
4. The 1/3-octave band SEL grids were summed over frequency and maximized over depth to generate a two-dimensional grid of broadband received levels.
5. A contouring algorithm was used to extract SEL contours from the received level data.
6. SEL contours were converted to GIS layers and rendered on thematic maps.

2.7. rms SPL Modeling

MONM does not directly model *rms* SPL. SEL and *rms* SPL for impulses, however, are related by a simple formula that depends only on the 90% energy duration of the impulses (Equation 3). Knowing the length of an impulse allows therefore the computation of *rms* SPL from SEL. For the current study, FWRAM was used to estimate the 90% energy length (T_{90}) for airgun sounds in Simpson Lagoon by modeling synthetic pressure waveforms along a limited number of transects. Range-dependent impulse-response functions were modeled at frequencies from 10 Hz to 2048 Hz in 1 Hz steps and convolved with the appropriate far-field source signatures of the airgun arrays (ref. Figures 3 and 4) to generate synthetic pressure waveforms along each transect. These waveforms were then analyzed to determine the 90% energy length as a function of range from the pile. Four different transects were modeled using FWRAM: two transects extended 20 km from the 620 in^3 airgun array operating outside the barrier islands and two transects extended over 10 km from the 320 in^3 airgun array operating inside the barrier islands. The two transects for the 640 in^3 array extended in the forward-endfire and broadside directions; those for the 320 in^3 array extended through the deepest channel between Spy and Leavitt Islands and parallel to the inshore edge of the barrier islands.

The FWRAM pulse length predictions were used to derive range-dependent conversion functions between SEL and *rms* SPL for airgun arrays operating inside and outside the barrier islands. A smoothed function representing the mean difference between *rms* SPL and SEL was fit to the FWRAM model predictions for the two modeling areas (Figure 8). The averaging pulse length T_{90} was constrained on precautionary grounds not to exceed 450 ms (corresponding to a difference of 3 dB between *rms* SPL and SEL) so that the *rms* SPL could not be underestimated by excessively long averaging times. Depending on the modeled array location, the appropriate conversion factor was applied to the SEL modeling grids from MONM to compute rms SPLs. The conversion factor for the array operating outside the barrier islands is constant with range (+9 dB); the conversion factor for the array operating inside the barrier islands is range-dependent (between +15 and +3 dB). As with the SEL scenarios, *rms* SPL values were maximized over depth and rendered as two-dimensional contours on thematic maps.

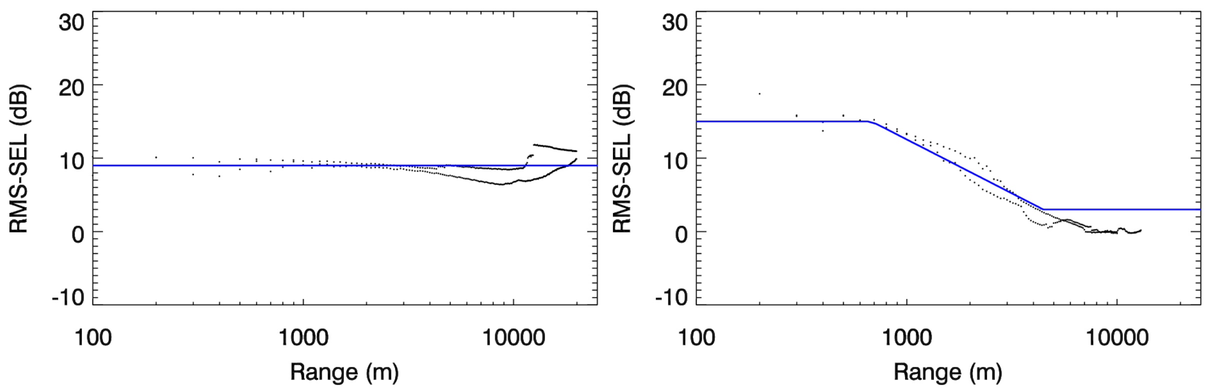

Figure 8: Conversion between SEL and *rms* SPL for airgun arrays operating outside (left) and inside (right) the barrier islands, as derived from four full-waveform modeling transects. Black dots are the FWRAM model results and the blue lines are the empirical fits thereof. The range-dependent conversion factor inside the barrier islands was limited to 3 dB (corresponding to 450 ms pulse length).

Previous measurements of two identical 880 in^3 airgun arrays operating inside and outside Spy and Leavitt Islands showed a spread in sound levels with range data (Hauser *et al*., 2008). To calculate ranges to SPL thresholds, Hauser *et al*. shifted the empirical SPL versus range curve fits by up to +6.1 and +10.6 dB to exceed 90% of the measured data outside and inside of the barrier islands, respectively. For this study, +3 and +5 dB safety factors have been added to the rms SPL results outside and inside the barrier islands, respectively, for the calculation of threshold radii and ensonified area. The safety factor is meant to account for uncertainty and spatial variability of the geoacoustics and sound speed profiles and the temporal variability of airgun array performance. The rms SPL contour maps do not include a safety factor.

3. Model Scenarios and Results

3.1. Overview of Model Scenarios

Three model scenarios were chosen to estimate the underwater acoustic footprints for seismic surveying outside and inside the barrier islands. The 640 in^3 array will be used outside and possibly inside the barrier islands, whereas the 320 in^3 array will only be used in the shallow waters inside the barrier islands. Sound is expected to propagate further in deeper water, so to estimate the maximum ensonification area, the source locations were chosen within BP's survey area in the deeper waters inside and outside the barrier islands (ref. Figure 1).

The first scenario consisted of the 640 in^3 array operating outside the barrier islands. The source location was the northeast corner of BP's survey area. At 15 m deep, it is the deepest location within the survey area. The UTM (zone 6) coordinates of this location are 410963E, 7836428N. The array was positioned parallel to planned survey lines with a bearing of 9.4°.

The second and third scenario sources were of the 640 in^3 and 320 in^3 arrays, respectively, operating at a location inside the barrier islands. The source location was selected to be aligned with the gap between Spy and Leavitt Islands, allowing sound to travel into deeper offshore waters past the barrier islands. The water depth at this location was 2.4 m. The UTM (zone 6) coordinates of this location are 397584E, 7828422N. The arrays were positioned parallel to planned survey lines with a bearing of 9.4°.

3.2. 640 in^3 Array Outside Barrier Islands

Figures 9 and 10 are contour maps of SEL and rms SPL for the 640 in^3 airgun array operating outside the barrier islands. Levels in the rms SPL contour map do not include a safety factor. To be precautionary, the maximum radii to sound level thresholds, and the area ensonified above them, were computed from rms SPL contours that included a +3 dB safety factor (see Section 2.7); those data are listed in Table 2. The maximum radii do not correspond geometrically to the ensonified areas because the sound level contours are not circular.

For this scenario, the rms pulse duration predicted using FWRAM was constant with range at around 100 ms, corresponding to rms SPL exceeding SEL by about 9 dB (Figure 8, left). The predicted pulse duration is likely too short at far ranges, as previous measurements of two identical 880 in^3 airgun arrays operating near the modeling location showed rms pulse duration to be around 600 ms at 20 km range (Hauser *et al.*, 2008). Out of plane scattering, which is not accounted for in FWRAM, increases pulse duration and is likely the cause for the pulse duration difference at far ranges. To better estimate the radius and ensonified area for the 120 dB threshold, the difference between rms SPL and SEL was set to 2 dB, *i.e.* the average difference at 20 km (farthest measurement range) for the 880 in^3 array measurements (Hauser *et al.*, 2008).

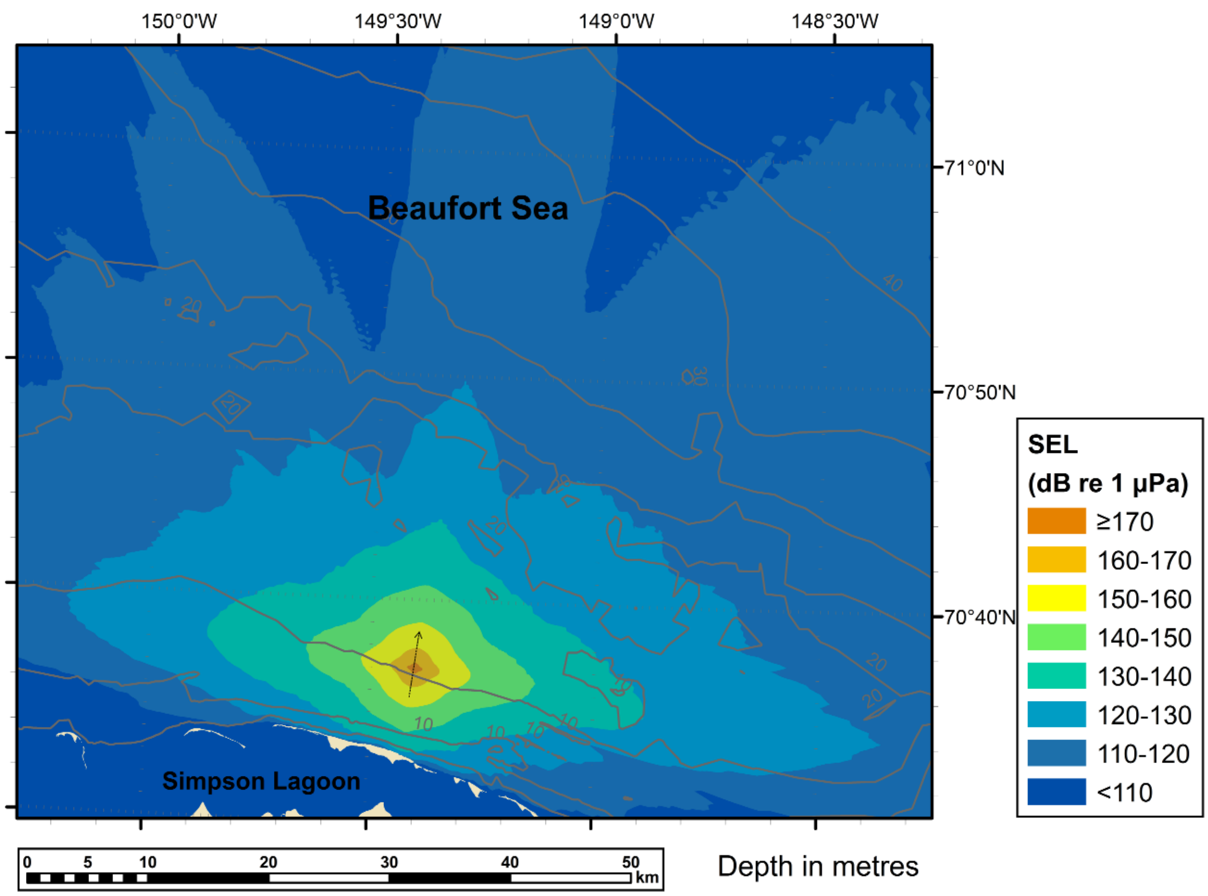

Figure 9: SEL contour map for the 640 in^3 array operating outside the barrier islands. The arrow indicates the tow direction of the array.

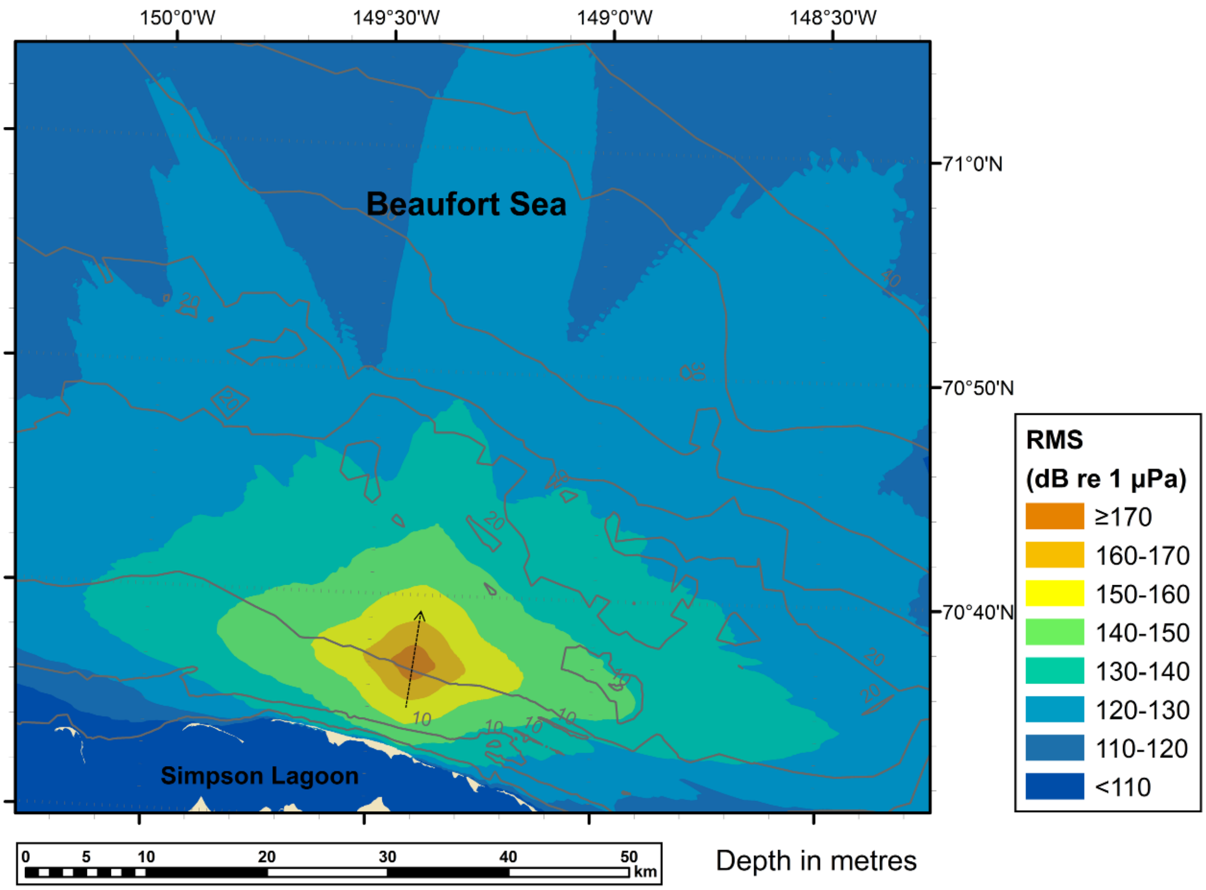

Figure 10: rms SPL contour map for the 640 in^3 array operating outside the barrier islands. SPL was estimated by adding 9 dB to SELs (Figure 8, left). SPL does not include a safety factor. The arrow indicates the tow direction of the array.

Table 2: Maximum radii to, and area ensonified above rms SPL thresholds for the 640 in^3 array operating outside the barrier islands. Radii and area are calculated from rms SPL results that include a 3 dB safety factor.

SPL_{rms90} Threshold (dB re 1 µPa)	Max Radius (km)	Ensonified Area (km^2)
190	0.12	0.033
180	0.95	1.3
170	2.5	12
160	5.5	53
120	44*	2100*

*Computed based on SPL-SEL conversion factor of 2 dB instead of 9 dB. See text above for a discussion.

3.3. 640 in^3 Array Inside Barrier Islands

Figures 11 and 12 are contour maps of SEL and rms SPL for the 640 in^3 airgun array operating inside the barrier islands. Levels in the rms SPL contour map do not include a safety factor. To be precautionary, the maximum radii to sound level thresholds, and the area ensonified above them, were computed from rms SPL contours that included a 5 dB safety factor (see Section 2.7); those data are listed in Table 3. The maximum radii do not correspond geometrically to the ensonified areas because the sound level contours are not circular.

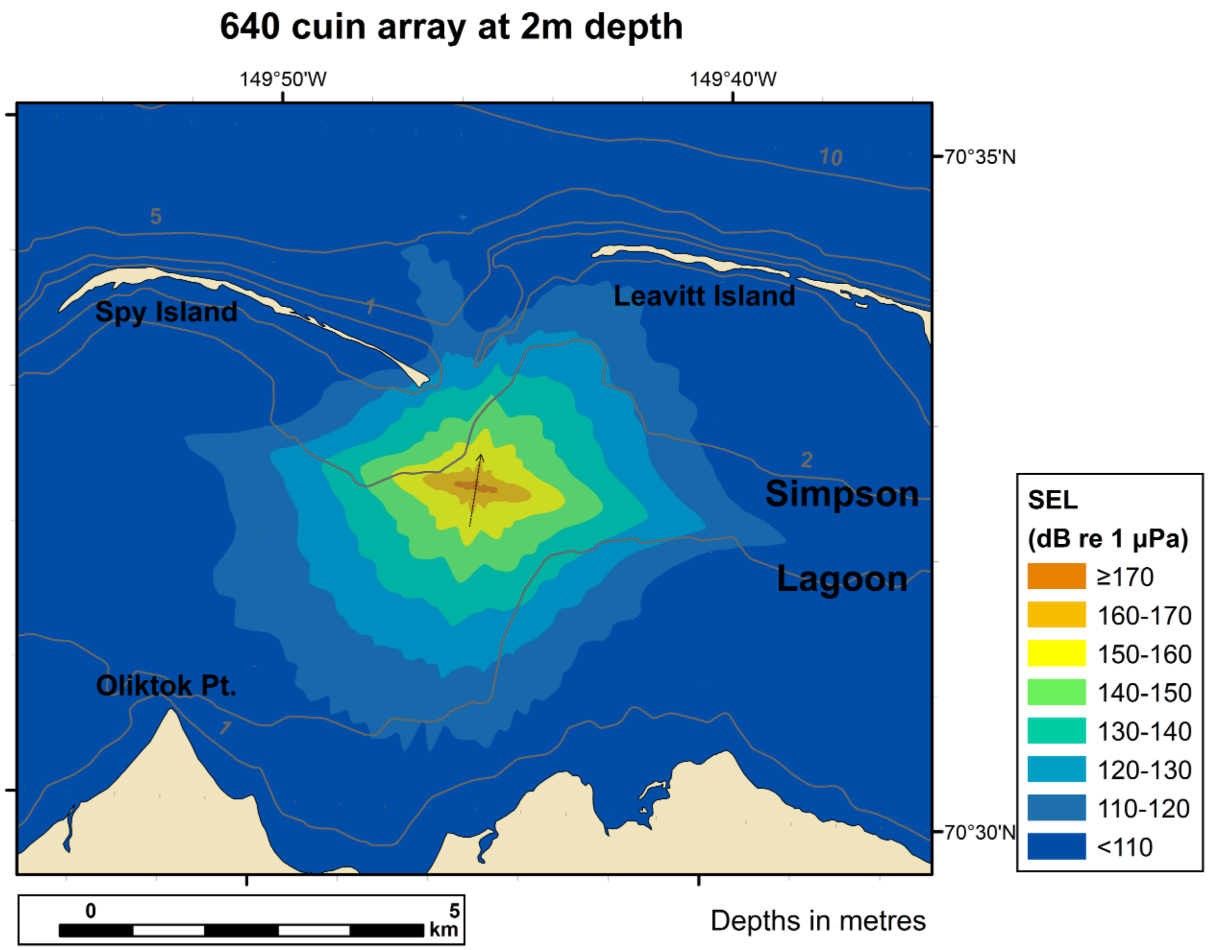

Figure 11: SEL contour map for the 640 in^3 array operating inside the barrier islands. The arrow indicates the tow direction of the array.

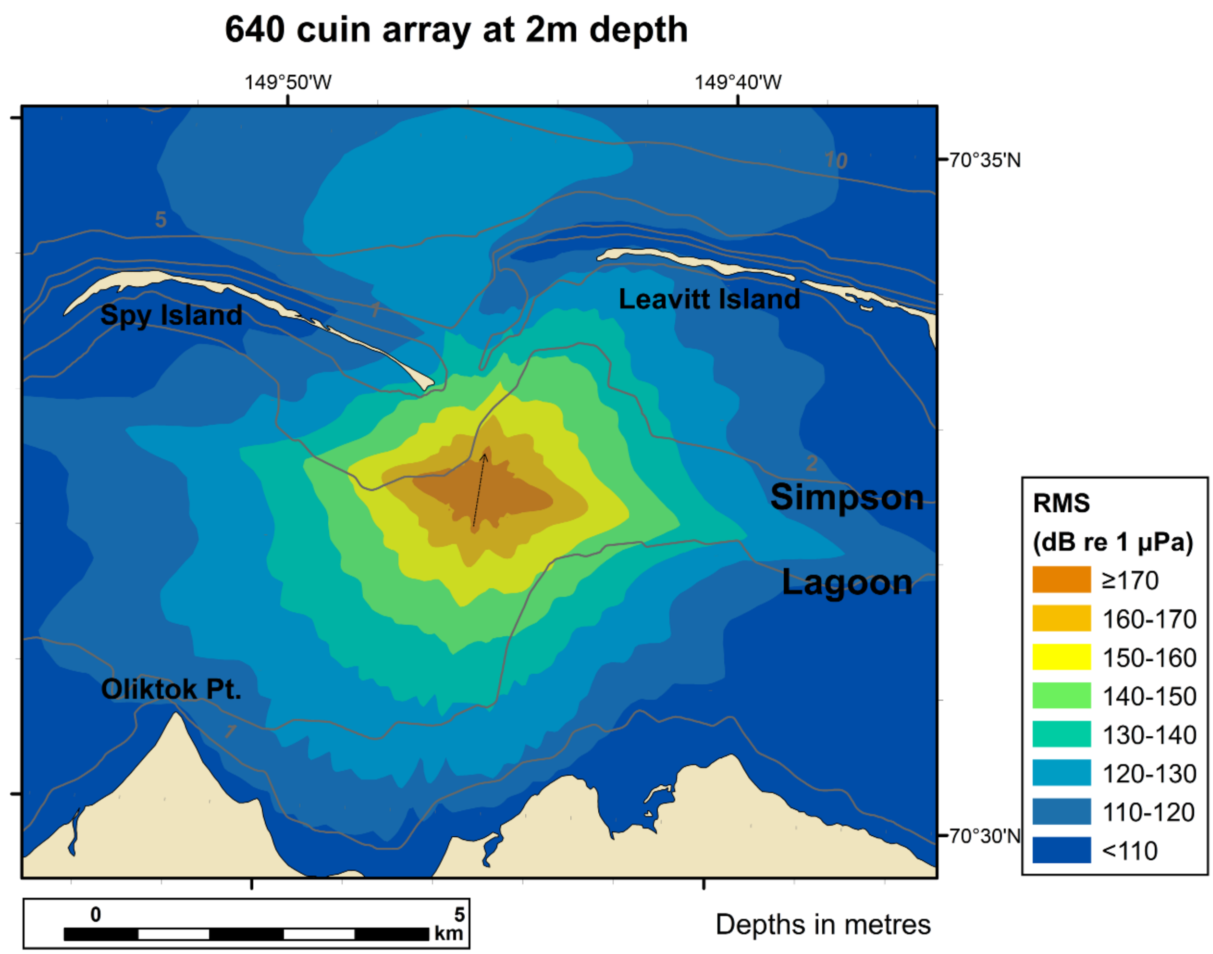

Figure 12: rms SPL contour map for the 640 in^3 array operating inside the barrier islands. SPL was estimated by adding a range-dependent correction factor to SEL results (Figure 8, right). SPL does not include a safety factor. The arrow indicates the tow direction of the array.

Table 3: Maximum radii to, and area endsonified above rms SPL thresholds for the 640 in^3 array operating inside the barrier islands. Radii and area are calculated from rms SPL results that include a 5 dB safety factor.

SPL_{rms90} Threshold (dB re 1 µPa)	Max Radius (km)	Ensonified Area (km^2)
190	0.31	0.055
180	0.75	0.45
170	1.2	1.1
160	1.8	4.8
120	6.4	69

3.4. 320 in^3 Array Inside Barrier Islands

Figures 13 and 14 are contour maps of SEL and rms SPL for the 320 in^3 airgun array operating inside the barrier islands. Levels in the rms SPL contour map do not include a safety factor. To be precautionary, the maximum radii to sound level thresholds, and the area ensonified above them, were computed from rms SPL contours that included a 5 dB safety factor (see Section 2.7);

those data are listed in Table 4. The maximum radii do not correspond geometrically to the ensonified areas because the sound level contours are not circular.

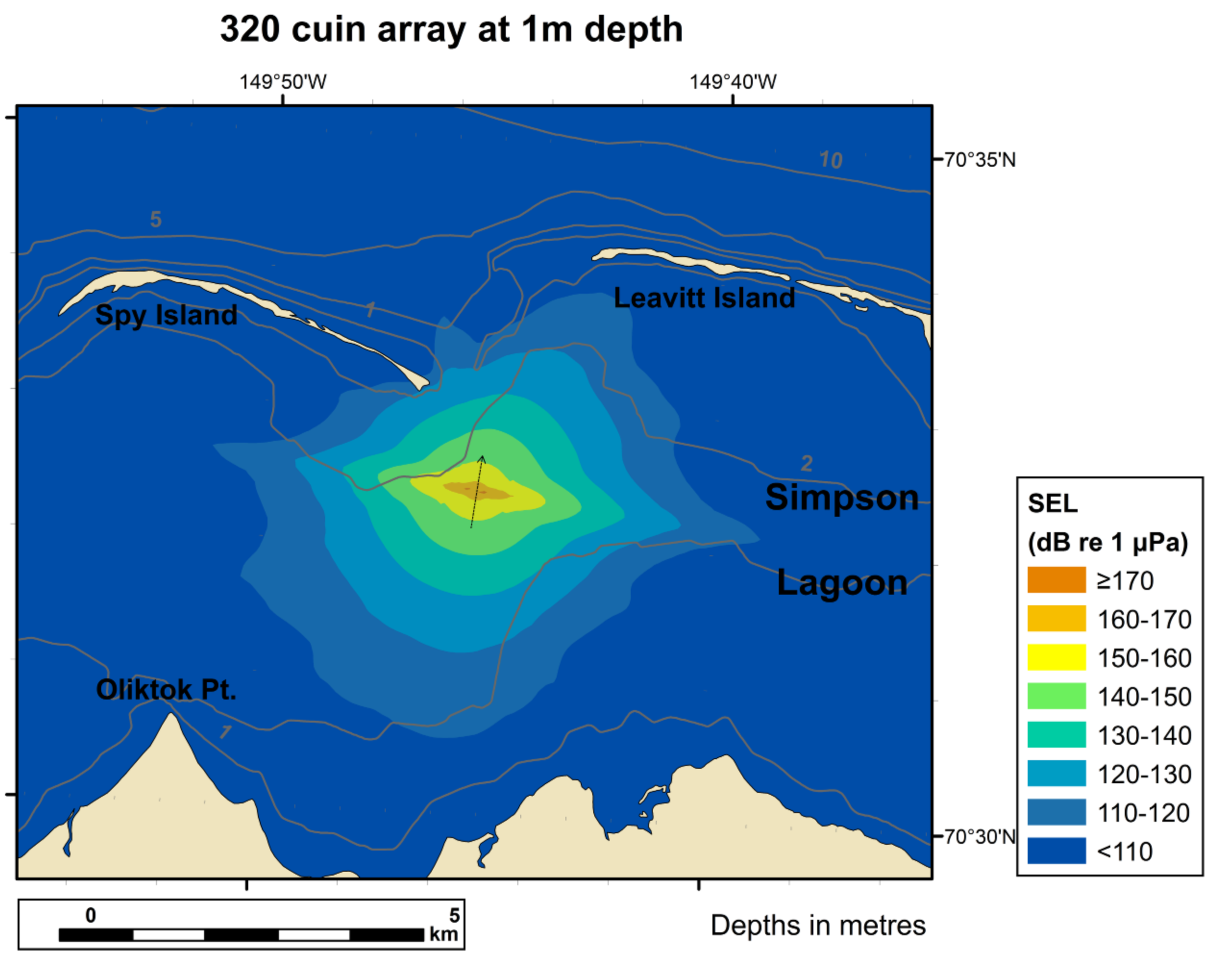

Figure 13: SEL contour map for the 320 in^3 array operating inside the barrier islands. The arrow indicates the tow direction of the array.

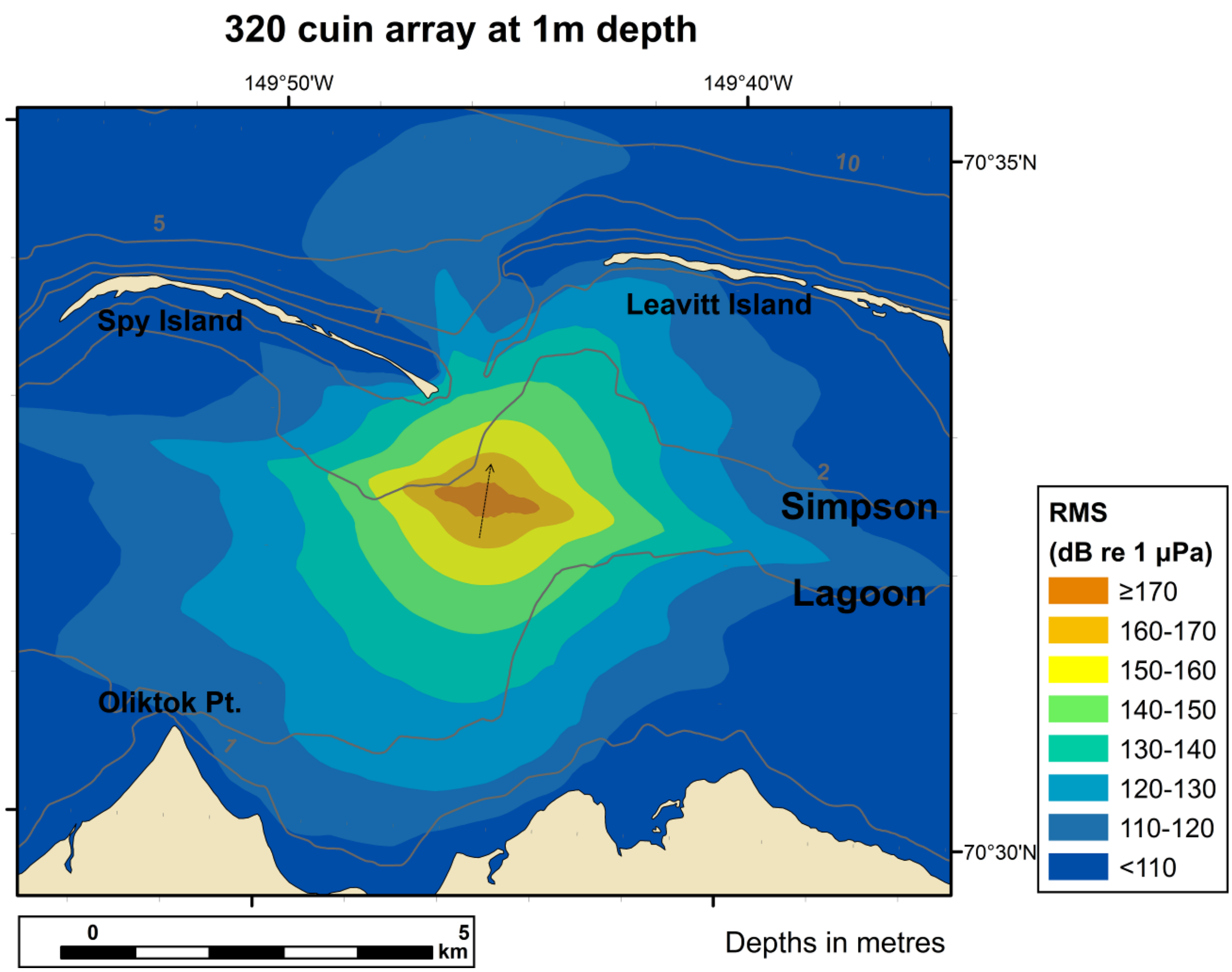

Figure 14: rms SPL contour map for the 320 in^3 array operating inside the barrier islands. SPL was estimated by adding a range-dependent correction factor to SEL results (ref. Figure 8, right). SPL does not include a safety factor. The arrow indicates the tow direction of the array.

Table 4: Maximum radii to, and area ensonified above rms SPL thresholds for the 320 in^3 array operating inside the barrier islands. Radii and area are calculated from rms SPL results that include a 5 dB safety factor.

SPL_{rms90} Threshold (dB re 1 µPa)	Max Radius (km)	Ensonified Area (km^2)
190	0.16	0.011
180	0.48	0.14
170	0.93	0.82
160	1.5	2.9
120	5.7	46

4. Discussion

Underwater sound level measurements were conducted for Eni/PGS's 2008 seismic survey where two identical 880 in^3 airgun arrays operated outside and inside of Spy and Leavitt Islands in water depths around 10 and 3 m, respectively (Hauser *et al*., 2008). Though the 880 in^3 airgun array had a larger volume and different far-field source signature than the proposed 640 and 320 in^3 arrays, it was considered informative to include a comparison of the 2008 measured radii and the ones modeled in this study for survey locations within the same area. Tables 5 and 6 list the maximum threshold radii from the two 880 in^3 arrays measured in 2008 and the modeled radii from the sites closest to the measurements outside and inside of the barrier islands respectively.

Though the 640 in^3 array has a smaller volume than Eni/PGS's 880 in^3 array used in 2008, the modeled threshold radii outside the barrier islands are larger for all threshold levels below 190 dB. This is likely because the water depth at the modeled source location is greater than that of the measured location (15 m versus 10 m depth). The 15 m water depth environment allows airgun sounds to propagate further.

The predicted 190 dB threshold radii for the 640 in^3 array is smaller for the source location outside the barrier islands than for the one inside. This could be due to the shallow water inside the barrier island trapping and concentrating the sound in the water column at short ranges; the deeper water outside the islands, by contrast, allows a more attenuating spherical spreading regime at the same distances. At farther ranges, on the other hand, shallow water supports sound propagation less well because of increased energy loss from sub-bottom interactions, resulting in smaller radii than in deep water. This predicted effect was in fact measured in Hauser *et al*., 2008.

Modeled radii at the site inside the barrier islands exceed the 2008 measured radii for threshold levels 190-160 dB of the 640 in^3 array and for 180-170 dB of the 320 in^3 array. This excess is likely due to the large range-dependent conversion offset used to estimate rms SPL from SEL. This conversion was based on results from the model FWRAM, which as discussed in Section 3.2 does not account for the increase in pulse duration due to out of plane scattering. The difference between rms SPL and SEL could therefore be smaller in reality.

Table 5: Sound level threshold radii from the Eni/PGS 880 in^3 array measurements and the modeled maximum radii for the 640 in^3 array operating outside of the barrier islands.

SPL_{rms90} Threshold (dB re 1 μPa)	SPL_{rms90} Threshold Radii (km)		
	880 in^3 Endfire Measurements	880 in^3 Broadside Measurements	640 in^3 Model Results
190	0.18	0.18	0.12
180	0.64	0.55	0.95
170	1.3	1.6	2.5
160	2.2	3.8	5.5
120	16	22	44*

*Computed based on SPL-SEL conversion factor of 2 dB. See text in section 3.2 for a discussion.

Table 6: Sound level threshold radii from the Eni/PGS 880 in^3 array measurements and the modeled maximum radii for the 640 and 320 in^3 arrays operating inside of the barrier islands.

SPL_{rms90} Threshold (dB re 1 μPa)	SPL_{rms90} Threshold Radii (km)			
	880 in^3 Endfire Measurements	880 in^3 Broadside Measurements	640 in^3 Model Results	320 in^3 Model Results
190	0.27	0.27	0.31	0.16
180	0.42	0.43	0.75	0.48
170	0.64	0.87	1.2	0.93
160	0.97	1.6	1.8	1.5
120	5.3	7.9	6.4	5.7

5. Summary and Conclusions

This modeling study was conducted to estimate the underwater acoustic footprints for the 640 and 320 in^3 airgun arrays to be used for BP's 2012 seismic survey in Simpson Lagoon (Harrison Bay, AK). Three scenarios were modeled to estimate the maximum radii to established sound level thresholds, and area ensonified above such thresholds, for the 640 in^3 array operating both offshore and inshore of the barrier islands and for the 320 in^3 array operating inshore of them. The estimates were compared to sound level versus range measurements for underwater airgun arrays previously performed in Simpson Lagoon (Hauser *et al*., 2008). On the basis of these measurements, and to account for environmental uncertainty and variability, safety margins were included in the radii and area calculations. The estimated maximum radii and ensonification areas listed earlier in the report are replicated below in tables 7 and 8.

Table 7: Maximum radii to rms SPL thresholds for the three modeled scenarios. Radii are calculated from rms SPL results that include a safety factor.

SPL_{rms90} Threshold (dB re 1 μPa)	SPL_{rms90} Threshold Radii (km)		
	640 in^3 outside barrier islands	640 in^3 inside barrier islands	320 in^3 inside barrier islands
190	0.12	0.31	0.16
180	0.95	0.75	0.48
170	2.5	1.2	0.93
160	5.5	1.8	1.5
120	44*	6.4	5.7

*Computed based on SPL-SEL conversion factor of 2 dB. See text in section 3.2 for a discussion.

Table 8: Area ensonified above rms SPL thresholds for the three modeled scenarios. Areas are calculated from rms SPL results that include a safety factor.

SPL_{rms90} Threshold (dB re 1 μPa)	Ensonified Area (km^2)		
	640 in^3 outside barrier islands	640 in^3 inside barrier islands	320 in^3 inside barrier islands
190	0.033	0.055	0.011
180	1.3	0.45	0.14
170	12	1.1	0.82
160	53	4.8	2.9
120	2100*	69	46

*Computed based on SPL-SEL conversion factor of 2 dB. See text in section 3.2 for a discussion.

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