INCIDENTAL HARASSMENT AUTHORIZATION REQUEST FOR THE NON-LETHAL HARASSMENT OF MARINE MAMMALS DURING THE PRUDHOE BAY OBS SEISMIC SURVEY, BEAUFORT SEA, ALASKA, 2014

FINAL DRAFT
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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) plans to conduct a three-dimensional (3D) ocean bottom sensor (OBS) seismic survey with a transition zone component on state and private lands, and federal and state waters in the Prudhoe Bay area of the Beaufort Sea during the open-water season of 2014. The seismic survey project area lies mainly within the Prudhoe Bay Unit (PBU) and also includes portions of the Northstar, Dewline, and Duck Island Units as well as non-unit areas (Figures 1 and 2). BPXA requests an Incidental Harassment Authorization (IHA) allowing non-lethal harassment of marine mammals incidental to this proposed 2014 OBS seismic survey. 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). BPXA initially requested an IHA for this activity in early 2013 and notified agencies on February 28, 2013 that the survey would not be conducted in 2013. The proposed 2014 OBS seismic survey has been optimized for completion in one season. This section provides operational details of the proposed OBS seismic survey. Information on the dates, duration, and project area are provided in Section 2.

1.1. Purpose

The purpose of the proposed OBS seismic survey is to obtain current, high-resolution seismic data to image existing reservoirs. This data will increase BPXA's understanding of the reservoir, allowing more effective reservoir management. Existing datasets of the proposed survey area include the 1985 Niakuk and 1990 Point McIntyre vibroseis on ice surveys. Data from these two surveys were merged for reprocessing in 2004. A complete set of OBS data has not previously been acquired in the proposed survey area.

1.2. Project Details

OBS seismic surveys are typically used to acquire three-dimensional (3D) 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 3D sub-surface image of the reservoir area. The generation of a 3D image requires the deployment of many parallel receiver lines spaced close together over the area of interest. The activities associated with the proposed OBS seismic survey include equipment and personnel mobilization and demobilization, housing and logistics, temporary support facilities, and seismic data acquisition.

Equipment and Personnel Mobilization and Demobilization

Mobilization, demobilization, and support activities are primarily planned to occur at West Dock, East Dock, and Endicott. Other existing pads within the PBU area may be utilized for equipment staging or support as necessary.

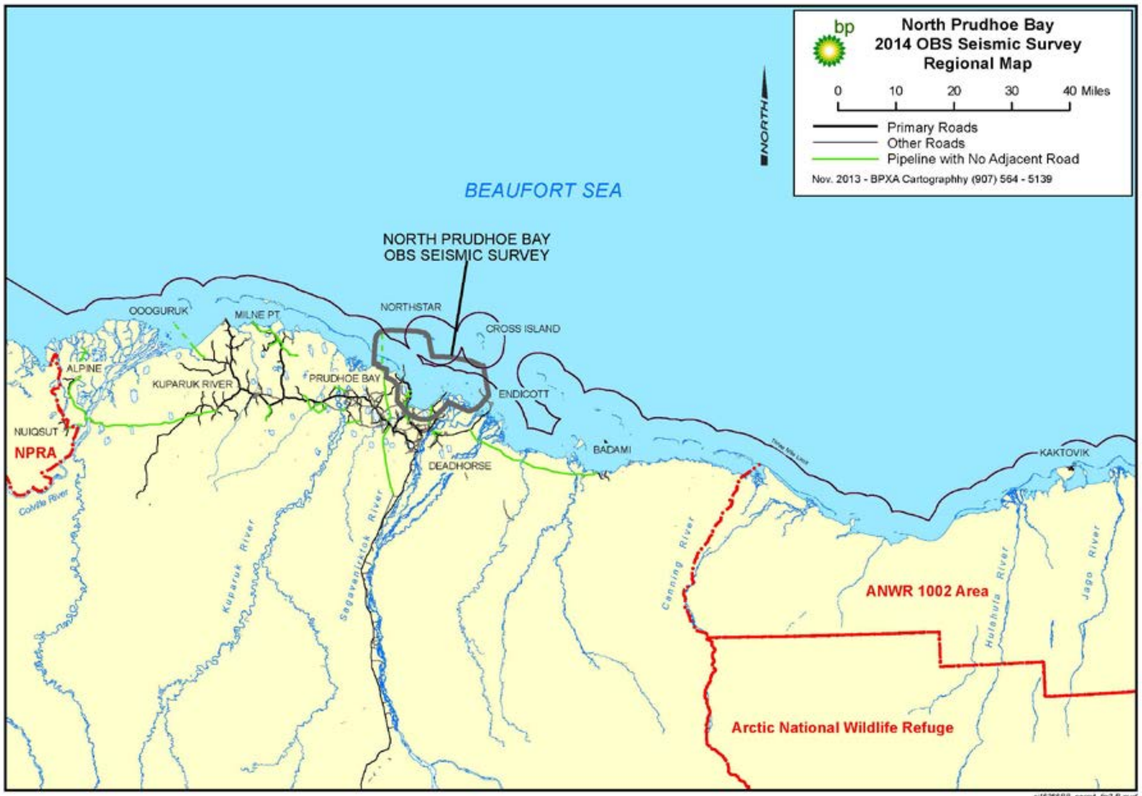

Figure 1. Overview of the eastern Beaufort Sea with the outline of the Prudhoe Bay seismic survey area

All vessels are expected to be transported to the North Slope by truck. It is possible that one of the vessels will be mobilized by sea past Barrow when ice conditions allow. The vessels will be prepared at the seismic contractor's base in Deadhorse, West Dock, or East Dock. Vessel preparation will include assembly of navigation and source equipment, testing receiver deployment and retrieval systems, loading recording and safety equipment, and initial fueling. Once assembled, the systems (including airguns) will be tested within the project area.

Equipment will be retrieved as part of the operations and during demobilization. Receiver retrieval and demobilization of equipment and support crew will be completed by the end of September. BPXA does not expect site restoration and rehabilitation to be necessary for this type of work.

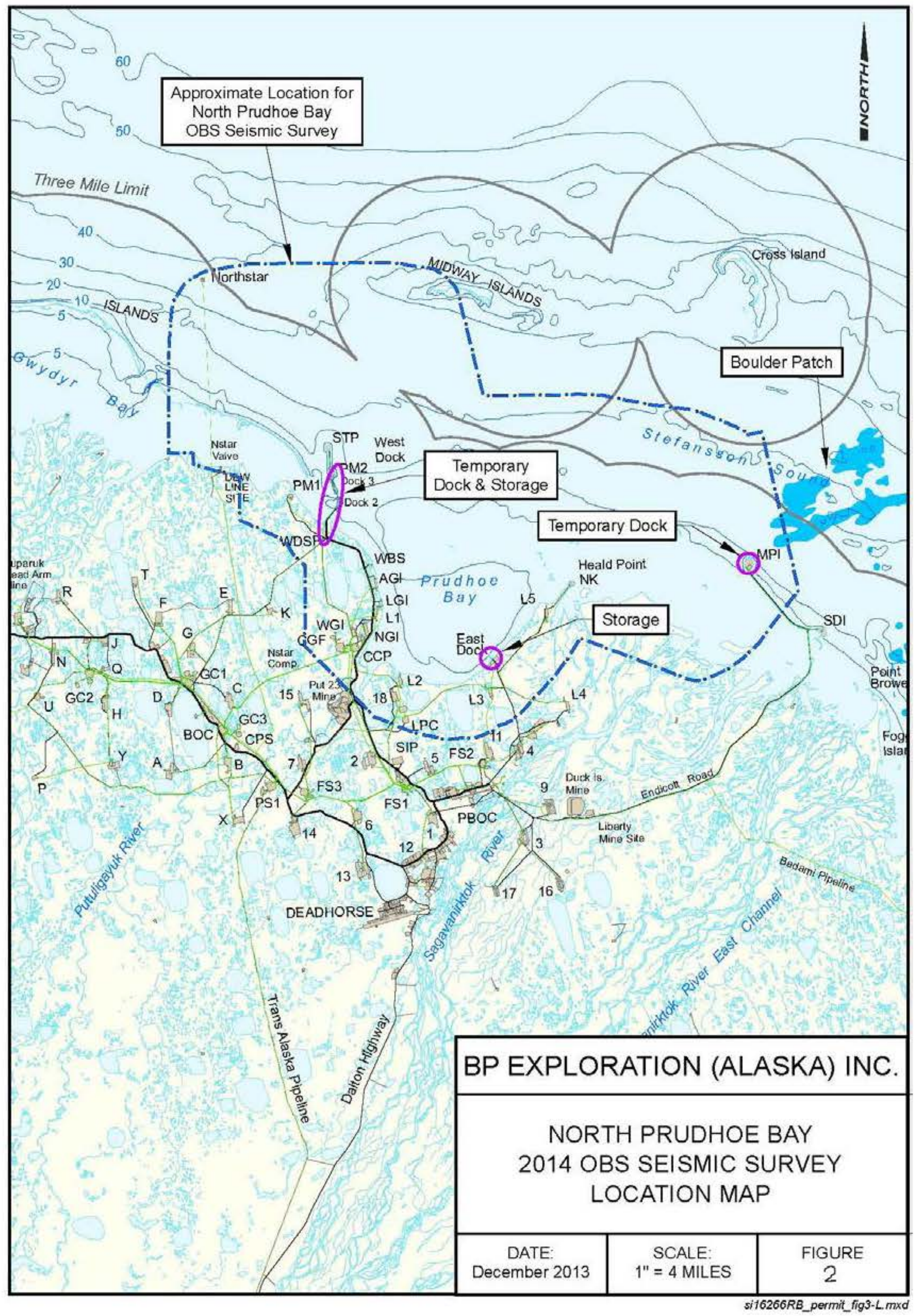

Figure 2. Approximate boundary of the proposed North Prudhoe Bay seismic survey area

Housing and Logistics

Approximately 220 people will be involved in the operation including seismic crew, management, mechanics, and Protected Species Observers (PSOs). Most of the crew will be accommodated at BPXA operated camps or Deadhorse. Some offshore crew will be housed on vessels.

Personnel transportation between camps, pads, and support facilities will take place by trucks and crew transport buses traveling on existing gravel roads. Shallow-water craft such as Zodiac-type vessels and ARKTOS™ (and Northstar hovercraft if needed and available) will be used to transport equipment and crews to shallow water and surf-zone areas of the survey area not accessible by road; ARKTOS™ will not be used in vegetated areas, including tundra. Helicopters will be used to transport equipment and personnel to onshore tundra areas and crews on foot will deploy equipment onshore. Trucks may also be used on the existing road system to transfer survey equipment and crews to the onshore portions of the survey area accessible by road and pads. Helicopter operations will be supported in Deadhorse.

Up to 10,000 gallons of fuel (mostly ultra-low sulfur diesel and small quantities of gasoline) may be temporarily stored on existing pads to support survey activities. Fuel may be transported to locations to refuel equipment. The vehicle transporting fuel to locations off pads (helicopter, boat, tracked buggy, or truck) will supply the necessary quantity of fuel at the time of transfer. Fueling of equipment may occur in floodplains and near water to accommodate marine and surf zone operations. All fueling will occur in accordance with applicable regulations and BP spill prevention practices.

Support Facilities

West Dock, Endicott, and East Dock, as well as other existing PBU infrastructure, will be utilized for seismic staging, crew transfers, resupply, and other support activities. Crew transfers and re-supply may also occur at other nearby vessel accessible locations (e.g., by beaching) if needed. For protection from weather, vessels may anchor near West Dock, near the barrier islands, or other nearshore area locations.

Receivers (i.e., nodes placed into cache bags) to be transported by helicopter via sling-load to the onsite project area for on-foot deployment may be temporarily staged on tundra adjacent to pads. These staging areas are not expected to exceed 200 by 200 ft and will be rotated as practicable to minimize tundra disturbance.

Helicopter support for equipment and personnel transport is scheduled to take place during one shift per 24-hour day. The helicopter will be based at the Deadhorse airport. A few staging areas may be strategically located at existing pads or gravel locations in the PBU to minimize flight time and weather exposure.

A temporary flexi-float dock may be located at West Dock to provide support for vessel supply operations, personnel transfers, and refueling. The dock size will be a maximum of 170 x 30 ft and will be comprised of sections that will be fastened on location and secured with spuds to the seafloor. If needed, a smaller temporary dock (up to 100 x 15 ft) may be used at Endicott for additional support during some operations in the eastern project area. Minimal and temporary disturbance to marine sediments is expected when docks are placed and removed.

Seismic Data Acquisition

The proposed seismic survey will use sensors located on the ocean bottom or buried below ground nearshore (surf zone) and onshore, as described in more detail in the section "Receiver Deployment and Retrieval." Sensors will be placed along north-south oriented receiver lines, with a minimum line spacing of 1,320 feet (ft). The sound source will be submerged compressed air (airgun) arrays towed behind source vessels. Source lines will be oriented perpendicular to receiver lines with typical minimum line spacing of 550 ft. In certain situations, such as when lines have been modified to avoid cultural sites, mitigate impacts to wildlife, or due to bathymetry or geographic features, additional infill source and receiver lines may be added to improve data imaging.

Equipment and Vessels

Equipment will include geophones/receivers, airguns, nodes and batteries, helicopters, tracked drills, and vessels. Table 1 lists the number and type of vessels and other vehicles anticipated to be used for the data acquisition. In the event that a specific vehicle or vessel is not available, a vehicle or vessel with similar parameters will be used. Any substitution will be in accordance with permit requirements.

Navigation and Data Management

Surveyors will deploy up to three navigation positioning base stations (survey control) onshore or on an island and may mark receiver locations in advance of the lay-out crews. Scouting of the project area and collecting bathymetry information necessary to identify site-specific conditions, such as water depth in near-shore areas will be performed prior to receiver deployment. A Differential Global Positioning System (DGPS) will be used for navigation. This navigation system connects to the onshore base stations and remotely links the operating systems on the vessels. The navigation system will display known obstructions, islands, identified areas of sensitivity, and pre-plotted source and receiver line positions; this information will be updated as necessary. The asset monitor will update the positions of each vessel in the survey area every few seconds providing the crew a quick display as to each vessel's position.

Tide gauges will also be temporarily installed in the operation area. Tide gauges will be used to provide real-time water depth to ensure operations occur in the prescribed water depths. The tide gauge information will be input into the navigation system to provide real-time assessment.

Table 1 Summary of Vessels and Other Equipment Involved in Proposed 2014 North Prudhoe OBC Seismic Survey

VESSEL TYPE	NUMBER (approx.)	DIMENSIONS (approx.)	MAIN ACTIVITY	FREQUENCY
OFFSHORE AND SURFZONE				
Source vessel: main	1	90 × 25 ft	Seismic data acquisition	24-hr operation
Source vessel: small	2	70 x 16 ft	Seismic data acquisition	24-hr operation
Receiver boats	4	85 x 24 ft 32 x 14 ft	Deploy and retrieve receivers in offshore zone	24-hr operation
Crew transport, HSE, and support vessels	2	45 × 14 ft	Transport crew and supplies	Typically twice daily
Support vessel	1	116.5 × 24 ft 23 × 15 ft	Crew support floating platform, if needed	24-hr operation
SURFZONE AND ONSHORE				
ARKTOS™	2		Deploy and retrieve receivers in surf zone and non-vegetated onshore areas	24-hr operation
Utility type vehicle*	Up to 6		Deploy and retrieve receivers in surf zone and non-vegetated delta areas. Transport fuel and water	24-hr operation
Zodiacs	Up to 3		Transport crew and supplies	24-hr operation
Airboats	Up to 2		Transport crew and supplies	24-hr operation
Northstar hovercraft	1		Transport crew and supplies	As needed and if available

** Utility type vehicles include tracked or wheeled buggy, catamaran, or similar equipment in combination.*

Receiver Deployment and Retrieval

The survey area has been separated into three different zones based upon the different types of receivers that will be used and the method of receiver deployment and retrieval for that zone. Deployment and retrieval methods have been designed to facilitate complete equipment retrieval at the end of the survey.

Offshore Zone

The offshore zone is defined as waters of 3 ft or deeper. Receiver boats will be used for the deployment and retrieval of receivers (marine nodes) that will be placed in lines onto the ocean bottom at about 110 ft spacing. Receivers will not be placed east of the Endicott Main Production Island (MPI), and will therefore not be placed in mapped concentrations of the Boulder Patch. Acoustic pingers will be deployed on every second node to determine exact positions of the receivers. The pingers transmit at frequencies ranging from about 19-36 kHz and have an estimated source level of 188-193 dB re µPa at 1m.

Surf Zone

The surf zone includes waters up to 6 ft deep along the coastline, non-vegetated tidelands, and lands within the river delta areas that are intermittently submerged with tidal, precipitation, and storm surge events. ARKTOS™ and utility type vehicles equipped with a bit of approximately 4-inch diameter will be used to either drill or flush the receivers to approximately 6 ft. Small vessels will then attach autonomous nodes to the receivers. The nodes will be protected from the water either through placement on specially designed floats anchored to the bottom or on support poles. Support poles will primarily be used in water less than 18 inches deep and in tidal surge areas to ensure that the nodes stay above surface waters and prevent them from becoming inundated as a result of fluctuating water levels. Receivers that are installed in the seabed may require warm water flushing to facilitate removal.

Onshore Zone

The onshore zone is the vegetated area from the coastline inland. Autonomous node receivers with geophones will be used in this area. Helicopters will be the main method to transport land crews and equipment. Equipment will be bagged, with each bag holding several nodes. Multiple bags will be transported via sling load from the staging area to the receiver lines and temporarily cached. Bag drop zones will be 500 to 1,000 ft apart and will be cleared for the presence of nesting birds prior to use. Crews on foot will walk from bag to bag and lay out the equipment at the surveyed location. Vessels may also be used to transport personnel and equipment to a staging area on the beach and vehicles may be used to transport personnel and equipment along the road system. Zodiac-type boats may be used in large lakes to deploy marine nodes. Boats, nodes, and crews will be transported via helicopter to and from the lakes.

Nodes will be located on the ground surface and the geophone(s) will be inserted approximately 3 ft below ground surface. Geophone installation will be either by hand using a planting pole or will be inserted into 1.5 inch diameter holes made with a hand-held drill. Support poles may be placed in lake margins and marshy areas of tundra as needed to ensure the nodes stay above surface waters and prevent them from becoming inundated as a result of fluctuating water levels. If conditions allow, geophones may be installed in the Sagavanirktok River Delta in early April until tundra closure using two tracked utility vehicle and a support vehicle. Upon completion of data acquisition and recording operations in a particular area, land crews will retrieve the nodes.

<u>Source Vessel Operations</u>

A total of three seismic source vessels will be used during the proposed survey. The source vessels will carry an airgun array that consists of two sub-arrays, however, it is possible that one of the source vessels will tow only one sub-array. The discharge volume of the sub-array will not exceed 620 cubic inch (in^3). Each sub-array consist of eight airguns (2 x 110, 2 x 90, 2 x 70, and 2 x 40 in^3) totaling 16 guns for the two sub-arrays with a total discharge volume of 2 × 620 in^3, or 1240 in^3. The 620 in^3 sub-array has an estimated source level of ~218 decibels referenced to 1 microPascal root mean squared (dB re 1 µPa rms) at 1 meter from the source. The estimated source level of the two sub-arrays combined is ~224 dB re 1 µPa rms (Table 2). In the shallowest areas only one sub-array may be used for a given source vessel. Table 2 summarizes the acoustic properties of the proposed airgun array. The smallest gun in the array (40 in^3) or a separate 10 in^3 airgun will be used for mitigation purposes.

The airgun subarrays will be towed at a distance of approximately 50 ft (15 m) from the source vessel's stern at depths ranging from approximately 3 to 6 ft, depending on water depth and sea conditions. 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 flip-flop mode (i.e., alternating shots); this means that one vessel discharges airguns when the other vessel is recharging. In some instances, only one source vessel will be operating, while the second source vessel will be engaged in refueling, maintenance, or other activities that do not require the operation of airguns. The expected shot interval for each source will be 10 to 12 seconds, resulting in a shot every 5 to 6 seconds due to the flip-flop mode of operation. The exact shot intervals will depend on the compressor capacity, which determines the time needed for the airguns to be recharged. Data will record autonomously on the nodes placed offshore, in the surfzone, and onshore and may be periodically checked for quality control.

Table 2. Proposed Airgun Array Configuration and Source Signatures as Predicted by the Gundalf Airgun Array Model for 2 m depth.

ARRAY SPECIFICS	620 IN^3 ARRAY	1240 IN^3 ARRAY
Number of guns	Eight 2000 psi sleeve airguns (2 x 110, 2 x 90, 2 x 70, and 2 x 40 in^3) in one array)	Sixteen 2000 psi sleeve airguns (4 x 110, 4 x 90, 4 x 70, and 4 x 40 in^3), equally divided over two sub-arrays of eight guns each
Zero to peak	6.96 bar-m (~237 dB re µPa @ 1 m)	13.8 bar-m (~249 dB re 1µPa @ 1 m)
Peak to peak	14.9 bar-m (~243 dB re µPa @ 1 m)	29.8 bar-m (~243 dB re 1µPa @ 1 m)
RMS pressure	0.82 bar-m (~218 dB re µPa @ 1 m)	1.65 bar-m (~224 dB re 1µPa @ 1 m)
Dominant frequencies	Typically less than 1 kHz	Typically less than 1 kHz

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 of July 1 to September 30, 2014. Mobilization of equipment to Deadhorse is expected to commence late May/early June 2014. The planned start date of receiver deployment is approximately July 1, 2014 with seismic data acquisition beginning when open water conditions allow. This has typically been around July 15. Seismic survey data acquisition may take approximately 45 days to complete, which includes downtime for weather and other circumstances. Seismic data acquisition will occur on a 24-hour per day schedule with staggered crew changes. Receiver retrieval and demobilization of equipment and support crew will be completed by the end of September. To limit potential impacts to the bowhead whale fall migration and subsistence hunting, airgun operation dates will be in accordance with the dates agreed upon in the Conflict Avoidance Agreement (CAA), historically ending August 25. Receiver and equipment retrieval and crew demobilization would continue after airgun operations end.

The general location of the proposed seismic survey in the Prudhoe Bay area, Beaufort Sea, Alaska is shown in Figure 2. The project area encompasses approximately 190 mi^2, comprised of approximately 129 mi^2 in water depths of 3 ft and greater, 28 mi^2 in waters less than 3 ft deep, and 33 mi^2 on land. The approximate boundaries of the project area are between 70°16’N and 70°31’N and between 147°52’W and 148°47’W and include state and federal waters as well as state and private lands. Activity outside the 190 mi^2 area may include source vessels turning from one line to the other while using mitigation guns, vessel transits, and project support and logistics.

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.

Whale and seal species as listed in Table 3 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). A request for a letter of authorization (LOA) to allow incidental non-lethal harassment of pacific walrus and polar bear during the proposed OBS seismic survey activities in the Prudhoe Bay area 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 whale species and four species of seals (Table 3). Two whale 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 encounters in the Prudhoe Bay area are therefore not expected. Of the six non-ESA listed whales, 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 Prudhoe Bay area. Abundance estimates of these four extralimital species are not provided in Table 3 and their status and distribution are only briefly discussed in Section 4.3. The ringed, bearded, and spotted seals are the most commonly occurring seal species in the Beaufort Sea. Ribbon seals occur mainly in the Chukchi Sea and western part of the Beaufort Sea and encounters in the Prudhoe Bay area are not expected. The Bering Sea distinct population segment (DPS) of bearded seals and Arctic stock of ringed seals have been listed as threatened under the ESA, effective as of February 26, 2013 (NMFS 2012a, 2012b). NMFS determined not to list the Bering Sea stock of spotted seals and the ribbon seals under the ESA, because they are currently not in danger of extinction or likely to become endangered in the foreseeable future (NMFS 2009, 2013a).

Table 3. Abundance estimates, habitat, and conservation status of marine mammals under NMFS jurisdiction that could or are likely to occur in the Beaufort Sea during the open-water season. Abundance estimates are not provided for species that are rare or extralimital to the Beaufort Sea.

SPECIES	ABUNDANCE[1]	HABITAT	ESA[2]	IUCN[3]
		WHALES		
Bowhead whale (Bering-Chukchi-Beaufort Stock)	16,892[4]	Pack ice, open water coastal, and offshore	Endangered	LC
Gray whale (eastern Pacific population)	19,126[5]	Coastal, lagoons	Not listed	LC
Beluga whale (Beaufort Sea Stock)	39,258	Offshore, ice edge, coastal, and lagoons.	Not listed	NT
Minke whale	Rare/Extralimital	Shelf, coastal	Not listed	LC
Humpback whale	Rare/Extralimital	Shelf, coastal	Endangered	LC
Narwhal	Rare/Extralimital	Offshore, ice edge	Not listed	NT
Killer whale	Rare/Extralimital	Variable habitats	Not listed	DD
Harbor Porpoise	Rare/Extralimital	Variable habitats	Not listed	--
		SEALS		
Ringed seal (Beaufort Sea Stock)	1,000,000[6]	Landfast and pack ice, open water	Threatened	LC
Bearded seal (Beringia DPS)	125,000[7]	Pack ice, open water	Threatened	LC
Spotted seal (eastern and central Bering Sea)	141,479[8]	Pack ice, open water, and coastal haulouts	Not listed	DD
Ribbon seal (eastern Bering Sea)	49,000[9]	Pack ice, open water	Not listed	DD

[1] Abundance estimates are derived from the most recent Alaska Marine Mammal Stock Assessment Reports (Allen & Angliss 2013), unless otherwise noted.

[2] U.S. Endangered Species Act of 1973

[3] IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. <www.iucnredlist.org>. Codes for IUCN classifications version 3.1: EN = Endangered; NT = Near Threatened; LC = Least Concern; DD = Data Deficient, and -- = not yet assessed. http://www.iucnredlist.org/apps/redlist/static/categories_criteria_3_1#categories.

[4] Estimate based on the 2011 bowhead census (Givens et al. 2013).

[5] Estimate based on 2006/2007 data (Allen & Angliss 2012).

[6] Reliable abundance estimates are currently not available (Allen & Angliss 2013). However, based on historical information, an abundance estimate of 1 million was considered reasonable (Kelly et al. 2010a).

[7] Reliable abundance estimates are currently not available (Allen & Angliss 2013). Based on available data, current total Bering Sea bearded seal population is considered to be twice the estimate reported by Verhoef et al. (2010): this is approximately 125,000 individuals (cited in Cameron et al. 2010).

[8] Based on Verhoef et al. (in review) as cited in Angliss & Allen (2013).

[9] Interim estimate used aerial survey data from 2003, 2007, and 2008 has been analyzed (Allen & Angliss 2013).

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 information on the population status and seasonal distribution of the marine mammal species listed in Table 3, based on the most recent data available.

4.1. Whales

Beluga Whale (Delphinapterus leucas)

There are five stocks of beluga whales in Alaska: the Cook Inlet, Bristol Bay, eastern Bering Sea, eastern Chukchi Sea, and Beaufort Sea stocks (Allen & Angliss 2013). 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 & Angliss 2013). The population estimate of the Beaufort Sea stock is based on 1992 data and the size estimate of the eastern Chukchi Sea stock arises from survey efforts in 1989-1991. The population trends of both stocks are currently unknown; however, based on available data, there is no evidence that the eastern Chukchi Sea stock is declining (Allen & Angliss 2013).

In spring, the Beaufort and Chukchi Sea stocks of beluga whales use open leads in the sea ice to migrate from their wintering grounds in the Bering Sea to the Arctic and to 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). 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 & 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 at these high latitudes 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.

Beluga whales are often seen migrating in large groups (Braham et al. 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 & 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, most beluga whales migrate in deep offshore waters along the ice edge more than 60 mi north of the Alaskan coast, both during the spring and fall migration (Clarke et a. 2012, 2013). Relatively few beluga sightings have been recorded in the nearshore area of Prudhoe Bay. Opportunistic sightings have been recorded from Northstar Island, the STP facility, and Endicott. During the 2008 OBC seismic survey in Foggy Island Bay, three sightings of eight individuals were observed at about 3 mi east of Endicott SDI (Aerts et al. 2008). In 2013, two adult belugas were reported at Endicott on August 10 for about two days. Two weeks later, a large group of belugas (no estimate provided) were seen in the same area. Observers of the ASAMM aerial survey also recorded more nearshore beluga sightings than historically seen (2013 daily flight summaries – NOAA website). Based on available information, we can expect to encounter beluga whales in or close to the survey area. However, the chance of such encounters during the summer period is small.

Bowhead Whale (Balaena mysticetus)

Four stocks of bowhead whales are recognized worldwide by the International Whaling Commission (IWC) for management purposes (Allen & Angliss 2013). The largest of these four stocks, the Western Arctic or Bering-Chukchi-Beaufort (BCB) stock, inhabits Alaskan waters. Commercial whaling decreased the bowhead population to approximately 3,000 whales (Woodby and Botkin 1993). Abundance estimates of whales from the BCB stock, before they were overharvested by commercial whaling, were between 10,400−23,000 whales. Since the ban on commercial whaling, the bowhead population has increased steadily. This is evidenced by data collected during 1977-2011 from ice-based counts, acoustic locations, and aerial transect data (Figure 9 in Givens et al. 2013). In 2011, the NSB successfully completed a new ice-based count of bowhead whales and estimated the population at ~16,892 animals with an annual growth rate of 3.7% (George et al. 2013; Givens et al. 2013). Although the bowhead whale is recovering well following its decline, it is currently still listed as endangered under the ESA, depleted by the MMPA (Allen & Angliss 2013), 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.

Whales of the BCB stock winter in the Bering Sea and migrate through the Bering Strait, Chukchi Sea, and Alaskan Beaufort Sea to their summer feeding grounds in the Mackenzie River Delta of the Canadian Beaufort Sea. Most bowheads arrive in the coastal areas of the eastern Canadian Beaufort Sea and Amundsen Gulf in late May and June, but some remain in the offshore pack ice of the Beaufort Sea until about mid-July. Starting about mid-August through late October, bowheads migrate westwards through the Alaskan Beaufort Sea to their wintering grounds in the central and western Bering Sea (Moore and Reeves 1993; Quakenbush et al. 2010). Late summer and fall aerial surveys have been conducted in the Alaskan Beaufort Sea since 1979 and have provided useful information on long-term bowhead whale migration and distribution patterns (see Ljungblad et al. 1986, 1987; Moore et al. 1989; Monnett and Treacy 2005; Treacy et al. 2006; Clarke et al. 2012, 2013). The main migration corridor is located over the continental shelf, typically within 34 mi of shore during years with light to moderate ice conditions (Treacy et al. 2006). 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 ft deep (Miller et al. 2002; Clarke et al. 2012) and few whales have been seen shoreward of the barrier islands in the Alaskan Beaufort Sea. In 2013, however, nearshore sightings were more common than historically observed (NOAA daily flight summaries at http://www.asfc.noaa.gov/nmml/cetacean/bwasp/2013).

Although most bowhead feeding activity occurs in the Canadian Beaufort Sea, feeding activity has also regularly been documented at Point Barrow and, less frequently, in other areas of the Alaskan Beaufort Sea (Richardson & Thomson 2002; Koski et al. 2008; BOWFEST and ASAMM annual reports). Satellite tagging data showed that some whales were moving back and forth during the summer feeding season between the Alaskan and Canadian Beaufort Sea (Quakenbush et al. 2010). Satellite data from one tagged whale that remained in the central Beaufort Sea for several weeks in July appeared to be associated with at least 14 whales (Clarke et al. 2012).

Bowhead whales may be encountered during the Prudhoe Bay seismic survey during the summer season, but likely in low numbers. Historically, only few bowhead whales have been recorded during the summer season close to shore (e.g., ASAMM 1979-2011 database), although this might have coincided with limited survey effort during this period. During the 2013 ASAMM aerial survey, a larger number of bowhead whales were seen in nearshore waters than would be expected based on historical data (daily flight summaries, available online at NOAA website). Vessel-based observers recorded one multiple species sighting of six animals, consisting of a few bowheads on August 16 near Narwhal Island during the OBC Liberty seismic survey (Aerts et al. 2008). During 2008 and 2010 aerial surveys from early July through early October, conducted as part of industrial operations in Harrison and Prudhoe Bay, only a few bowheads were seen before mid-August. None of these whales were close to shore (Christie et al. 2010; Brandon et al. 2011). Bowhead whales were more commonly observed later in the season, but most animals were seen at distances of more than 15 mi from shore.

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, which is believed to occur mainly along the coast of eastern Asia (Rice et al. 1984; Swartz et al. 2006) and summers near Sakhalin Island, Russia. Recent satellite tagging and photo-identification data suggests that there is overlap between the eastern and western populations.

Though populations have fluctuated greatly, the eastern Pacific gray whale population has recovered significantly from commercial whaling, and was delisted from the ESA in 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). NMFS does not consider the eastern Pacific stock of gray whales 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 & Swartz 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. 2000). 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 (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).

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). A total of five gray whales (3 sightings) were sighted during 30 years of BWASP/ASAMM aerial surveys (database available on the NOAA website). Two of these whales were seen in the Prudhoe Bay area. 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). In 2008, a multiple species sighting of six animals consisting of bowhead and gray whales were observed during the Liberty seismic survey in Foggy Island Bay close to Narwhal Island (Aerts et al. 2008). A few gray whales have also been observed in the Canadian Beaufort Sea (Rugh and Fraker 1981) 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, the probability of encountering gray whales during the OBS seismic survey is low.

4.2. Seals

Bearded Seal (Erignathus barbatus)

Bearded seals have a circumpolar distribution. In Alaska, they occur over the continental shelf waters of the Bering, Chukchi, and Beaufort seas (Burns 1981). There is no reliable estimate of bearded seal abundance in Alaskan waters (Allen & Angliss 2013; Cameron et al. 2010). The abundance in the Bering Sea, based on aerial survey data collected in the central Bering Sea pack ice in 2007, is estimated at ~125,000 (Cameron et al. 2010). In the Chukchi Sea, the number of animals is estimated at ~27,000, based on data from 1999-2000 spring aerial surveys flown along the coast from Shishmaref to Barrow (Cameron et al. 2010). Aerial surveys of the eastern Beaufort Sea conducted in June during 1974–1979, resulted in an average estimate of 2,100 individuals (Stirling et al. 1982), uncorrected for animals in the water. Since the survey area covered roughly half of the ice-covered continental shelf of the western Beaufort Sea, the estimated number of bearded seals in the Beaufort Sea is thought to be 1.5 times 2,100 or ~3,150 (Cameron et al. 2010). Based on these numbers the Alaskan stock of bearded seals is considered to be greater than ~155,000 (NMFS 2012a) and may be as large as 250,000–300,000 (Popov 1976, Burns 1981, MMS 1996). NMFS listed the Alaska stock of bearded seals, part of the Beringia DPS, as threatened under the ESA, effective February 26, 2013 (NMFS 2012a).

Bearded seals are closely associated with sea ice, specifically when they breed, give birth, raise young, molt, and rest. Bearded seals migrate seasonally with the advance and retreat of sea-ice (Kelly 1988). As the ice recedes in the spring, bearded seals migrate from their winter grounds in the Bering Sea north through the Bering Strait (mid-April to June) to areas along the margin of the multi-year ice in the Chukchi Sea or to nearshore areas of the central and western Beaufort Sea. Pupping takes place on top of the ice from late-March through May, primarily in the Bering and Chukchi seas. Some pupping occurs on moving pack ice in the Beaufort Sea. Bearded seals do not form herds, although loose aggregations of animals may occur. Spring surveys along the Alaskan coast indicate that bearded seals prefer areas of 70% to 90% sea ice coverage (Allen & Angliss 2013). They generally inhabit areas of shallow water (less than 65 ft) that are seasonally ice-covered (Cameron et al. 2009). As the ice forms again in the fall and winter, most seals move south with the advancing ice edge through the Bering Strait into the Bering Sea where they spend the winter (Cameron et al. 2010). This southward migration is less noticeable and predictable than the northward movements in late spring and early summer (Burns 1981; Kelly 1988). Some bearded seals may overwinter in the Chukchi and Beaufort seas, but conditions are likely not as favorable.

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). Similar numbers were recorded during barge-based vessel surveys conducted from 2005 to 2007 (Green & Negri 2005; Green et al. 2007). Bearded seals were commonly sighted during aerials surveys conducted in the Beaufort Sea (Moulton et al. 2003; Clarke et al. 2011, 2012, 2013). During BPXA's OBC seismic survey in Foggy Island Bay, close to the proposed project area, observers recorded a limited number of seal sightings (18) of which one was a confirmed bearded seal (Aerts et al. 2008). Based on available data, bearded seals are expected to occur in the survey area, but the number of sightings is expected to be small.

Spotted Seal (Phoca largha)

The spotted seal is found from the Beaufort Sea to the Sea of Japan. They are 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). There is no reliable estimate of the size of the Alaskan stock of spotted seals. The most current abundance estimate for the eastern and central Bering Sea is 141,479 animals (95% CI 92,769–321,882). This number is derived from aerial surveys conducted by NMML in 2007 from U.S. Coast Guard icebreakers that provided greater access to the central and eastern Bering Sea pack ice (Ver Hoef et al., in review, as cited in Allen & Angliss 2013). NMFS conducted a status review of the spotted seal to determine if listing under the ESA was warranted, because of concerns about changing ice conditions and associated potential habitat loss (Boveng et al. 2009). Based on this status review, NMFS did not 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).

Like other ice seals, spotted seals overwinter in the Bering Sea. From late fall through spring, spotted seal habitat-use is closely associated with the distribution and characteristics of seasonal sea ice. The ice provides a dry platform away from land predators during the whelping, nursing, breeding, and molting periods. 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 herds break up when the usable sea ice disappears in early summer and spotted seals move toward ice-free coastal waters from Bristol Bay through western Alaska to the Chukchi and Beaufort seas. Unlike other ice seals, spotted seals use coastal haulouts for at least part of the summer. Spotted seals are commonly seen in bays, lagoons, and estuaries, but also range offshore as far north as 69-72°N. When sea ice begins to form in the fall, spotted seals occupy the ice habitat, moving southwards to the Bering Sea overwintering areas (Lowry et al. 1998).

Spotted seals have been observed frequently in the central Alaskan Beaufort Sea in recent years, although in low numbers. Haulout sites in the Beaufort Sea include Oarlock Island, Pisasuk River, the Colville River Delta, and Sagavanirktok River, of which the latter is near the Prudhoe Bay 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 & Negri (2005, 2006) and Green et al. (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) 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 mostly spotted seals in July and August, while other seal species were more commonly observed in September and October. During BPXA's OBC seismic survey in Foggy Island Bay, just southeast of the proposed project area, observers recorded a limited number of seal sightings (18) of which one confirmed spotted seals (Aerts et al. 2008). During seismic data acquisition in Prudhoe Bay, we expect that spotted seals will be encountered in the project area, though in low numbers.

Ringed Seal (Phoca hispida)

Ringed seals have a circumpolar distribution and are year round residents in the Beaufort, Bering, and Chukchi seas (King 1983). There is currently no complete population estimate available for the entire Alaskan stock (Allen & Angliss 2013). 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. There is increasing concern about the future of the ringed seal due to receding ice conditions and potential habitat loss. NMFS listed the Arctic stock of ringed seals as threatened under the ESA, effective February 26, 2013 (NMFS 2012b).

Like the other ice seals, ringed seals are closely associated with sea ice during breeding, pupping, and molting. 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 199; Moulton and Lawson 2002; Green et al. 2007). Satellite-tagging data revealed that ringed seals cover large distances between foraging areas and haulout sites during the open-water season (Lowry et al. 1998; 2000, Kelly et al. 2010b; Herreman et al. 2012). The time spent on haulout sites is much shorter than the time spent foraging in open water. For example, in July, ringed seals spent 70% of the time in open water, increasing to ≥90% in August (Kelly et al. 2010b).

Ringed seals have routinely been observed during previous seismic surveys in this region and time period (e.g., Aerts et al. 2008; Funk et al. 2008; Savarese et al. 2010; Brandon et al. 2011; Reiser et al. 2011), during monitoring from Northstar Island (e.g., Aerts & Richardson 2009, 2010) and during aerial surveys flown for bowhead whales (Clarke et al. 2011). They are typically the most abundant seal 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. Despite being the most abundant seal species, the number of seals that we expect to encounter during the proposed OBS survey is low. This is based on seal observation data from recent similar shallow water seismic surveys in the central Beaufort Sea (Aerts et al. 2008; Hauser et al. 2008; HDR 2012).

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). We don't expect to encounter any of these species during the proposed Prudhoe Bay seismic survey.

Minke whales are relatively common in the Bering and southern Chukchi seas and have recently also been sighted in the northeastern Chukchi Sea (Aerts et al. 2013; Clarke et al. 2013). Minke whales are rare in the Beaufort Sea. They have not been reported in the Beaufort Sea during the BWASP/ASAMM surveys (Clarke et al. 2011, 2012; 2013; Monnet and Treacy 2005) and there was only one observation in 2007 during vessel-based surveys in the region (Funk et al. 2010).

Humpback whales have not generally been found in the Arctic Ocean. However, subsistence hunters have spotted humpback whales in low numbers around Barrow and there have been several confirmed sightings of humpback whales in the northeastern Chukchi Sea in recent years

(Aerts et al. 2013; Clarke et al. 2013). The first confirmed sighting of a humpback whale in the Beaufort Sea was recorded in August 2007 (Hashagen et al. 2009) when a cow and calf were observed 54 mi east of Point Barrow. No additional sightings have been documented in the Beaufort Sea.

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 & Angliss 2013). Killer whales have been seen infrequently in the Beaufort Sea (Leatherwood et al. 1986; Allen & Angliss 2013). George et al. (1994) reported that killer whales are seen at Point Barrow in low numbers each year. No killer whales have been reported in the Beaufort Sea during the BWASP/ASAMM surveys conducted from 2006–2012 (Clarke et al. 2011, 2012, 2013). Oil industry staff based at Northstar Island and the Endicott Main Production Island reported occasional unconfirmed killer whale sightings.

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 & Angliss 2013). 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.

Harbor porpoise occur from Point Barrow along the western Alaskan coast, along the Aleutians and throughout southeast Alaska (Allen & Angliss 2013) but are considered extralimital in the Beaufort Sea. However, a small number of porpoises were seen in recent years (Hauser et al. 2008; Lyons et al. 2009).

Ribbon seals are found in the North Pacific Ocean and parts of the Arctic Ocean, most often along the pack ice (Allen and Angliss 2013). Ribbon seals have been sighted in very low numbers in the northeastern Chukchi Sea (Aerts et al. 2013; 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, although three animals were reported during a vessel-based marine mammal monitoring program near Prudhoe Bay in 2008 (Savarese et al. 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 OBS seismic survey in Prudhoe Bay, Beaufort Sea, for the period July 1 through September 30, 2013. "Level B harassment" is defined under the MMPA as "*any act of pursuit, torment or annoyance which has the potential to disturb a marine mammal or marine mammal stock in the wild by causing* *disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding or sheltering.*"

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 airguns used for data acquisition; and
- Physical presence of vessels in the area, i.e., 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. Disturbance reactions, such as avoidance, may occur among some whales and seals in proximity to the source vessels when these vessel are actively discharging their airguns. Airgun sounds may also mask natural sounds of importance to marine mammals. No serious injury to whales and seals is expected from exposure to airgun sounds or from 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.

In summary, BPXA seeks authorization of incidental non-lethal harassment of whales and seals from pulsed sounds generated during the permitted seismic survey activities.

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 OBS seismic survey activities in Prudhoe Bay. Section 7 provides a summary of potential impacts from airgun sounds on marine mammals. In theory, exposure to airgun sounds can lead to a temporary reduction in hearing sensitivity or permanent hearing damage in marine mammals in close proximity to the source (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). The current thresholds for the onset of potential "level A harassment" from pulsed sounds are 190 dB re 1 µPa (rms) for seals and 180 dB re 1 µPa (rms) for whales under NMFS jurisdiction. The threshold for potential "Level B harassment" from pulsed sounds is 160 dB re 1 µPa (rms) for all marine mammals (NMFS 2005). More information regarding marine mammal responses to pulsed sounds has become available since these criteria were established (e.g., Southall et al. 2007) and updated acoustic criteria are therefore being developed (NMFS 2013b). The new acoustic thresholds with potential for level A harassment will reflect species-specific differences in hearing sensitivity and duration of sound exposure. The new criteria for potential level B harassment will likely be based on dose-response curves specific to different marine mammal groups, acknowledging that marine mammals do not all react similarly to sound exposure and that not all individuals will respond when exposed to sounds.

Actual observations of impacts from sound exposure meeting the definition of “harassment” or “take” are rare, in part due to the difficulties associated with making and interpreting observations at sea. With that in mind sound exposures are being used as surrogates for “takes.” The number of whales and seals potentially “taken” by airgun sounds requested in this IHA application are thus based on estimated number of exposures, realizing that exposures do not equal “take.”

Number of possible exposures are based on estimated animal densities in the estimated area ensonified with pulsed sound levels of 160 dB re 1µPa (rms) or more during the course of the season based on best available data. Species most likely to be encountered in the survey area in relatively high numbers are ringed seals, followed by bearded and spotted seals (see Section 4). Most bowhead whales occur farther offshore during July or August, although some animals have been observed in nearshore areas in the past few years (Clarke et al. 2013; 2013 ASAMM daily flight summaries). We don’t expect to encounter bowhead whales within the project area during the survey period, and if we do, only in low numbers. Gray and beluga whales could also occur in the project area, however the chance of encounters is low. Although we don’t expect to see any whale species that are rare or extralimital to the Beaufort Sea, we have requested harassment authorization for a few animals to cover incidental occurrences.

Section 6.1 describes the approach used to estimate marine mammal densities representative for the area and season of operation. Section 6.2 summarizes the anticipated distances to received sound levels from the proposed airgun arrays, derived from existing measurements. The estimated numbers of marine mammals potentially exposed and the requested authorization are summarized in Section 6.3.

6.1. Marine Mammal Density Estimates

During data acquisition, the source vessels of the proposed OBS Prudhoe Bay seismic survey will cover an area of about 190 mi^2 in water depths ranging from 3 to 50 ft. Seismic data acquisition will be halted at the start of the Cross Island fall bowhead whale hunt, as agreed upon in the CAA. The total duration of seismic data acquisition in the Prudhoe Bay area is estimated to be approximately 45 days. About 25% of downtime is included in this total, so the actual number of days that airguns are expected to be operating is about 34, based on a continuous 24-hr operation.

Most whale species are migratory and therefore show a seasonal distribution, with different densities for the summer period (covering July and August) and the fall period (covering September and October). Seal species in the Beaufort Sea do not show a distinct seasonal distribution during the open water period between July and October. Data acquisition of the proposed seismic survey will only take place in summer (before start of Nuiqsut whaling), so we have estimated only summer densities for this IHA application. Whale and seal densities in the Beaufort Sea will further depend on the presence of sea ice. However, if ice cover within or close to the seismic survey area is more than approximately 10%, seismic survey activities may not start or be halted. Densities related to ice conditions are therefore not included in this IHA application.

Spatial differentiation is another important factor for marine mammal densities, both in latitudinal and longitudinal gradient. Taking into account the shallow water operations of the proposed seismic survey area and the associated area of influence, we used data from the nearshore zone of the Beaufort Sea for the calculation of densities, if available.

Density estimates are based on best available data. Because available data did not always cover the area of interest, this is subject to large temporal and spatial variation, and correction factors for perception and availability bias were not always known, there is some uncertainty in the data and assumptions used in the estimated number of exposures. To provide allowance for these uncertainties, maximum density estimates have been provided in addition to average density estimates.

Beaufort Sea Whale Densities

Beluga Whale

The 1979–2011 BWASP aerial survey database, available from the NOAA website (http://www.afsc.noaa.gov/ NMML/software/bwasp-comida.php), contains a total of 62 belugas (31 sightings) in block 1, which covers the nearshore and offshore Prudhoe Bay area. Except for one solitary animal in 1992, all these belugas were seen in September or October; the months with most aerial survey effort. None of the sightings occurred south of 70°N, which is to be expected because beluga whales generally travel much farther north (Moore et al. 2000). The summer effort in the 1979–2011 database is limited. We thus considered the 2012–2013 data to be the best available data for calculating beluga summer densities (Clarke et al. 2013; http://www.asfc.noaa.gov/nmml/cetacean/bwasp/2013), even though the 2013 daily flight summaries posted on NOAA's website have not undergone post-season QAQC.

To estimate the density of beluga whales in the Prudhoe Bay area, we used the 2012 on-transect beluga sighting and effort data from the ASAMM surveys flown in July and August in the Beaufort Sea. The area most applicable to our survey was the area from 140W-154W and water depths of 0-20 m (Table 13 in Clarke et al. 2013). In addition, we used beluga sighting and effort data of the 2013 survey, as reported in the daily flight summaries on the NOAA website. We intended to only select flights that covered block 1. However, in many cases the aerial surveys flown in block 1 also covered blocks 2 and 10, which were much farther from shore. Because it was difficult to determine the survey effort specific to block 1 from the available information, we included the sighting and effort data from block 2 and 10 in our calculations. We used the number of individuals counted on transect, together with the transect kilometers flown, to calculate density estimates (Table 4). To convert the number of individuals per transect kilometer (ind/km) to a density per area (ind/km^2), we used the effective strip width (ESW) of 0.614 km for belugas calculated from 2008-2012 aerial survey data flown with the Commander aircraft (Ferguson, personal communication 30 Oct 2013).

Table 4. Summary of beluga sighting and effort data from the 2012 and 2013 ASAMM aerial surveys flown in July and August in the Beaufort Sea. See text for more details on how we derived the number of individuals per kilometer (ind/km) and densities (ind/km^2).

YEAR	EFFORT (IND/KM)	NR. IND	IND/KM	IND/KM^2
2012	1431	5	0.0035	0.0028
2013	7572	99	0.0131	0.0182
			Average	*0.0105*
			Maximum	*0.0182*
			Minimum	*0.0028*

Bowhead Whale

To estimate summer bowhead whale densities, we used data from the 2012 and 2013 ASAMM aerial surveys flown in the Beaufort Sea (Clarke et al. 2013; www.asfc.noaa.gov/nmml/). The 1979–2011 ASAMM database contains only one on-transect bowhead whale sighting during July and August (in 2011), likely due to the limited summer survey effort. In contrast, the 2012 and 2013 surveys include substantial effort during the summer season and are thus considered to be the best available data, even though the 2013 daily flight summaries posted on NOAA's website have not undergone post-season QAQC.

To estimate the density of bowhead whales in the Prudhoe Bay area, we used the 2012 on-transect bowhead sighting and effort data from surveys flown in July and August in block 1 (Table 4 in Clarke et al. 2013). In addition, we used the on-transect bowhead sighting and effort data of the 2013 survey, as reported in the daily flight summaries on the NOAA website. We intended to only select flights that covered block 1. However, in many cases the aerial surveys flown in block 1 also covered blocks 2 and 10, which were much farther from shore. Because it was difficult to determine the survey effort specific to block 1 from the available information, we included the sighting and effort data from block 2 and 10 in our calculations (Table 5). To convert the number of individuals per line transect (ind/km) to a density per area (ind/km^2), we used the effective strip width (ESW) of 1.15 km for bowheads, calculated from 2008-2012 aerial survey data flown with the Commander aircraft (Ferguson, personal communication 30 Oct 2013).

Table 5. Summary of bowhead sighting and effort data from the 2012 and 2013 ASAMM aerial surveys flown in July and August in the Beaufort Sea. See text for more details on how we derived the number of individuals per kilometer (ind/km) and densities (ind/km^2).

YEAR	EFFORT (IND/KM)	NR. IND	IND/KM	IND/KM^2
2012	1493	5	0.0033	0.0015
2013	3973	88	0.0221	0.0096
			Average	*0.0055*
			Maximum	*0.0096*
			Minimum	*0.0015*

Other whale species

No densities have been estimated for gray whales and for whale species that are rare or extralimital to the Beaufort Sea (humpback whale, minke whale, killer whale, harbor porpoise, narwhal; see Table 3), because sightings of these 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, approximately 40 mi (65 km) 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 but is very unlikely. For the purpose of this IHA request, small numbers have been included in the requested “take” authorization to cover incidental occurrences of any of these species during the proposed survey (see Section 6.3).

Beaufort Sea Seal Densities

Ice seals of the Beaufort Sea are mostly associated with sea ice and most census methods count seals 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. 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 distances traveled during the open water season (Herreman et al. 2012).

To estimate densities for ringed, bearded, and spotted seals, we used data collected during four shallow water OBC seismic surveys in the Beaufort Sea (Harris et al. 2001, Aerts et al. 2008, Hauser et al. 2008, HDR 2012). Habitat and survey specifics are very similar to the proposed survey, therefore these data were considered to be more representative than basking seal densities from spring aerial survey data (e.g., Moulton et al. 2002; Frost et al. 2002, 2004).

Because survey effort in kilometers was only reported for one of the surveys, we used sighting rate (ind/h) for calculating potential seal exposures. No distinction is made in seal density between summer and autumn season. Also, no correction factors have been applied to the reported seal sighting rates.

Seal species ratios

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 mi 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). In 2008, two OBC seismic surveys occurred in the Beaufort Sea, one in Foggy Island Bay, about 15 mi SE of Prudhoe Bay (Aerts et al. 2008), and the other at Oliktok Point, > 30 mi west of Prudhoe Bay (Hauser et al. 2008). In 2012, an OBC seismic was done in Simpson Lagoon, bordering the area surveyed in 2008 at Oliktok Point (HDR 2012). Based on the number of identified individuals the ratio ringed, bearded, and spotted seal was 75%, 8%, and 17%, respectively in Foggy Island Bay (Aerts et al. 2008), 22%, 39%, and 39%, respectively at Oliktok Point (Hauser et al. 2008), and 62%, 15%, and 23%, respectively in Simpson Lagoon (HDR 2012). Because it is often difficult to identify seals to species, a large proportion of seal sightings were unidentified in all four OBC surveys described here. The total seal sighting rate was therefore used to calculate densities for each species, using the average ratio over all four surveys for ringed, bearded, and spotted seals, i.e., 63% ringed, 17% bearded, and 20% spotted seals.

Seal sighting rates

During the 1996 OBC survey (Harris et al. 2001) the sighting rate for all seals during periods when airguns were not operating was 0.630 ind/h. The sighting rate during non-seismic periods was 0.046 ind/h 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 recorded 0.0674 ind/h when airguns were not operating (Hauser et al. 2008), and the maximum sighting rate during the Simpson Lagoon OBC seismic survey was 0.030 ind/h (HDR 2012).

The average seal sighting rate, based on these four surveys, was 0.193 ind/h. The maximum was 0.63 ind/h and the minimum 0.030 ind/h. Using the proportion of ringed, bearded, and spotted seals as mentioned above, we estimated the average and maximum sighting rates (ind/h) for each of the three seal species (Table 6).

Whale and Seal Density Summary

For the purpose of calculating the potential number of beluga and bowhead whale exposures to received sound levels of ≥160 dB re 1µPa, we used the minimum density from Tables 4 and 5 as the average density. The reason for this decision is that the 2012 data only covered block 1 and were considered more representative. To derive a maximum estimated number of exposures we used the average densities from Tables 4 and 5. We considered this approach reasonable because the 2013 beluga and bowhead whale sighting data included areas outside the zone of influence of the proposed project. For example, in 2013, only 3 of the 89 beluga sightings were seen in block 1. Table 6 summarizes the densities we used in the calculation of potential number of exposures.

Table 6. Estimated summer densities of whales and sighting rates of seals (average and maximum) for the proposed North Prudhoe Bay survey. Densities are provided in number of individuals per square kilometer (ind/km^2), sighting rates in number of individuals per hour (ind/h). No densities or sighting rates were estimated for extralimital species.

SPECIES	SUMMER DENSITIES (IND/KM^2)	
	AVERAGE	MAXIMUM
Bowhead whale	0.0015	0.0055
Beluga whale	0.0028	0.0105
	SUMMER SIGHTING RATES (IND/H)	
	AVERAGE	MAXIMUM
Ringed seal	0.122	0.397
Bearded seal	0.033	0.107
Spotted seal	0.039	0.126

6.2. Safety and Disturbance Zone Distances

Due to the natural variability in the marine environment, application of precautionary correction factors, and data interpretation in the generation of circular isopleths, there was a poor agreement between modeled and measured distances (Aerts & Streever 2013; Appendix A). In addition, the isopleths used for mitigation purposes and calculation of “takes” derived from sound source verification (SSV) measurement of similar airgun arrays in similar environments showed large variations. For the proposed 2014 seismic survey, we therefore used existing SSV measurements to establish distances to received sound pressure levels of 190, 180, 160, and 120 dB re 1µPa (rms).

Airgun arrays consist of a cluster of independent sources. Because of this, and many other factors, sounds generated by these arrays therefore do not propagate evenly in all directions. We included both broadside and endfire measurements of the array in calculating distances to the various received sound levels. Broadside and endfire measurements are not applicable to mitigation gun measurements.

Five SSV measurements exist of an array consisting of eight airguns (totaling to 880 in^3) in the shallow water environment of the Beaufort Sea. All these measurements were from 2008: one in Foggy Island Bay and four in Oliktok Point (two source vessels and two water depths). There is one measurement of a 16 airgun array (640 in^3), from the 2012 Simpson Lagoon OBC seismic survey along water depths of ~40-60 ft (outside the barrier islands). Table 7 shows average, maximum, and minimum measured distances to each of the four received SPL rms levels of the 880 in^3 array and the 880 and 640 in^3 arrays combined. We used the average distance of the combined 640-880 in^3 SSV measurements as our mitigation radii (Table 8). Although the discharge volumes of the proposed subarray (620 in^3) and combined subarrays (1240 in^3) are different than the airgun arrays measured before, the acoustic properties are very similar due to the airgun configuration (number of guns and sizes). As an example, the rms source level of the eight-gun 880 in^3 array and the eight-gun 620 in^3 arrays are very similar (217 and 218 dB re 1µPa rms, respectively). Likewise, the rms source levels of the 16-gun 640 in^3 and 1240 in^3 were comparable (223 and 224 dB re 1µPa rms, respectively). We therefore considered the distances derived from the existing airgun arrays as summarized in Table 7 representative for the proposed 620-1240 in^3 arrays.

Table 7. Average distances (in meters) to four received rms SPLs (in dB re 1 µPa) calculated from existing SSV measurements of airgun arrays with discharge volumes of 880, 640, 40 and 10 in^3. bs = broadside, ef = endfire, n = number of measurements.

AIRGUN DISCHARGE VOLUME (IN^3)		DISTANCE (IN METERS)							
		190 dB		180 dB		160 dB		120 dB	
		bs	*ef*	*bs*	*ef*	*Bs*	*ef*	*bs*	*ef*
880 IN^3	Avg	206		464		1,741		11,217	
(n=10)	*Max*	*278*	*270*	*752*	*640*	*3,800*	*2,200*	*22,000*	*16,000*
	Min	*160*	*100*	*430*	*340*	*1,100*	*970*	*4,096*	*4,400*
640–880 IN^3	Avg	257		602		2,182		11,663	
(n=12)	*Max*	*516*	*502*	*1,386*	*1,196*	*4,616*	*4,163*	*22,000*	*16,000*
	Min	*160*	*100*	*430*	*340*	*1,100*	*800*	*4,096*	*4,400*
40 IN^3	Avg	66		187		1,092		6,288	
(n=3)	*Max*	*138*		*293*		*1,602*		*9,221*	
	Min	*24*		*110*		*740*		*3,242*	
10 IN^3	Avg	16		45		451		10,783	
(n=4)	*Max*	*53*		*120*		*600*		*16,000*	
	Min	*3*		*20*		*280*		*5,000*	

Three shallow water SSV measurements were used to calculate the average, maximum, and minimum distances for the 40 in^3 mitigation gun (Table 7). Two measurements were from the 2012 Simpson lagoon seismic survey (in water depths of ~40-60 ft and 6.5 ft) and one measurement from the 2011 Harrison Bay shallow hazard survey in 6.5 ft water depth (from a 4 x 10 in^3 cluster). We derived at the distances for the 10 in^3 mitigation gun from four shallow hazard SSV measurements in the Beaufort Sea: one in 2007, two in 2008, and one in 2011. The values presented in Table 7 are similar to the average values in Table 4.5-12 (page 4-60) of NMFS' Arctic SDEIS (NMFS 2013b).

Table 8. Distances (in meters) to be used for mitigation purposes for the proposed airgun arrays of the 2014 North Prudhoe OBS seismic survey.

AIRGUN DISCHARGE VOLUME (IN^3)	DISTANCE (IN METERS)	
	190 dB RE 1 µPA	180 dB RE 1 µPA
620 – 1240 in^3	300	600
40 in^3	70	200
10 in^3	20	50

6.3. Number of marine mammals potentially affected

The current threshold for the onset of potential "level B harassment" from pulsed sounds for marine mammals under NMFS jurisdiction is 160 dB re 1 µPa (rms) (NMFS 2005). The radii associated with received sound levels of 160 dB re 1 µPa (rms) or higher were therefore used to calculate the number of potential marine mammal exposures to airgun sounds for this IHA application. 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 shutdown and power down measures (see Section 11 for a summary of the mitigation measures).

The potential number of marine mammals that might be exposed to the 160 dB re 1 µPa (rms) sound pressure level was calculated differently for whales and seals as described in the sections below. Table 9 summarizes the number of potential marine mammal exposures to pulsed sound levels of ≥160 dB re 1 µPa (rms) during the proposed seismic data acquisition and specifies the number for which authorization is requested.

Number of Whales Potentially Exposed to ≥160 dB

The potential number of bowhead and beluga whales that might be exposed to the 160 dB re 1 µPa (rms) sound pressure level was calculated by multiplying:

- the expected bowhead and beluga density as provided in Table 4 and 5;
- the anticipated area around each source vessel that is ensonified by the 160 dB re 1 µPa (rms) sound pressure level; and

- the estimated number of 24-hr days that the source vessels are operating.

The area expected to be ensonified by the 620-1240 in^3 array was determined based on the maximum distance to the 160 dB re 1 µPa (rms) sound pressure level as determined from the maximum 640-880 in^3 array measurements (Table 7), rounded to 5 km. Based on a radius of 5 km, the 160 dB isopleth used in the exposure calculations was 78.5 km^2. It is expected that on average, two source vessels will be operating simultaneously, although one source vessel might sometimes be engaged in crew change, maintenance, fueling, or other activities that do not require the operation of airguns. The minimum distance between the two source vessels will be about 550 ft. Although there will be an overlap in ensonified area, for the estimated number of exposures we summed the exposed area of each source vessel. Using the maximum distance and summing the isopleths of both source vessels provides us with conservative estimates of marine mammal exposures.

The estimated number of 24-hr days of airgun operations was determined by assuming a 25% downtime during the 45-day planned data acquisition period. Downtime is related to weather, equipment maintenance, mitigation implementation, and other circumstances. The total number of full 24-hr days that data acquisition is expected to occur is ~34 days or 816 hours.

Average and maximum estimates of the number of bowhead and beluga whales potentially exposed to sound pressure levels of 160 dB re 1µPa (rms) or more are summarized in Table 9. 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 number of exposures for these species provided in Table 9 is based on the likelihood of incidental occurrences.

The average and maximum number of bowhead whales potentially exposed to sound levels of 160 dB re 1µPa (rms) or more is estimated at ~8 and ~29, respectively. Assuming a population size of about 18,837 animals in 2014, based on the 2011 population estimate of ~16,892 animals and an annual growth rate of 3.7% (Givens et al. 2013), the number of exposed animals represents <0.02% of the population. The maximum number was used as the requested authorization, based on the unexpected large numbers of bowheads observed in August during the 2013 ASAMM survey. The average and maximum number of potential beluga exposures to 160 dB is ~15 and ~36, respectively. This is less than 0.1% of the population size as reported in the most recent stock assessment (39,258 animals; Allen & Angliss 2013). Belugas are known to show aggregate behavior and can occur in large numbers in nearshore zones, as evidenced by the sighting at Endicott in August 2013. For the unlikely event that a group of belugas appears within the 160 dB isopleth during the seismic survey, we added a number of 75 to the requested authorization. Chance encounters with small numbers of other whale species are possible, but exposures to 160 dB or more are not likely for these species.

These estimated exposures do not take into account the mitigation measures that will be implemented, such as Protected Species Observers (PSOs) 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.

Number of Seals Potentially Exposed

The estimated number of seals that might be exposed to pulsed sounds of 160 dB re 1 μPa (rms) is calculated by multiplying:

- the expected species specific sighting rate as provided in Table 4; and
- the total number of hours that each source vessel will be operating during the data acquisition period.

The estimated number of hours that each source vessel will operate its airguns was determined by assuming a 25% downtime during a 45-day survey period, which is a total of 816 hours (34 days of 24 hour operations). It is expected that on average, two source vessels will be operating simultaneously, while the third source vessel is engaged in crew change, maintenance, fueling, or other activities that do not require the operation of airguns. As a comparison, during a similar survey in Simpson Lagoon, the three source vessels were operating their airguns for a total of ~710 hrs to cover an area of 110 mi^2. The 816 hours of airgun operations for the North Prudhoe survey seems therefore a reasonable estimate. The resulting average and maximum number of ringed, bearded, and spotted seal exposures based on 816 hours of airgun operations are summarized in Table 9. We assumed that all seal sightings would occur within the 160 dB isopleth.

Table 9. Average and maximum estimated number of whales and seals potentially exposed to sound levels of 160 dB re 1μPa (rms) or more during the Prudhoe Bay OBC seismic survey. The number of animals for which Level B harassment authorization is requested is specified in a separate column.

SPECIES	NR OF IND POTENTIALLY EXPOSED TO ≥160 DB		REQUESTED LEVEL B HARASSMENT AUTHORIZATION
	AVG	MAX	
Bowhead whale	8	29	29
Beluga whale	15	56	15 (75)*
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	100	324	100
Bearded seal	27	87	27
Spotted seal	32	103	32
Ribbon seal	0	3	3

* *A number of 75 is added to the requested authorization for the unlikely event that a group of belugas appears within the 160 dB isopleth during the seismic survey*

The maximum number of ringed seals potentially exposed is estimated at 324, is <0.1% of the estimated population size of the Beaufort Sea stock (Table 3). The maximum number of bearded seals (87) and spotted seals (103) potentially exposed to sound levels of 160 dB or more represent <0.05% and <0.1% of their estimated population sizes, respectively. BPXA's requested authorization for harassment of seals covers the average number of animals potentially exposed, based on the sighting numbers from the three most recent OBC seismic surveys. Also, seals 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). It is therefore probable that at the received level of 160 dB re 1 µPa (rms), only a small percentage of seals would actually be disturbed. Any disturbance to seals 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 from the proposed airgun operations, including the pinger systems that will be used to locate receivers. Several factors should be considered when determining the potential impact from sound exposure, such as what species will be exposed, for how long, to what frequencies, at what levels, and how do these parameters compare with an animal's hearing ability. We don't have the answers to all of these factors and, consequently, we know little about the incidence and nature of long-term noise effects in most marine mammals, making it difficult to estimate probable risks from anthropogenic sources for wild marine mammal populations. However, there is some knowledge about marine mammal responses to airgun sounds, which we summarized below based on available literature.

7.1. Potential effects of airgun sounds

Based on the species and circumstances, airgun sounds can have different effects on marine mammal species, such as temporary or permanent hearing impairment, non-auditory injury, masking of natural sounds important to marine mammals, or behavioral disturbance (Richardson et al. 1995).

Hearing Impairment and Non-Auditory Injury

Permanent or temporary hearing impairment or threshold shifts could occur when marine mammals are exposed to very strong sounds or to less strong sounds for a prolonged period. Close proximity to airgun pulses has the potential for permanent or temporary threshold shifts (PTS or TTS) in marine mammals, but specific documentation does not exist because it is difficult to assess TTS or PTS outside laboratory conditions. Current policy regarding exposure of marine mammals to high-level sounds is that whales and seals 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. Based on an extensive review and syntheses of newly available data on possible TTS and PTS onset in marine mammals from pulsed sounds (Southall et al. 2007), it was suggested that threshold criteria for TTS and PTS should be based on peak sound pressure levels or sound exposure levels. Efforts are currently underway to revise the existing criteria taking into account the most recent scientific data on TTS (NMFS 2013b).

In theory, hearing impairment and non-auditory physical effects (e.g., stress, neurological effects, bubble formation, and other types of organ or tissue damage) might occur in marine mammals exposed to strong, pulsed underwater sounds. However, the limited data available do not provide definitive evidence that any of these effects occur even for marine mammals in close proximity to large arrays of airguns. Most baleen whales, some toothed whales (including belugas), and some seals show behavioral avoidance of source vessels operating airguns. In addition, the planned monitoring and mitigation measures include shutdowns of the airguns should animals enter designated "safety radii." Given the brief duration of exposure of any marine mammal in combination with the proposed monitoring and mitigation measures, auditory impairment or other non-auditory physical effects are unlikely to occur during the present project. The following subsections provide more detail about current knowledge of TTS, PTS, and non-auditory physical effects from pulsed sounds.

Permanent and Temporary Threshold Shift (PTS, TTS)

Noise induced hearing loss occurs when sensitive structures in the inner ear are damaged, which can happen following exposure to harmful noise, i.e., very loud impulsive sounds or very loud continuous sounds over a long duration. These sensitive structures, called cochlear hair cells, are small sensory cells that convert sound energy into electrical signals that travel to the brain. Once damaged, hair cells cannot grow back. PTS occurs when exposure to impulsive or continuous noise results in damage of hair cells and thus in permanent hearing loss. TTS or temporary hearing loss occurs following sound exposures less severe than those that cause PTS.

No direct information is available about what sound characteristics have the potential to elicit onset of PTS in marine mammals. Instead, the potential for PTS has been derived from studies measuring the onset of TTS. Most of these studies were conducted with captive toothed whales, such as bottlenose dolphins and beluga whales (see review in Southall et al. 2007). Both species are mid-frequency cetaceans. Only limited information on TTS exists for high-frequency cetaceans (e.g., Lucke et al. 2008; Popov et al. 2011) and none for low-frequency cetaceans (baleen whales). To derive criteria for auditory injury, Southall et al. (2007) used the TTS data available for mid-frequency cetaceans as a surrogate for the low- and high-frequency cetaceans, assuming that all groups have similar auditory mechanisms. Animals do not perceive equally well at all frequencies within their functional hearing range. Sound sources that have their primary spectral components at frequencies that animals can only perceive at high received sound levels, if at all, are less likely to affect the animal. Species-specific frequency weighing has been developed to weigh the importance of sound levels in a manner reflective of the receiver's sensitivity to those frequencies (Nedwell and Turnpenny 1998). The test sounds used in TTS experiments consist of frequencies that fall well within the functional hearing range of the animals, though not necessarily always within their best hearing sensitivity. Most TTS experiments in which toothed whales, porpoises, and seals were exposed to sound signals used non-pulse tones of frequencies from about 2-115 kHz. Toothed whales exposed to such tones of various duration, showed brief, mild TTS at received sound pressure levels (SPL) of 190–204 dB re 1µPa (Schlundt et al. 2000; Finneran et al. 2005, Finneran & Schlundt 2007). Harbor porpoises seemed to be more susceptible to TTS than harbor seals when exposed to octave-band white noise centered around 4 kHz for 60 minutes (Kastelein et al. 2012). TTS studies with baleen whales do not exist, thus levels or properties of sound that are required to induce TTS in baleen whales are unknown.

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 severe TTS or 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.

Masking

Anthropogenic underwater sound has the potential to interfere with the communication of marine mammal species or can affect their ability to detect environmental sounds. This phenomenon, also called masking, can occur when the frequency of the introduced sound is close to that used by the animal and 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: their calls could be detected between seismic pulses (e.g., Richardson et al. 1986; McDonald et al. 1995; Greene et al. 1999; Nieukirk et al. 2004). Studies from northern Norway and the Gulf of Mexico 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. 2013). 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 whales 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.

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. Seals and small toothed whales seem generally more tolerant to exposures of airgun pulses than baleen whales.

Behavioral Disturbance

Behavioral responses to sound exposure can be variable, ranging from subtle changes in behavioral parameters (e.g., breathing rate, travel speed, dive time) to more conspicuous changes in activities (e.g., disruption to feeding or migration) and displacement. Short-term subtle behavioral responses that are within the animal’s normal range and do not have any biological significance are not considered to 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).

Behavioral reactions to sound are context-specific and depend on the species 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; Ellison et al. 2011). 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 reported behavioral observations. Baleen whale behavioral studies exist mainly for bowhead, humpback, and gray whales. Less detailed data are available for other baleen whale species. Toothed whales are not likely to occur in the project area.

Baleen whales

Studies of gray, bowhead, and humpback whales have determined that received levels of pulses in the 160–170 dB re 1 µPa rms range appear to cause obvious avoidance behavior in some individuals. For the much smaller airgun arrays of this seismic survey, measured distances to received levels of 160 dB re 1 µPa rms ranged from about 0.5 to 3 mi (about 0.8 to 5 km) depending on various factors (see Table 7). Baleen whales within those distances of operating source vessels may show avoidance or other disturbance reactions, but few baleen whales are expected to occur in the Prudhoe Bay 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 mi (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 1µPa·s^{-2} as summed over 15 minutes (Blackwell et al. 2013). 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. (2008) 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 in^3 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 Prudhoe Bay seismic project will be conducted during the summer, when most bowhead whales are commonly feeding in the Mackenzie River Delta. As part of the planned mitigation measures, BPXA will end data acquisition (i.e., the use of airguns) in late August at a date agreed upon in the CAA. Impacts to bowhead whales from the proposed activities are therefore expected to be minimal, if they occur at all.

Toothed whales

Based on the relatively limited information available about the potential impacts from airgun sounds on toothed whales (compared to the more extensive studies conducted on baleen whales), it can be concluded that reactions of toothed whales to large airgun arrays are variable and generally seems to be confined to a smaller radius than has been observed for baleen whales. There are a few studies that report on responses of various toothed whales to airgun 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 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 mi (7-13 km) or full array exposures at 0.6-8 mi (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 & Osmek 1998; Stone 2003). An example are the lower sighting rates of beluga whales within 6.2-12 mi (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 mi (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. The small range within which these levels would occur, combined with the low numbers of beluga whales expected to be encountered create a minimal expectation of impact on toothed whales.

Seals

Seals are generally even less responsive to airgun sounds than whales 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 seals, 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 seal 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 seal individuals or populations.

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. 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 or live strandings of marine mammal species.

7.2. Potential effects of pinger signals

A pinger system (Sonardyne Acoustical Pingers) will be used during seismic operations to position the receivers. These pingers transmit very short pulses of sounds. 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.

Hearing Impairment and Non-Auditory 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.

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 are within the animal’s normal range and do not have any biological significance, do not rise to a level requiring a small “take” authorization.

Stranding and Mortality

Some stranding events of mid-frequency cetaceans were attributed to sonar surveys in the area (e.g., Southall et al. 2006). Recently, an independent scientific review panel concluded that the mass stranding of approximately 100 melon-headed whales in northwest Madagascar in 2008 was primarily triggered by a multi-beam echosounder system (Southall et al. 2013). However, considering the use and acoustic specification of pingers during the proposed survey, the shallow water environment, the unlikely presence of toothed whales in the area, and planned monitoring and mitigation measures, no marine mammal injury, death, or strandings are expected.

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 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 >200 mi west from the survey area. It is the largest community on the Alaska's Beaufort Sea coast. 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 55 mi southwest of the project area. The 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 120 mi east of the project area. 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 10). 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). 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 mi a day (EDAW/AECOM 2007). In Barrow, most whales were historically taken during spring whaling. More recently, however, the efficiency of the spring harvest appeared to be lower than the fall 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.

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 mi east of the Prudhoe Bay survey area. Nuiqsut whalers harvest an average of 2 bowheads each year (Table 10). 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 mi of the community (ADNR 2009). Kaktovik whalers harvest an average of 2–3 bowhead whales each year (Table 10).

Table 10. Average number (standard deviation) of bowhead whales landed in Barrow, Nuiqsut, and Kaktovik between 1974-1977 and 1978-2011 (the quota was instituted in 1978). Source: Suydam & George 2012

VILLAGE	1974-1977 AVERAGE/YEAR	1978-2011 AVERAGE/YEAR
Barrow	15.5 (7.05)	15.5 (8.23)
Nuiqsut	0	2.0 (1.22)
Kaktovik	1.5 (1.0)	2.5 (1.0)

Beluga Whale

The harvest of beluga whales is managed cooperatively through an agreement between NMFS and the Alaska Beluga Whale Committee (ABWC). From 2005-2009, 5-48 beluga whales were harvested annually from the Beaufort Sea stock (Allen & Angliss 2013), with a mean annual take of 25.8 animals. Both Nuiqsut and Kaktovik harvest few beluga whales, mostly opportunistically during the fall bowhead hunt.

Seals

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.

8.2. Anticipated Impact

The proposed seismic survey will take place between 1 July and 30 September, with seismic data acquisition occurring in July and August. The project area is located >200 mi east from Barrow, approximately 55 mi northeast from Nuiqsut (but just south of Cross Island), and 120 mi west from Kaktovik. Potential impact on the subsistence hunt from the planned activities is expected mainly from sounds generated by airguns. Due to the timing of the project and the distance from the surrounding communities, there will be no effects on spring harvesting and little or no effects on the occasional summer harvest of beluga whale and subsistence seal hunts (ringed and spotted seals are primarily harvested in winter, while bearded seals are hunted during July-September in the Beaufort Sea). The community of Nuiqsut may begin fall whaling activities in late August to early September from Cross Island (just north of the survey area). As part of the planned mitigation measures, BPXA will complete all airgun operations at a date agreed upon by the Nuiqsut whaling captains as captured in the CAA. No or little impact on the fall bowhead hunt from the proposed activities is therefore expected to occur.

BPXA will participate in a 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 activities of the proposed OBS seismic survey are not expected to result in any permanent impact on habitats or food resources that are of importance to marine mammals. 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 whales and seals, 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 seals and some whales, 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 (Fechhelm & Griffiths 2001). While there is limited data on the impacts of airguns on food resources of whales and seals, there is no information to suggest that any potential impacts will affect marine mammal populations. During the proposed seismic survey BPXA proposes to conduct a monitoring study that might increase our knowledge about impacts on fish from airgun sounds in a field setting (see Section 13).

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.

None of the project activities have the ability to damage or otherwise destruct marine mammal habitat that would result in habitat loss or modification.

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 airgun sounds into the marine environment is the main source of potential impacts on marine mammals 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 TTS or PTS or behavioral changes. 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 NMFS. The mitigation measures can be divided into two main groups:

1. General mitigation measures that apply to all vessels involved in the survey (Section 11.1); and
2. Specific mitigation measures that apply to source vessels operating airguns (Section 11.2).

The primary purpose of the 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). PSOs are an important component in implementing these mitigation measures. Section 11.3 provides information on the PSO observation protocol, communication procedures, and data recording.

11.1. General mitigation measures

These general mitigation measures apply to all vessels that are part of the Prudhoe Bay 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.

- To minimize collision risk with marine mammals, vessels shall not be operated at speeds that would make collisions likely. When weather conditions require, such as when visibility drops, vessels shall adjust speed accordingly to avoid the likelihood of marine mammal collisions;
- The source vessels and most other vessels working offshore do not have propellers. However, vessel operators of small craft with propellers shall check the waters immediately adjacent to their vessels to ensure that no marine mammals will be injured;
- 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 ft (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; and
    - Avoiding multiple changes in direction and speed.
- 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; and
- In the event that any aircraft (such as helicopters) are used offshore 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 ft above sea level (ASL) when within 0.3 mile (0.5 km) of groups of whales; and
    - 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 sound pressure levels of 190 dB dB re 1µPa (rms) for seals and 180 dB re 1µPa (rms) for whales.

PSOs on board 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 determined based on existing SSV measurements (Table 8). PSOs will use these distances to monitor the safety zones during the entire project. When marine mammals are observed within, or about to enter, these designated safety zones, PSOs 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.

During ramp up, BPXA intends to implement the common procedure of doubling the number of operating airguns at 5-minute intervals, starting with the smallest gun in the array. For the 620 in^3 sub-array this is estimated to take approximately 15 minutes and for the 1240 in^3 airgun array approximately 20 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 minutes (seals) or 30 minutes (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) has not been sighted for at least 15 minutes (seals) or 30 minutes (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, 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 PSO 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 PSOs 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; and
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 has been visually observed leaving the safety zone of the full array, or has not been seen within the zone for 15 minutes (seals) or 30 minutes (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-hr operations. PSOs 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; and
- 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.

11.3. Protected Species Observers

Two marine mammal observers (referred to as PSOs) will be present on each seismic source vessel. Of these two PSOs, one will be on watch at all times to monitor the 190 and 180 dB safety zones for the presence of marine mammals during airgun operations. The main objectives of the vessel-based marine mammal monitoring are as follows:

1. To implement mitigation measures during seismic operations (e.g. course alteration, airgun power-down, shut-down and ramp-up); and
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.

Protected Species Observer Protocol

BPXA intends to work with experienced PSOs. 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 PSOs, their monitoring protocol, and mitigation measures to be implemented.

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). PSOs 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 PSO in consultation with the other PSOs.

The source vessels will offer suitable platforms for marine mammal observations. Observations will be made from locations where PSOs have the best view around the vessel. During daytime, the PSO(s) will scan the area around the vessel systematically with reticle binoculars and with the naked eye. Because the main purpose of the PSO on board the vessel is detecting marine mammals for the implementation of mitigation measures according to specific guidelines, we prefer to keep the information to be recorded as concise as possible. This will allow the observer to focus on detecting marine mammals. The following information will be collected:

- Environmental conditions – consisting of sea state (in Beaufort Windforce scale according to NOAA), visibility (in km, with 10 km indicating the horizon on a clear day), and sun glare (position and severity). These will be recorded at the start of each shift, whenever there is an obvious change in one or more of the environmental variables, and whenever the observer changes shifts;
- Project activity – consisting of airgun operations (on or off), number of active guns, line number. This will be recorded at the start of each shift, whenever there is an obvious change in project activity, and whenever the observer changes shifts; and

- Sighting information – consisting of the species (if determinable), group size, position and heading relative to the vessel, behavior, movement, and distance relative to the vessel (initial and closest approach). These will be recorded upon sighting a marine mammal or group of animals.

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 shutdown procedures will be implemented immediately. To assure prompt implementation of power-downs and shutdowns, multiple channels of communication between the PSOs and the airgun technicians will be established. During the power-down and shutdown, the PSO(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 (seals) or for 30 minutes (whales). Direct communication with the airgun operator will be maintained throughout these procedures.

Data Recording

All marine mammal observations and any airgun power-down, shutdown, and ramp up will be recorded in a standardized format. Data will be entered into or transferred to a custom database. The accuracy of the data entry will be verified daily through QAQC procedures. Recording 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 other programs for further processing and archiving.

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 considers participation in the CAA, with the Alaska Eskimo Whaling Commission (AEWC) and North Slope communities' Whaling Captains' Associations, as the written Plan of Cooperation with the nearby communities with respect to subsistence bowhead whale hunting. This stakeholder-driven approach to multi-use management has proven to be very effective in reducing conflicts (Lefevre 2013).

With regard to a plan of cooperation for other marine mammal species, BPXA will communicate with subsistence users in the area to ensure that our activities do not prevent access to the resources should hunting of animals other than the bowhead whale take place during the proposed survey.

12.1. Stakeholder Engagement

BPXA has begun discussions with the AEWC to develop a CAA intended to minimize potential interference with bowhead subsistence hunting. Initial CAA coordination meetings began in September 2013. BPXA also attended and participated in meetings with the AEWC on December 13, 2013 and will attend future meetings to be scheduled in 2014. The CAA, when executed, will describe measures to minimize any adverse effects on the availability of bowhead whales for subsistence uses.

The North Slope Borough Department of Wildlife Management (NSB-DWM) will be consulted and BPXA plans to present the project to the NSB Planning Commission in 2014. BPXA will hold meetings in the community of Nuiqsut to present the proposed project, address questions and concerns from community members, and provide them with contact information of project management to which they can direct concerns during the survey.

During the NMFS Open-Water Meeting in Anchorage in 2013, BPXA presented their proposed projects to various stakeholders that were present during this meeting. BPXA will provide updates to the projects and their monitoring and mitigation measures during the open water meeting of 2014.

BPXA will continue to engage with the affected subsistence communities regarding its Beaufort Sea activities, as done throughout the history of BPXA's Alaska North Slope operations. As in previous years, BPXA will meet formally and/or informally with several stakeholder entities: the North Slope Borough (NSB) Planning Department, NSB-DWM, NMFS, AEWC, Inupiat Community of the Arctic Slope (ICAS), Inupiat History Language and Culture Center (IHLC), USFWS, Nanuq and Walrus Commissions, and ADF&G.

Project information was provided to and input on subsistence obtained from the AEWC and Nanuq Commission at the following meetings:

- AEWC, October 17, 2013
- Nanuq Commission, October 17, 2013

Additional meetings with relevant stakeholders will be scheduled and a record of attendance and topics discussed will be maintained and submitted to NMFS.

12.2. Measures to Reduce Impact

The measures to reduce impacts and ensure communication with the community listed below were developed from the 2013 CAA and previous NSB Development Permits (with specific stipulations addressing subsistence users under NSBMC 19.70.050).

BPXA will comply with the CAA terms and NSB permit stipulations to address plans to meet with the affected community to resolve conflicts and notify the communities of any changes in the operation. More detailed information about the mitigation measures that will be implemented to reduce impacts to marine mammals are outlined in Section 11 of the IHA request.

- PSOs on board vessels are tasked with looking out for whales and other marine mammals in the vicinity of the vessel to assist the vessel captain in avoiding harm to whales and other marine mammals.;
- Vessels and aircraft will avoid areas where species that are sensitive to noise or vessel movements are concentrated;
- Communications and conflict resolution are detailed in the CAA. BPXA will participate in the Communications Center that is operated annually during the bowhead subsistence hunt;
- Communications with the village of Nuiqsut to discuss community questions or concerns including all subsistence hunting activities;
    - Pre-project meeting(s) with Nuiqsut representatives will be held at agreed times with groups in the community of Nuiqsut. If additional meetings are requested, they will be set up in a similar manner;
- Contact information for BPXA will be provided to community members and distributed in a manner agreed at the community meeting;
- BPXA has contracted with a liaison from Nuiqsut who will help coordinate meetings and serve as an additional contact for local residents during planning and operations;
- Inupiat Communicators will be employed and work on seismic source vessels. They will also serve as PSOs; and
- BPXA and contractors will follow a Polar Bear and Pacific Walrus Awareness and Interaction Plan addressing food and waste management, personnel training, reporting guidance on sightings, and safety and communication regarding polar bears.

12.3. Future Plan of Cooperation Consultations

BPXA continues to engage with the relevant subsistence communities regarding its Beaufort Sea activities, as done throughout the history of BPXA's Alaska North Slope operations. With regard to the 2014 North Prudhoe OBS seismic project, BPXA will present the data on marine mammal sightings and the results of the marine mammal monitoring and mitigation as part of our 90-day report to the regulatory authorities. We will present the results at the 2015 NMFS Open-Water Meeting in Anchorage, which is attended by many representatives of interested stakeholder groups, including the NSB DWM and AEWC.

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.

In keeping with guidance provided by the NMFS in Section 5.3 of the 2013 Supplemental Draft Environmental Impact Statement (SDEIS), BPXA considered a number of monitoring and reporting opportunities that could contribute to the collective knowledge of marine mammals, marine mammal prey, and marine mammal habitat. The potential to conduct meaningful research on impacts of airgun sounds on marine mammals during the shallow water North Prudhoe OBS seismic survey is limited due to the small number of animals in the region and other factors. However, the potential to conduct research on fish species in relation to airgun operations–including prey species important to ice seals–may yield valuable information relevant to Section 5.3.1(e) of the SDEIS, which calls for “an increase in our understanding of how the activity affects marine mammal habitat, such as through effects on prey sources or acoustic habitat.” The effect of airgun sounds on large-scale fish behavior is an issue of concern not only for marine mammal conservation but also for the Inupiat traditional Arctic cisco fishery in Nuiqsut, Alaska.

13.1. Fish and Airgun Sound Monitoring

The North Prudhoe OBS seismic survey offers a unique opportunity to assess the impacts of airgun sounds on fish, specifically on changes in fish abundance in fyke nets that have been sampled in the area for more than thirty years. During the first two months of the open water season from 1981 through 2013, biologists contracted by BP checked fyke nets daily, with the exception of 1999 and 2000. Figure 3 shows the fyke net locations relative to the planned seismic operation and Figures 4 and 5 show fyke net sampling and a fyke net design. Primary species caught are Arctic cisco (*Coregonus autumnalis*), least cisco (*Coregonus sardinella*), northern Dolly Varden (*Salvalinus malma*), broad whitefish (*Coregonus nasus*), humpback whitefish (*Coregonus pidschian*), Arctic flounder (*Liopsetta glacialis*), fourhorn sculpin (*Myoxocephalus quadricornis*) and rainbow smelt (*Osmerus mordax*). In a typical year, more than 50,000 fish representing 18 species are caught in the fyke nets. In 2012, more than 30,000 fish were caught of which about 40% consisted of Arctic cisco and broad whitefish (Fechhelm & Raborn 2013).

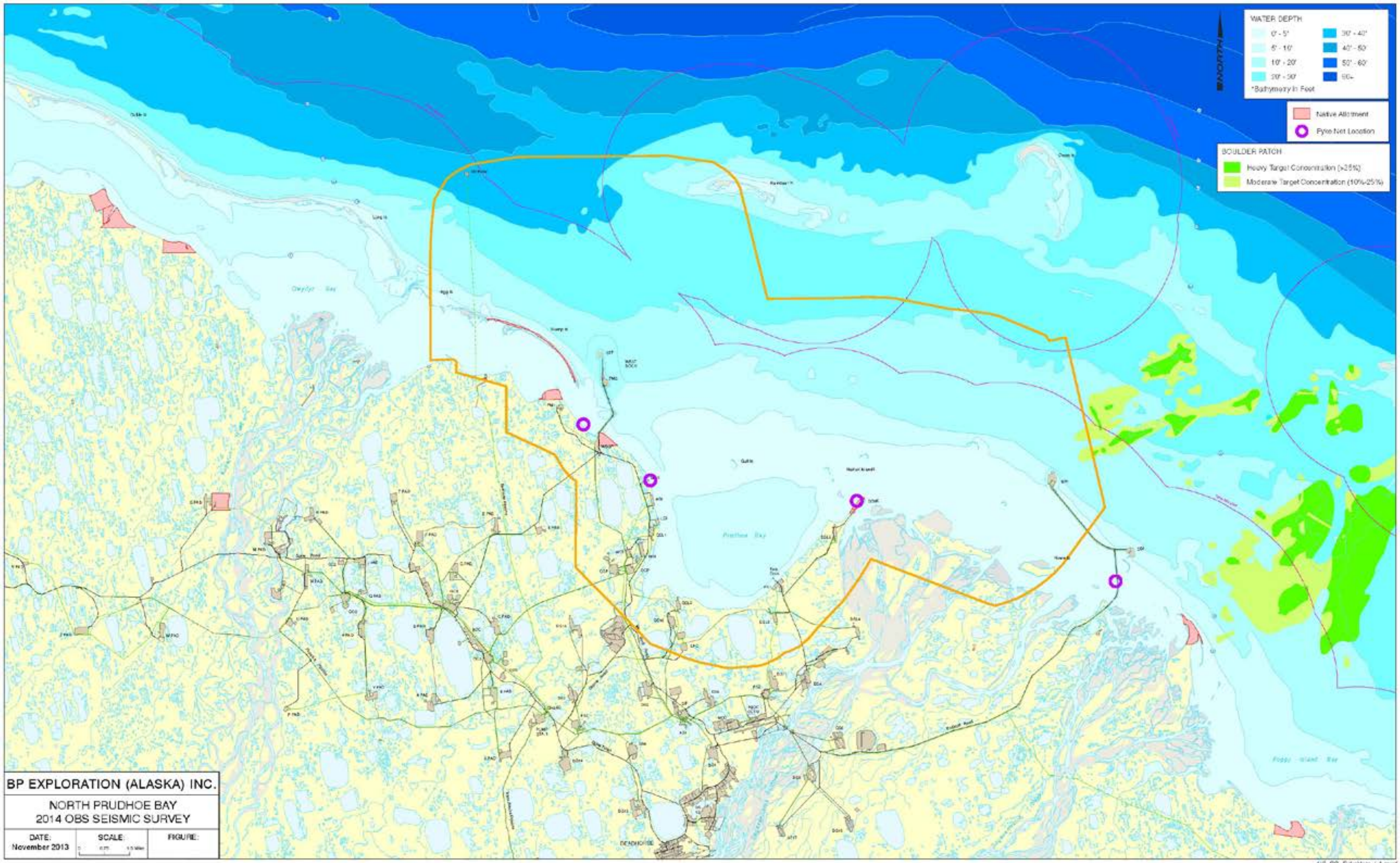

Figure 3. North Prudhoe Bay Seismic Program and location of long-term fyke net stations. Water depth at fyke net stations is 1-1.5 m.

Figure 4. Fyke net sampling in Prudhoe Bay.

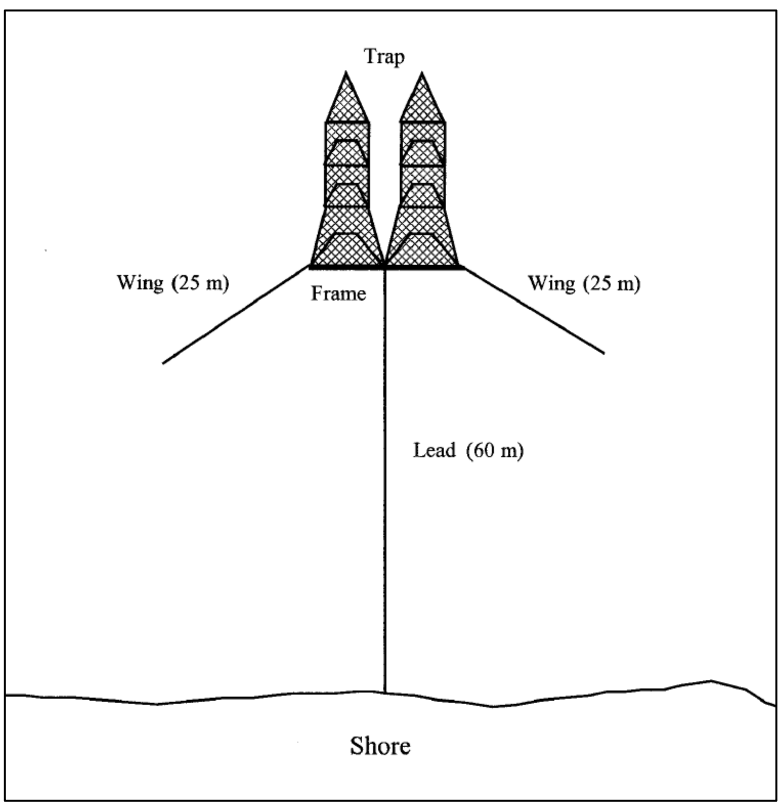

Figure 5. Fyke net design and layout.

During the two-month study period, fish are counted and sized every day, unless sampling is prevented by weather, the presence of bears, or other events. Fish mortality is also noted. The fish-sampling period coincides with the North Prudhoe seismic survey, resulting in a situation where each of the four fyke nets will be exposed to varying daily exposures to airgun sounds. That is, as source vessels move back and forth across the project area, fish caught in nets will be exposed to different sounds levels at different nets each day.

To document relationships between fish catch in each fyke net and received sound levels, BP will attempt to instrument each fyke net location with a recording hydrophone. Recording hydrophones, to the extent possible, will have a dynamic range that extends low enough to record near ambient sounds and high enough to capture sound levels during relatively close approaches by the airgun array (i.e., likely levels as high as about 200 dB re 1 uPa). Bandwidth will extend from about 10 Hz to at least 500 Hz.

In addition, because some fish (especially salmonids) are likely to be sensitive to particle velocity instead of or in addition to sound pressure level, BP will attempt to instrument each fyke net location with a recording particle velocity meter.

Acoustic and environmental data will be used in statistical models to assess relationships between acoustic and fish variables. Table 8 lists possible variables that could be included in the analyses.

Table 8. Possible acoustic, fish, and environmental variables that could be considered for multi-variate analyses to determine the impact from airgun sounds on fish.

Fish variables	Acoustic variables	Environmental variables
Daily fish abundance per net (probably in Log of Catch per Unit Effort)	Daily maximum rms and peak sound pressure levels	Julian day
Daily number of fish mortalities for each species in each net	Daily maximum per pulse sound exposure levels	Daily wind conditions
	Daily cumulative sound exposure levels	Daily water temperatures
	Daily average such as Leq (equivalent continuous noise level)	Tide conditions
	Daily average and maximum particle velocity values	

Additional analyses may compare catch rates immediately before and after the beginning of airgun operations and immediately before and after cessation of airgun operations. Other analyses could assess changes in multi-year catch patterns that could be attributed to the seismic survey.

Details of the study, including a detailed analytical plan, will be determined after the study has been approved as part of the Incidental Harassment Authorization. These details will be developed in consultation with an expert panel. Professor Art Popper and Dr. Tony Hawkins, both world-renowned for their work with fish responses to underwater sound, have agreed to serve on the panel. Other panelists invited to serve on the panel will include a fisheries biometrician, a North Slope Borough biologist, a NOAA representative, and a subsistence hunting representative from Nuiqsut.

13.2. Reporting

90-day report

BPXA will submit a report to NMFS within 90 days after the end of the seismic survey summarizing relevant project information and results from the PSO program. Summaries of the project activities and results of the marine mammal monitoring and mitigation data will include the following information:

- Summary of project start and end dates, airgun activity, number of guns, and the number and circumstances of implementing ramp up, power down, shutdown, and other mitigation actions;
- Marine mammal observation effort in total number of hours and total number of line kilometers. This will include a summary of environmental conditions that can affect marine mammal detection, such as visibility and sea state;
- A summary of marine mammal sighting information, such as species observed, group sizes, behavior, distribution, and the date and time of each sighting;
- A summary of sighting information related to airgun activity, including (a) marine mammal sighting rates; (b) sighting distances (initial and closest point of approach); and (c) observed behaviors and movements; and
- An estimate of seal and whale exposures to sound levels of 160 dB re 1µPa (rms) and a comparison to the estimated exposures in the IHA application. BPXA cannot provide estimates of “takes” since it is impossible to determine which exposures would have resulted in a behavioral response that would be considered a “take” as defined by the MMPA.

Fish and Airgun Sound Report

BP will present the results of the fish and airgun sound study to NMFS in a detailed report that will also be submitted to a peer reviewed journal for publication, presented at a scientific conference, and presented in Barrow and Nuiqsut.

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 effects related to activities that produce anthropogenic sound.

BPXA remains committed to an improved understanding of the cumulative effects of multiple sound sources. 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 on marine mammals associated with underwater sound. Experts from the NSB, the NMFS, the Marine Mammal Commission (MMC), and a number of other organizations have participated in this working group. The NSB also contributed funding and logistical support. The method developed by the working group, as it stands in late 2013, includes three key steps:

1. Model the acoustic footprint in a region of interest over a period of interest (e.g., the Beaufort Sea during a fall migration);
2. Let simulated whales (animats) swim through the modeled footprint, and
3. Collect sound exposure data from each of the animats swimming through the modeled footprint and analyze this data.

In 2012, BP, with the support of the working group, presented the method to the Society of Petroleum Engineers in Perth, Australia, and published a summary paper in the proceedings from the conference (Streever et al. 2012). In late 2013, the working group submitted a paper fully describing the method to a technical journal for publication. The working group continues to pursue a qualitative method for assessing cumulative effects. BP has been contacted by various individuals associated with the National Research Council about interest in the issue and the approach adopted by the expert working group. BP hopes to see this effort continued and expanded in the coming year.

In 2013, BP, with ConocoPhillips and LAMA Ecological, hosted a workshop on modeling and measurement of underwater sounds as they apply to development of mitigation radii at the Alaska Marine Science Symposium in Anchorage. The workshop led to further work presented at the 2013 Third International Conference on the Effects of Underwater Sound on Aquatic Life. This work will be published in the conference proceedings.

BP continues to support conferences and workshops related to underwater sound, including, for example, the 2013 Third International Conference on the Effects of Underwater Sound on Aquatic Life. Support includes both funding and organizational assistance.

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APPENDIX A

Comparison of Modeled and Measured Underwater Sound Isopleths and Implications for Marine Mammal Mitigation in Alaska

Modeled and Measured Underwater Sound Isopleths and Implications for Marine Mammal Mitigation in Alaska

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Abstract

Prior to operating airguns in Alaska, industry is usually required to model underwater sound isopleths, some of which have implications for mitigation and monitoring of potential marine mammal impacts. Field measurements are often required to confirm or revise model predictions. We compared modeled and measured airgun sound isopleths from 2006–2012 and found poor agreement. Natural variability in the marine environment, application of precautionary correction factors, and data interpretation in the generation of circular isopleths all contributed to the observed poor agreement. A broader understanding of the realities of modeled and measured underwater sound isopleths will contribute to improved mitigation practices.

1. Introduction

In seismic operations, the oil and gas industry tows airguns behind vessels to generate sound impulses. These vessels are generally referred to as "source vessels." Images of the stratigraphy underlying the seabed are generated from reflected sound impulses. These images are used to guide exploration and production drilling, manage existing reservoirs, and identify hazards buried in the seabed. As such seismic operations are essential to the offshore oil and gas industry.

The sound impulses generated by airguns could, under certain circumstances, "take" marine mammals. The United States Marine Mammal Protection Act (MMPA) requires efforts to prevent "take", a term that means actual injury as well as disruption of behavioral patterns (including migration, breathing, nursing, breeding, feeding, or sheltering). In addition, the MMPA requires efforts to document the number of "takes" that can occur despite preventative measures. Actual observations of impacts meeting the definition of "take" are rare, in part due to the difficulties associated with making and interpreting observations at sea. With that in mind, sound exposures are often used as a surrogate for "takes."

During airgun operations in the Alaskan Arctic, marine mammal mitigation and monitoring required by the government in its administration of the MMPA requires knowledge of the extent of the 190, 180, 160, and 120 dB re 1 µPa (rms) isopleths. Airguns cannot be operated if seals are present within the 190 dB re 1 µPa (rms) isopleth or if cetaceans are present within the 180 dB re 1 µPA (rms) isopleth. The 160 and 120 dB re 1 µPa (rms) isopleths can trigger additional mitigation requirements. Also, animals exposed to impulsive sounds of 160 dB re 1 µPa (rms) or more (such as those associated with airguns) or continuous sounds of 120 dB re 1 µPa (rms) or more (such as those associated with vessel operations) are assumed to be potentially "taken" regardless of whether harm or meaningful behavioral responses are observed.

"Take" estimates for airgun sounds are generally derived by multiplying the extent of the modeled or measured sound isopleths of 160 dB re 1 µPa (rms) with expected species densities from scientific surveys or field observations made during previous seismic operations in the area of interest. Both sound isopleths and species densities are associated with high levels of uncertainty. In this paper we focus on the uncertainties associated with sound isopleths.

Information on the extent of sound isopleths comes from acoustic models and from acoustic measurements. Acoustic models combine information about source levels with information about factors known to affect sound propagation (including water depth, water temperature, salinity, and seabed characteristics) to yield three dimensional (distance and depth) estimated distances at which various sound levels are received. Acoustic measurements typically rely on hydrophones recording at numerous distances from a source. Both endfire and broadside measurements are sometimes reported. Endfire measurements, or measurements from the bow and stern aspects of a source vessel, are usually collected using several bottom founded hydrophones that record airgun sounds while the source vessel approaches and moves away. Broadside measurements, from the port or starboard aspects of a source vessel, are usually collected by three or more recording hydrophones placed in a line perpendicular to the source vessel's direction of travel. In contrast to acoustic models, acoustic measurements typically yield two-dimensional (distance but not depth) estimated distances at which various sound levels are received. In both cases, to facilitate mitigation and monitoring requirements in the field, isopleths are generally plotted as circles even if models or measurements indicate that actual isopleths have an irregular shape.

Over the past six years in the Alaskan Arctic, airgun operators have used both acoustic models (to predict the extent of sound isopleths) and acoustic measurements (to verify the modeled predictions). In this paper, we compare sound isopleths derived from models to those derived from measurements. In addition, we discuss the causes and ramifications of the differences in estimates derived from models and measurements, and we assess the degree to which agreement has improved over time.

2. Data Compilation of Modeled and Measured Sound Isopleths

Modeled sound isopleths from airgun operations in the Alaskan Arctic are generally reported in Requests for an Incidental Harassment Authorization (IHA) of Marine Mammals submitted to the National Marine Fisheries Service (NMFS), the government agency responsible for administering the MMPA as it applies to seals and whales. Detailed results of acoustic measurements conducted during airgun operations of the oil and gas industry are documented in monitoring reports which, according to the IHA stipulations, have to be submitted to the NMFS within 90 days of survey completion.

We obtained IHA Requests and 90-day monitoring reports of seismic surveys in the Alaskan Arctic during the period 2006–2012 from the website of the NMFS Office of Protected Resources (http://www.nmfs.noaa.gov/pr/permits/incidental.htm) (Ireland et al., 2007; Aerts et al., 2008; Funk et al., 2008; Hauser et al., 2008; Hannay & Warner 2009; O'Neill et al., 2010; Chorney et al., 2011; Warner & Hipsey, 2011; Warner & MCCrodan, 2011; McPherson & Warner, 2012) . We only compiled isopleth information for sound pressure levels that are assumed to have the potential to harm marine mammals (190 and 180 dB re 1µPa rms, for pinnipeds and cetaceans, respectively), that are used for calculating behavioral "takes" of airgun sounds (160 dB re 1µPa rms), or that might trigger mitigation requirements under some circumstances (120 dB re 1µPa rms). When available, we included both endfire and broadside measurements of the airgun sounds.

Modeled and measured isopleths from various airgun operations, involving different airgun discharge volumes and taking place in different areas, were compiled in a single database. We included the following information if available: year of survey, total airgun discharge volume (cubic inches [in^3]), smallest airgun in array (in^3), water depth in survey area (meters [m]), modeled distances to the four received sound pressure levels (m), and measured distances to the four sound pressure levels for both endfire and broadside aspects.

3. Results of Sound Isopleth Comparisons

We compiled 133 records of modeled and measured sound isopleth data from airgun operations in the Chukchi and Beaufort Seas from 2006 through 2012. Airgun operations included offshore marine streamer seismic surveys, ocean bottom cable (OBC) seismic surveys, and shallow hazard surveys. Offshore marine streamer seismic surveys used airgun discharge volumes ranging from 3,000−3,390 in^3 (up to 24 airguns) and occurred in water depths of 15−50 m. OBC seismic surveys took place in shallower water (1−20 m) and used airgun discharge volumes ranging from 320−880 in^3 (with up to 16 guns). The shallow hazard surveys for which we compiled sound isopleth data were done in water depths of 15−50 m, using 1−4 airguns of 10 in^3 each. Modeling and measurements were also done for the mitigation gun, i.e., the smallest gun in the array. Discharge volumes of mitigation guns ranged from 10−70 in^3.

Although modeling and measurement occasionally yielded sound isopleths that were in close agreement with one another, differences could be substantial (Fig. 1). For example, differences in distances to modeled and measured sound isopleths were as high as 920 m, 2,900 m, 13,405 m, and 130,000 m for the 190, 180, 160, and 120 dB re 1 µPa (rms) isopleths, respectively. Even for the smallest sources—those with airgun volumes of 10−70 in^3—differences between modeled and measured sound isopleths were as high as 150 m, 360 m, 1,120 m, and 11,392 m for the 190, 180, 160, and 120 dB re 1 µPa (rms) isopleths, respectively. Percentage differences in measured and modeled sound isopleths from the smaller airgun arrays and higher sound pressure levels were more substantial than for the larger arrays and lower sound pressure levels (Fig.1). In many cases, differences between modeled and measured estimates for a single source along a single transect were positive for some isopleths and negative for others. There was no pattern apparent between modeled and measured distances that would suggest a clear path to a correction factor. Also, there was no evidence of improved agreement over time, as might be expected if methods were improving as experience accumulated (Fig. 2). In fact, the only clear pattern was one of generally increasing differences with distance from the source, as would be expected at the larger distance scales associated with isopleths for lower sound pressure levels (Fig. 2).

Figures 1 and 2 somewhere here

4. Discussion

Distance discrepancies between modeled and measured sound pressure level isopleths can be attributed to a number of causes, ranging from inadequate input data for models to decisions about how to interpret modeled and measured data and how to convert output to circular mitigation and monitoring zones. Model predictions of underwater sound isopleths require knowledge of the source and of sound propagation. Underwater sound propagation is complex and dependent on numerous factors, such as, but not limited to, water depth, bottom type and relief, surface reflection, absorption and sound speed profile (influenced by temperature and salinity, among other), source depth, and source characteristics (e.g., frequency composition, directivity). Many of these factors are subject to temporal and spatial variability and it is unlikely that data used in models routinely reflect actual conditions during measurements.

Because uncertainty is inherent to modeling, cautionary adjustments are sometimes made to input data. For example, source levels are sometimes elevated by 3 dB re 1µPa (rms). Likewise, conservative interpretations are introduced in the measured sound isopleths that are used for mitigation purposes. In most cases, regression lines drawn through measured data points are adjusted upward to assure that 90% or in some cases 100% of data points are below the regression line used to define mitigation isopleths.

Modeling typically results in isopleths with an irregular shape, reflecting differences to modeled sound pressure levels at different depths and at different directions that are related to source directivity and sound propagation. However, the practical needs of mitigation and monitoring require conversion of these irregular shapes to circles. Typically, these circles are drawn to capture the greatest modeled distance to each isopleth, regardless of depth or bearing from the source. Measurements, on the other hand, are typically undertaken along one or a few bearings (forward, aft, and abeam of the source vessel) and at a single depth, typically close to the seabed. Measurements taken abeam of the source vessel are usually based on a small number of data points. Measurements are sometimes extrapolated to capture isopleths beyond the range of the measurements, which has the capacity to introduce substantial errors, especially at the 160 and 120 dB re 1μPa (rms). When measurements are collected at more than one bearing, the bearing with the longest distance to each isopleth is often used to define the circle used for mitigation and monitoring. The conversion of irregularly shaped polygons to circles may account for most of the modeling versus measured discrepancies described in this paper.

The challenges associated with modeling isopleths, the practice of limiting measurements to a single depth and a small number of bearings from a source vessel, and the practical need to convert irregularly shaped isopleths to circles for the purpose of mitigation and monitoring explain the poor agreement between modeled and measured isopleths. There is little reason to believe that agreement between modeled and measured isopleths will improve unless substantial changes are made to methods, including standardization of all aspects of the process. However, the real issue may not be one of improving agreement of modeled and measured isopleths, but rather one of applying mitigation distance requirements that adequately protect marine mammals without unnecessarily disrupting seismic operations. This requires not only improved methods of defining sound isopleths, but also an improved understanding of the levels and kinds of sounds likely to harm marine mammals and improved methods of detecting and ranging marine mammals under field conditions.

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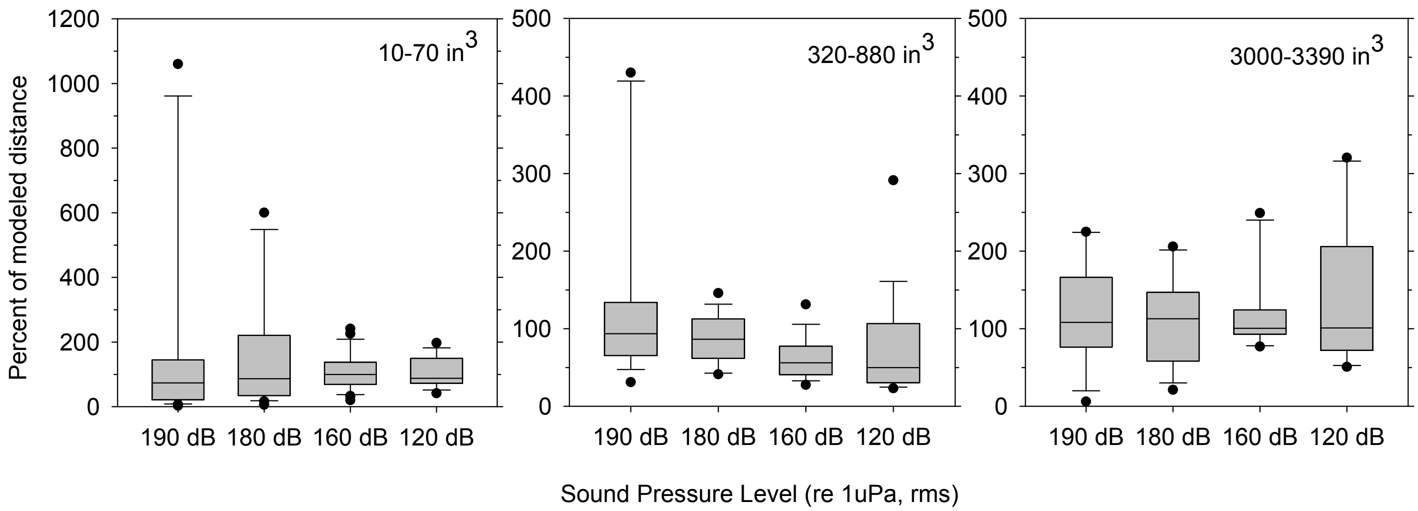
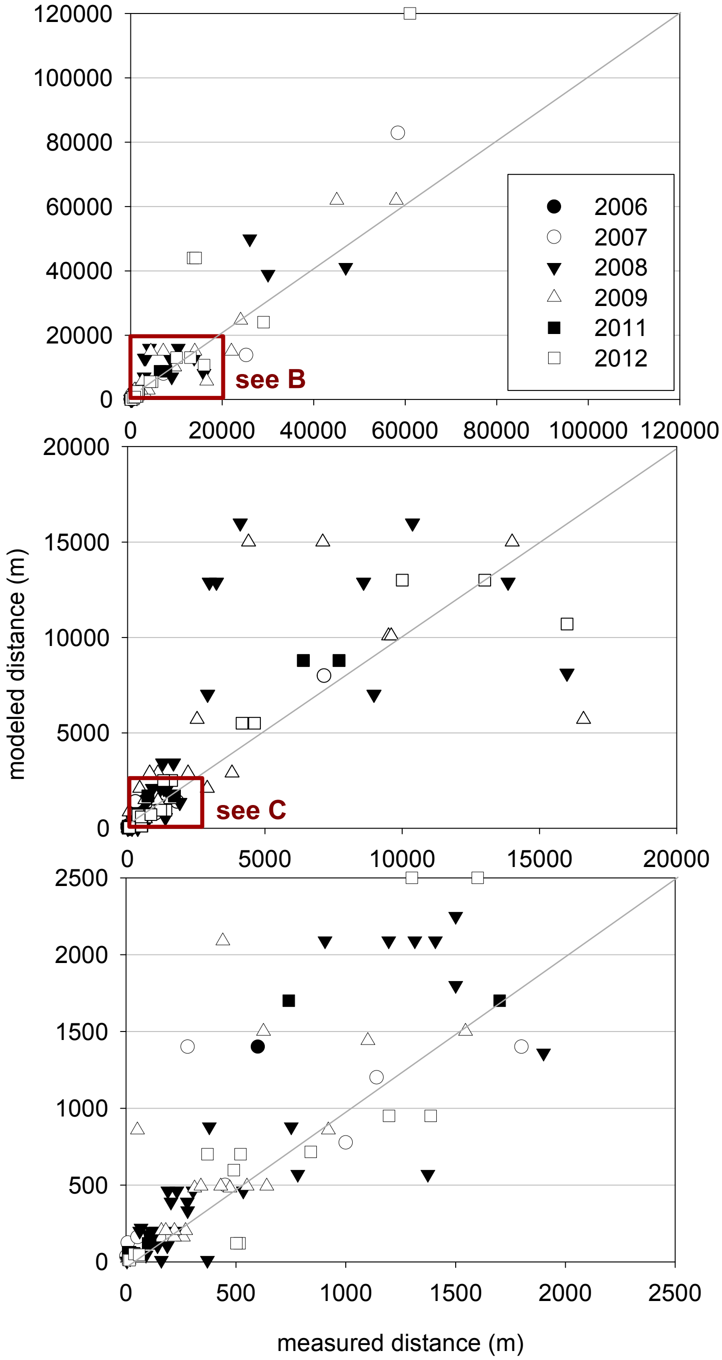
Figure legends

Figure 1. Differences between measured and modeled sound isopleths for four different sound pressure levels and three airgun volume categories. The difference is expressed in percentage of modeled distances. Boxplots show the 5, 25, 50, 75, and 95% percentage values. Note the different scale used for the 10-70 in^3 airgun graph, in which two outliers (1600% and 3600% for the 190 dB and 180 dB re 1µPa sound levels, respectively) are not displayed.

Figure 2. Modeled versus measured distances from several airgun sources to various received sound pressure levels for surveys conducted in the Alaskan arctic from 2006–2012. Points on the diagonal line represent 100% agreement between modeled and measured distances. Graphs are shown in three different scales as represented by the red squares.


Percent of modeled distance
0
200
400
600
800
1000
1200
10-70 in3
320-880 in3
3000-3390 in3
0
100
200
300
400
500
190 dB
180 dB
160 dB
120 dB
Sound Pressure Level (re 1uPa, rms)



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