ENDANGERED SPECIES ACT – SECTION 7 CONSULTATION

BIOLOGICAL OPINION

AGENCY: National Marine Fisheries Service, Office of Protected Resources

ACTIVITY: Issuance of Incidental Harassment Authorization under section 101(a)(5)(a) of the Marine Mammal Protection Act to BP Offshore, Inc. for seismic surveys in the Simpson Lagoon in 2012.

CONSULTATION CONDUCTED BY: National Marine Fisheries Service, Alaska Region

APPROVED BY: ______________________

DATE ISSUED: 6.21.12

Table of Contents

I. PRESENTATION OF THIS OPINION

Biological opinions are constructed around several basic sections that represent specific requirements placed on the analysis by the ESA and implementing regulations. These sections contain different portions of the overall analytical approach described here. This section is intended as a basic guide to the reader of the other sections of this opinion and the analyses that can be found in each section. Each step of the analytical approach described below will be presented in this opinion in either detail or summary form.

<u>Description of the Proposed Action</u> – This section contains a basic summary of the proposed federal action and any interrelated and interdependent actions. This description forms the basis of the first step in the analysis where we consider the various elements of the action and determine the stressors expected to result from those elements. The nature, timing, duration, and location of those stressors define the action area and provide the basis for our exposure analyses.

<u>Status of the Species</u> – This section provides the reference condition for the species at the listing and designation scale. These reference conditions form the basis for the determinations of whether the proposed action is likely to jeopardize the species. Other key analyses presented in this section include critical information on the biological and ecological requirements of the species and the impacts to species from existing stressors.

<u>Environmental Baseline</u> – This section provides the reference condition for the species within the action area. The baseline includes the impacts of past and on-going actions (except the effects of the proposed action) on the species. This section also contains summaries of the impacts from stressors that will be ongoing in the same areas and times as the effects of the proposed action and includes future federal actions for which consultation has been completed (future baseline). This information forms part of the foundation of our exposure, response, and risk analyses.

<u>Effects of the Proposed Action</u> – This section details the results of the exposure, response, and risk analyses NMFS conducted for listed species.

<u>Cumulative Effects</u> – This section summarizes the impacts of future non-federal actions reasonably certain to occur within the action area. Similar to the rest of the analysis, if cumulative effects are expected, NMFS determines the exposure, response, and risk posed to individuals of the species.

Synthesis and Integration – In this section of the opinion, NMFS presents the summary of the effects identified in the preceding sections and then details the consequences of the risks posed to individuals to the species or Distinct Population Segment at issue.

Conclusions - Finally, this document concludes whether the proposed action is likely to result in jeopardy to the continued existence of a species.

Legal and Policy Framework

The purposes of the ESA, "*…are to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, to provide a program for the conservation of such endangered species and threatened species, and to take such steps as may be appropriate to achieve the purposes of the treaties and conventions set forth in subsection (a) of this section*." To help achieve these purposes, the ESA requires that, "*Each Federal agency shall, in consultation with and with the assistance of the Secretary, insure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of designated critical habitat…*"

Jeopardy Standard

The "jeopardy" standard has been further interpreted in regulation (50 CFR 402.02) as a requirement that federal agencies insure that their actions are not reasonably expected to reduce appreciably *the likelihood of both the survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution*. It is important to note that the purpose of the analysis is to determine whether or not appreciable reductions are reasonably expected, but not to precisely quantify the amount of those reductions. As a result, our assessment often focuses on whether a reduction is expected or not, but not on detailed analyses designed to quantify the absolute amount of reduction or the resulting population characteristics (abundance, for example) that could occur as a result of proposed action implementation.

The parameters of productivity, abundance, and population spatial structure are important to consider because they are predictors of extinction risk, the parameters reflect general biological and ecological processes that are critical to the survival and recovery of the listed species, and these parameters are consistent with the "reproduction, numbers, or distribution" criteria found within the regulatory definition of jeopardy (50 CFR 402.02).

Additional requirements on the analysis of the effects of an action are described in regulation (50 CFR 402) and our conclusions related to "jeopardy" generally require an expansive evaluation of the direct and indirect consequences of the proposed action, related actions, and the overall context of the impacts to the species and habitat from past, present, and future actions as well as the condition of the affected. Recent court cases have reinforced the requirements provided in section 7 regulations that NMFS must evaluate the effects of a proposed action within the context of the current condition of the species, including other factors affecting the survival and recovery of the species.

Consultations designed to allow federal agencies to fulfill these purposes and requirements are concluded with the issuance of a biological opinion or a concurrence letter. Section 7 of the ESA and the implementing regulations (50 CFR 402), and associated guidance documents (*e.g.*, USFWS and NMFS 1998) require biological opinions to present: (1) a description of the proposed Federal action; (2) a summary of the status of the affected species and its critical habitat; (3) a summary of the environmental baseline within the action area; (4) a detailed analysis of the effects of the proposed action on the affected species and critical habitat; (5) a description of cumulative effects; and (6) a conclusion as to whether it is reasonable to expect the proposed action is not likely to appreciably reduce the species' likelihood of both surviving and recovering in the wild by reducing its numbers, reproduction, or distribution or result in the destruction or adverse modification of the species' designated critical habitat. Since no critical habitat has been designated or proposed for any species in this opinion, none of the critical habitat elements listed above are included in this document.

Consultation History and Source Documents

NMFS's Office of Protected Resources requested formal consultation on this action by letter received April 20, 2012. As oil and gas exploration expands in the Chukchi and Beaufort Seas, more analyses like this one are being conducted. This opinion draws on information presented and analyzed in other recent opinions including the biological opinion prepared to evaluate the proposed issuance of an incidental harassment authorization to Shell in connection with exploratory drilling operations in the Beaufort Sea (NMFS 2012c) and an Arctic Regional Biological Opinion on MMS oil and gas leasing and exploration in the Beaufort and Chukchi Seas (2008). This opinion also used information in both BP's IHA application (BP 2012) and NMFS Protected Resources' *Federal Register* notice for the authorization (NMFS 2012a), as well as its environmental assessment of the action under NEPA(NMFS 2012b).

II. DESCRIPTION OF THE PROPOSED ACTION

This opinion will address authorization by NMFS of the incidental and unintentional taking of bowhead whales, ringed seals, and bearded seals due to ocean bottom cable seismic surveys by BP in the Simpson Lagoon area of the Beaufort Sea. Section 101 (a)(5) of the Marine Mammal Protection Act (MMPA), directs the Secretary of Commerce to allow, upon request by U.S. citizens engaged in a specific activity (other than commercial fishing) in a specified geographical region, the incidental but not intentional taking of small numbers of marine mammals if certain findings are made. Such authorization may be accomplished through regulations and issuance of letters of authorization under those regulations, or through issuance of an incidental harassment authorization (IHA). These authorizations may be granted only if an activity would have no more than a negligible effect on the species (or stock) in question, if the activity would not have an unmitigable adverse impact on the availability of the marine mammals for subsistence uses, and if the permissible method of taking and requirements pertaining to the monitoring and reporting of such taking are set forth to ensure the activity will have the least practicable adverse effect on the species or stock and its habitat. These authorizations are often requested for oil and gas activities which produce underwater noise capable of harassing or harming marine mammals. Harassment is a form of taking otherwise prohibited by the MMPA and ESA.

On December 5, 2011, NMFS received an application from BP requesting an IHA for the Simpson Lagoon Ocean Bottom Cable Seismic Survey 2012 in the Beaufort Sea.

The proposed activities that have the potential to disturb marine mammals include exposure to pulsed sounds from vessel sonar systems, pingers, and airguns used during the seismic survey; exposure to sounds from helicopter traffic flying to and from the barrier islands to deploy and retrieve receivers; and physical presence of vessels in the area. Eleven marine mammal species have the potential to be impacted by BP’s Simpson Lagoon, Beaufort Sea OBC program:

- Cetacean species - bowhead whale (*Balaena mysticetus*) is the most commonly occurring cetacean species in the action area; killer whale (*Orcinus orca*); beluga whale (*Delphinapterus leucas*); gray whale (*Eschrichtius robustus*); minke whale (*Balaenoptera acutorostrata*); and humpback whale (*Megaptera novaeangliae*) is extralimital in this area of the Beaufort Sea.

- Pinniped species - ringed seal (*Phoca hispida*)is the most commonly occurring pinniped species in the action area; bearded seal (*Erignathus barbatus*); ribbon seal (*Histriophoca fasciata*); and spotted seal (*P. largha*).

NMFS's proposed action is to issue an IHA to BP for the take of these eleven marine mammal species, by harassment, incidental to conducting the Simpson Lagoon OBC surveys during the 2012 open-water season (i.e., July through October). NMFS published a Notice of Proposed IHA and request for comments in the *Federal Register* on May 1, 2012 (77 FR 25830). NMFS has also prepared a draft environmental assessment of the proposed IHA (NMFS, 2012).

This Biological Opinion incorporates much of the information presented within the NMFS's Notice of Proposed IHA and environmental assessment, as well as pertinent research on matters related to oil exploration and its potential impacts on bowhead whales and pinnipeds. Traditional knowledge and the observations of Inupiat hunters are presented in this analysis. This knowledge contributes, along with western science, to a more complete understanding of these issues. Consideration of both these systems of knowledge strengthens our assessment of potential effects.

While the primary action considered in this opinion is the authorization of incidental take under the MMPA as described above, the specifics associated with BP's seismic survey in the Beaufort Sea represent indirect or associated activities that are broadly considered to be part of the action. We present an overview of these actions below. Detailed discussions of the BP seismic survey may be found in the applications for the IHA here: http://www.nmfs.noaa.gov/pr/pdfs/fr/fr77-25830.pdf

Description of the Specified Activity

BP is planning three dimensional (3-D) ocean bottom cable (OBC) seismic surveys in the Simpson Lagoon area of the Beaufort Sea during the open water season of 2012, Figure 1.

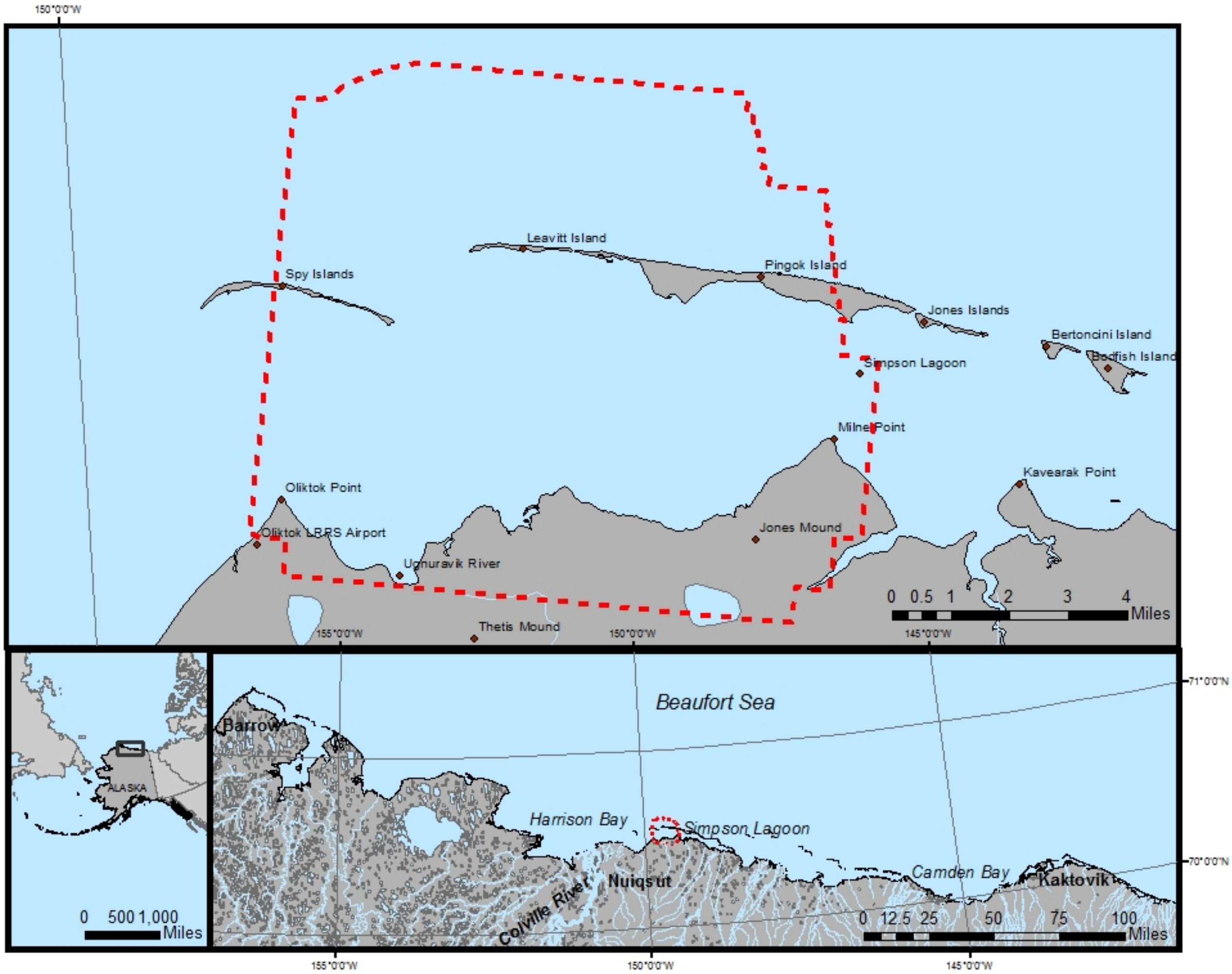


Figure 1. Simpson Lagoon seismic survey area of the Beaufort Sea depicted by red dashed line.

The proposed seismic survey utilizes receivers (hydrophones and geophones) connected to a cable that would be deployed from a vessel to the seabed or would be inserted in the seabed in very shallow water areas near the shoreline. The generation of 3D seismic images requires the deployment of many parallel cables spaced close together over the area of interest. Therefore, OBC seismic surveys require the use of multiple vessels for cable deployment and recovery, data recording, airgun operation, re-supply, and support. The proposed 3D OBC seismic survey in Simpson Lagoon would be conducted by CGGVeritas.

Seismic Source Arrays

A total of three seismic source vessels (two main source vessels and one mini source vessel) would be used during the proposed survey. The sources would be arrays of sleeve airguns. Each main source vessel would carry an array that consists of two sub-arrays. Each sub- array contains eight 40 in^3 airguns, totaling 16 guns per main source vessel with a total discharge volume of 2 × 320 in^3, or 640 in^3. This 640 in^3 array has an estimated source level of ~223 dB re 1 mPa (rms). The mini source vessel would contain one array with eight 40 in^3airguns for a total discharge volume of 320 in^3. The estimated source level of this 320 in^3 array is 212 dB re 1 mPa (rms). The arrays of the main source vessels would be towed at a distance of ~30 feet (ft, or 10 m) from the stern at 6 ft (2 m) depth, which is remotely adjustable if needed. The array of the mini source vessel would be towed at a distance of ~20 ft (7 m) from the stern at 3 ft (1 m) depth, also remotely adjustable when needed. The source vessels will travel along pre-determined lines with a speed varying from ~1 to 5 knots, mainly depending on the water depth. To limit the duration of the total survey, the source vessels would be operating in a flip-flop mode, with the operating source vessels alternating shots; this means that one vessel discharges airguns when the other vessel is recharging. Outside the barrier islands, the two main source vessels would be operating with expected shot intervals of 8 to 10 seconds, resulting in a shot every 4 to 5 seconds due to the flip-flop mode of operation. Inside the barrier islands all three vessels (the two main source vessels and the mini vessel) may be operating at the same time in this manner. The exact shot intervals would depend on the compressor capacity, which determines the time needed for the airguns to be recharged. Seismic data acquisition would be conducted 24 hours per day.

Receivers and Recording Units

The survey area in Simpson Lagoon has water depths of 0 to 9 ft (0 to 3 m) between the shore and barrier islands and 3 to 45 ft (1 to 15 m) depths north of the barrier islands. Because different types of receivers would be used for different habitats, the survey area is categorized by the terms onshore, islands, surf-zone and offshore. Onshore is the area from the coastline inland. Islands are the barrier islands. Surf zone is the 0 to 6 ft (0 to 2 m) water depths along the onshore coastline. Offshore is defined as depths of 3 ft (1 m) or more. There is a zone between 3 and 6 ft (1 and 2 m) which may be categorized both as surf zone and as offshore. The receivers that would be deployed in water consist of multiple hydrophones and recorder units (Field Digitizing Units or FDUs) placed on Sercel ULS cables. Approximately 5,000 hydrophones would be connected to the ULS cable at a minimum of 82.5 ft (27.5 m) intervals and secured to the ocean bottom cable. Surface markers and acoustic pingers will be attached to the cable at various intervals to ensure that the battery packs can be located and retrieved when needed and to determine exact positions for the hydrophones. This equipment would be deployed and retrieved with cable boats. The data received at each FDU would be transmitted through the cables to a recorder for further processing. This recorder will be installed on a boat- barge combination and positioned close to the area where data are being acquired. While recording, the boat- barge combination is stationary and expected to utilize a two or four point anchoring system. In the surf-zone, receivers (hydrophones or geophones) would be bored or flushed up to 12 ft (4 m) below the seabed. These receivers will transmit data through a cable (as described above) and have an attached line to facilitate retrieval after recording is completed. Autonomous recorders (nodes) would be used onshore and on the islands. The node is located on the ground and its geophone would be inserted into the ground by hand with the use of a planting pole. Deployment of the autonomous receiver units would be done by a lay-out crew on the ground using helicopters for personnel and equipment transport and/or approved summer travel vehicles (onshore) and a support boat (for the islands). Data from nodes can be remotely retrieved from a distance (up to a kilometer). Retrieval of data may be from a boat or a helicopter. Equipment would be picked up after recording is complete.

Survey Design

The total area of the proposed seismic survey is approximately 110 mi^2, which includes onshore, surf-zone, barrier islands, and offshore (Figure 2). For the proposed survey, the receiver cables with hydrophones and recording units would be oriented in an east-west direction. A total of approximately 44 receiver lines would be deployed at the seafloor with 1,100–1,650 ft (367–550 m) line spacing. Total receiver line length would be approximately 500 miles (825 km). The source vessel would travel perpendicular over the offshore receiver cables along lines oriented in a north-south direction. These lines would have a length of approximately 3.75 miles (6.2 km) and a minimum spacing of 660 ft (220 m). The total length of all source lines is approximately 4,000 miles (6,600 km), including line turns. The position of each receiver deployed onshore, in the surf zone and on the barrier islands will be determined using Global Positioning System (GPS) positioning units. Due to the variable bathymetry of the survey area, determining positions of receivers deployed in water may require more than one technique. A combination of Ocean Bottom Receiver Location (OBRL), GPS and acoustic pingers will be used. For OBRL, the source vessel fires a precisely positioned single energy source multiple times along either side of the receiver cables. Production data may also be used instead of dedicated OBRL acquisition. Multiple energy sources are used to triangulate a given receiver position. In addition, Sonardyne acoustical pingers would be located at predetermined intervals on the receiver lines. The pingers are located on the ULS cables and transmit a signal to a transponder mounted on a vessel. This allows for an interpolation of the receiver locations between the acoustical pingers on the ULS cable and also serves as a verification of the OBRL method. The Sonardyne pingers transmit at 19–36 kHz and have a source level of 188–193 dB re mPa at 1m.

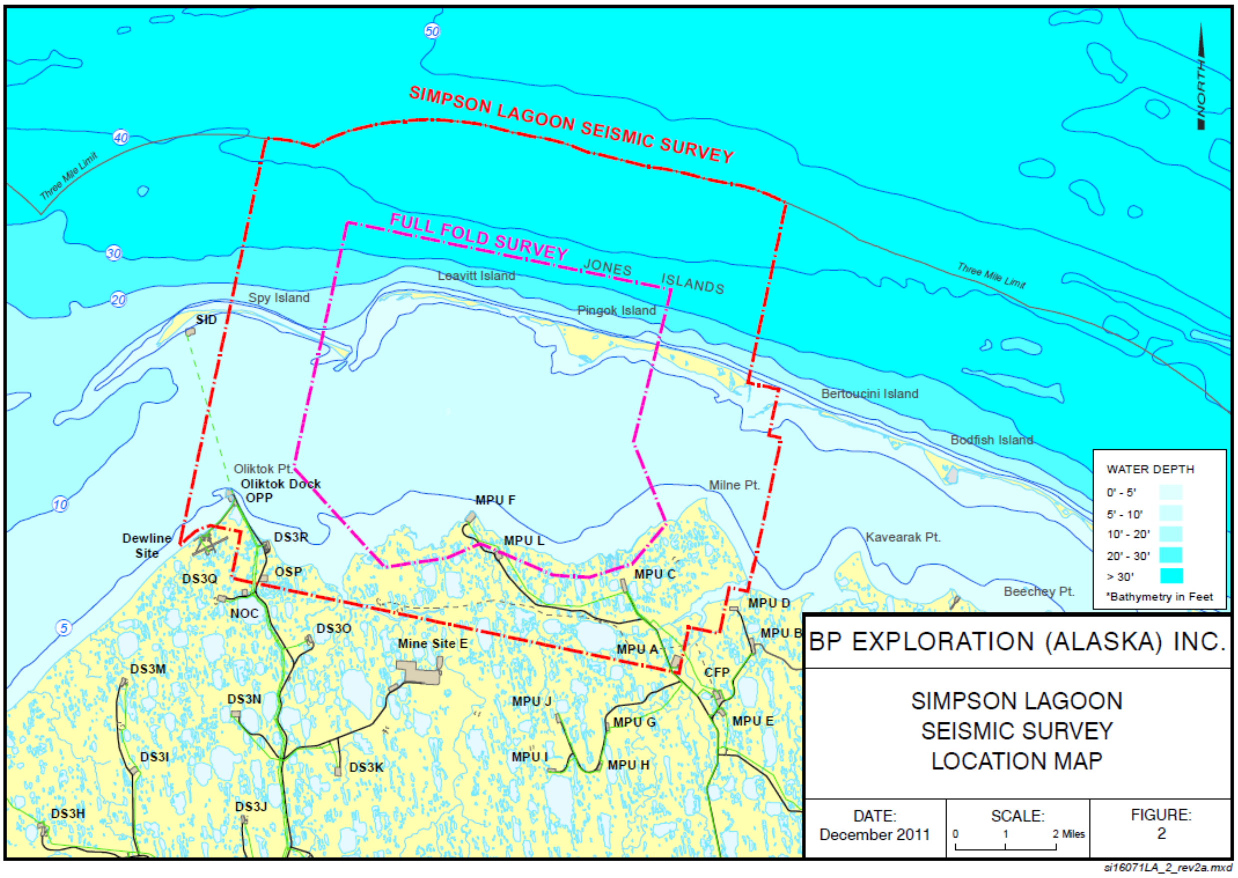


Figure 2. Simpson Lagoon seismic survey area. The pink dashed line represents the area where data needs to be acquired and the red dashed line shows the area covered by the receiver and source lines. Placement of the recorder barge may occur outside these lines. Also note that support vessels will transit between West Dock, Oliktok Point and the survey area (BP, 2011).

Vessels and Other Equipment

The proposed Simpson Lagoon OBC seismic survey would involve 14 to 16 vessels, as listed in Table 1 below. The contracting of vessels has not been finalized to date. However, BP states it would contract vessels with parameters similar to those described in this table. If contracted vessels differ significantly from those described, BP would submit an amendment to address these changes where required.

Table 1. Summary of number and type of vessels involved in the proposed Simpson Lagoon OBC seismic survey. The dimensions provided are approximate.

Vessel type	**Number**	**Dimensions**	**Main activity**	**Frequency**
Source Vessel: Main	2	71 × 20 ft	Seismic data acquisition inside and outside barrier islands	24-hr operation
Source Vessel: Mini	1	55 × 15 ft	Seismic data acquisition inside barrier islands	24-hr operation
Recorder barge with tug boat	1	116.5 × 24 ft (barge); 23 × 15 ft	Seismic data recording	24-hr operation

		(tug)		
Cable boats	5 – 6	42.6 × 13 ft	Deploy and retrieve receiver cables (with hydrophones/geophones)	24-hr operation
Crew transport vessels	2	44 × 14 ft	Transport crew and supplies to and from the working vessels	Intermittently, minimum every 8 hours
Shallow water crew and support boats	2 – 3	34 × 10.5 ft	Transport 2 – 5 people and small amounts of gear for the boats operating in the shallower parts of the survey area	Intermittently
HSSE vessel	1	38 × 15 ft	Support SSV measurements, HSSE (health, safety, security, and environmental) compliance	As required

To deploy and retrieve receivers in water depths less than those accessible by the cable boats (surf-zone), equipment such as airboats, buggies or an Arktos (amphibious craft) and/or Jon boats may be used. Helicopters and/or approved tundra travel vehicles would be used for deployment of receiver units onshore as well on the barrier islands. In the case of helicopters being used, the flight altitude would be at 1,500 feet for 3 to 6 times each day during gear deployment and retrieval on barrier islands and on shore (i.e., for about 14 days in late July and early August for deployment and for about 14 days probably after the Cross Island hunt, which typically ends around September 10). Vessels and other equipment would be transported to the North Slope in late May/early June by trucks. Equipment would be staged at the CGGVeritas pad for preparation. Vessel preparation would include assembly of navigation and source equipment, cable deployment and retrieval systems and safety equipment. Once assembled, vessels would be launched at either West Dock or Milne Point. Deployment, retrieval, navigation and source systems will then be tested near West Dock or in the project area prior to commencement of operations.

Crew Housing and Transfer

The total number of people that would be involved is about 220, including crew on boats, camp personnel, mechanics, and management. There are no accommodations available on the source vessels or cable boats for the crew directly involved in the seismic operations, so crews would be changed out every 8 to 12 hours. Two vessels would be used for crew transfers.

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

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

Dates, Duration, and Action Area

NMFS Office of Protected Resources is proposing incidental harassment authorization for the period July 1 to October 15, 2012. Anticipated duration of seismic data acquisition is approximately 50 days, depending on weather and other circumstances. To limit potential impacts to the bowhead whale migration and the subsistence hunt, no airgun operations would take place in the area north of the barrier islands after August 25, 2012 (Figure 2). Surf zone geophone retrieval may continue for a brief period after airgun operations are complete.

Transportation of vessels to West Dock would occur by road in late May/early June. It is not anticipated that vessels would need to transit by sea; however, in case this does occur the transit would take place when ice conditions allow and in consideration of the spring beluga and bowhead hunt in the Chukchi Sea.

The project area encompasses 110 square miles in Simpson Lagoon, Beaufort Sea, Alaska. The approximate boundaries of the total surface area are between 70°28′ N and 70°39′ N and between 149°24′W and 149°55′ W (Figure 2). About 46 mi^2 (41.8%) of the survey area is located inside the barrier islands in water depths of 0 to 9 ft (0 to 3 m), and 36 mi^2 (32.7%) outside the barrier islands in water depths of 3 to 45 ft (1 to 15 m). The remaining 28 mi^2 (25.5%) of the survey area is located on land (onshore and barrier islands), which is solely being used for deployment of the receivers. The planned start date of seismic data acquisition offshore of the barrier islands is July 1, 2012, depending on the presence of ice. Open water seismic operations can only start when the project area is ice free (i.e. < 10% ice coverage), which in this area normally occurs around mid-July (+/- 14 days). Limited layout of receiver cables might be possible on land and barrier islands before the ice has cleared.

Mitigation, Monitoring, Reporting, and Recording Measures

The following sections represent a combination of different kinds of mitigation, monitoring, reporting, and recording measures. All the measures that follow would help to minimize effects to endangered species and species proposed for listing under the ESA as a result of the IHA. These measures are considered part of the action being analyzed. Additional recommendations appear in the Conservation Recommendations section of this document to be considered for this and future similar actions.

Mitigation Measures

In order to issue an incidental take authorization under Section 101(a)(5)(D) of the MMPA, NMFS must set forth the permissible methods of taking pursuant to such activity, and other means of effecting the least practicable adverse impact on such species or stock and its habitat, paying particular attention to rookeries, mating grounds, and areas of similar significance, and on the availability of such species or stock for taking for certain subsistence uses. For the proposed BP open-water seismic survey in the Beaufort Sea, BP worked with NMFS and proposed the following mitigation measures to minimize the potential impacts to marine mammals in the project vicinity as a result of the marine seismic survey activities. These proposed mitigation measures are considered part of the action being analyzed.

The proposed mitigation measures are divided into four major groups:

(1) Sound source measurements,
(2) Establishing exclusion and disturbance zones,
(3) Vessel and helicopter related mitigation measures, and
(4) Mitigation measures for airgun operations.

The primary purpose of these mitigation measures is to detect marine mammals within, or about to enter designated exclusion zones and to initiate immediate shutdown or power down of the airgun(s), therefore it's very unlikely injury or temporary threshold shifts (TTS) to marine mammals would occur, and Level B harassment of marine mammals would be reduced to the lowest level practicable.

(1) Sound Source Measurements

The acoustic monitoring program has two objectives: (1) to verify the modeled distances to the exclusion and disturbance zones from the 640 in^3 and 320 in^3 airgun arrays and to provide corrected distances to the PSOs; and (2) to measure vessel sounds (i.e., received levels referenced to 1 m from the sound source) of each representative vessel of the seismic fleet, to obtain information on the sounds produced by these vessels.

Verification and Establishment of Exclusion and Disturbance Zones
Acoustic measurements to calculate received sound levels as a function of distance from the airgun sound source will be conducted within 72 hours of initiation of the seismic survey. These measurements will be conducted according to a standard protocol for the 640 in^3 array, the 320 in^3 array and the 40 in^3 gun, both inside and outside the barrier islands. The results of these acoustic measurements will be used to re-define, if needed, the distances to received levels of 190, 180, 160 and 120 dB. The distances of the received levels as a function of the different sound sources (varying discharge volumes) will be used to guide power-down and ramp-up procedures. A preliminary report describing the methodology and results of the verification for at least the 190 dB and 180 dB (rms) exclusion zones will be submitted to NMFS within 14 days of completion of the measurements.

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

(2) Establishing Exclusion and Disturbance Zones

Under current NMFS guidelines, the ‘‘exclusion zone’’ for marine mammal exposure to impulse sources is customarily defined as the area within which received sound levels are ≥180 dB re 1 mPa (rms) for cetaceans and ≥190 dB re 1 mPa (rms) for pinnipeds. These safety criteria are based on an assumption that SPL received at levels lower than these will not injure these animals or impair their hearing abilities, but that at higher levels might have some such effects.

Disturbance or behavioral effects to marine mammals from underwater sound may occur after exposure to sound at distances greater than the exclusion zones (Richardson et al. 1996). An acoustic propagation model, i.e., JASCO's Marine Operations Noise Model (MONM), was used to estimate the distances to received sound levels of 190, 180, 170, 160, and 120 dB re 1mPa (rms) for pulsed sounds from the 640 in^3 and 320 in^3 airgun arrays. Modeling methodology and results are described in detail in the appendix of the BP's IHA application (BP 2011). Table 6 summarizes the distances from the source to specific received sound levels based on MONM modeling.

The distances to received sound levels of 160 dB re 1 mPa (rms) of the 640 in^3 airgun array were used to calculate the numbers of marine mammals potentially harassed by the activities. The distances to received levels of 180 dB and 190 dB re 1 mPa (rms) are mainly relevant as exclusion radii to avoid level A harassment of marine mammals through implementation of shut down and power down measures (see details below).

(3) Vessel and Helicopter Related Mitigation Measures

These proposed mitigation measures apply to all vessels that are part of the Simpson Lagoon seismic survey, including crew transfer vessels.

•Vessel operators shall avoid concentrations or groups of whales and vessels shall not be operated in a way that separates members of a group. In proximity of feeding whales or aggregations, vessel speed shall be less than 10 knots.

•When within 900 feet (300 m) of whales vessel operators shall take every effort and precaution to avoid harassment of these animals by:

Reducing speed and steering around (groups of) whales if circumstances allow, but never cutting off a whale's travel path;

Avoiding multiple changes in direction and speed.

•Vessel operators shall check the waters immediately adjacent to a vessel to ensure that no marine mammals will be injured when the vessel's propellers (or screws) are engaged.

•To minimize collision risk with marine mammals, vessels shall not be operated at speeds that would make collisions with whales likely. When weather conditions require, such as when visibility drops, vessels shall adjust speed accordingly to avoid the likelihood of injury to whales.

•Sightings of dead marine mammals would be reported immediately to the BP representative. BP is responsible for ensuring reporting of the sightings according to the guidelines provided by NMFS.

•In the event that any aircraft (such as helicopters) are used to support the planned survey, the mitigation measures below would apply:

- Under no circumstances, other than an emergency, shall aircraft be operated at an altitude lower than 1,000 feet above sea level (ASL) when within 0.3 mile (0.5 km) of groups of whales.
- Helicopters shall not hover or circle above or within 0.3 mile (0.5 km) of groups of whales.

(4) Mitigation Measures for Airgun Operations

The primary role for airgun mitigation during seismic survey is to monitor marine mammals near the seismic source vessel during all daylight airgun operations and during any nighttime start-up of the airguns. During the seismic survey PSOs will monitor the pre- established exclusion zones for the presence of marine mammals. When marine mammals are observed within, or about to enter, designated exclusion 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.

Ramp Up Procedure

Ramp up procedures for an airgun array involve 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. The rate of ramp up shall be no more than 6 dB of source level per 5 min period. BP states that it intends to double the number of airguns operating at 5 minute intervals during ramp up. For the 640 in^3 airgun array of the Simpson Lagoon seismic survey this is estimated to take 20 minutes, and for the 320 in^3 array 15 minutes. During ramp up, the exclusion zone for the full airgun array will be observed. The ramp up procedures will be applied as follows:

- A ramp up, following a cold start, can be applied if the exclusion zone has been free of marine mammals for a consecutive 30-minute period. The entire exclusion zone must have been visible during these 30 minutes. If the entire exclusion zone is not visible, then ramp up from a cold start cannot begin.
- Ramp up procedures from a cold start will be delayed if a marine mammal is sighted within the exclusion 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 exclusion zone or until the animal(s) is not sighted for at least 15 or 30 minutes. The 15 minutes applies to small toothed whales and pinnipeds, while a 30 minute observation period applies to baleen whales and large toothed whales.
- 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 exclusion zone or until the animal(s) is not sighted for at least 15 minutes (small toothed whales and pinnipeds) or 30 minutes (baleen whales and large toothed whales). This assumes there was a continuous observation effort prior to the shutdown and the entire exclusion zone is visible.
- If, for any reason, electrical power to the airgun array has been discontinued for a period of 10 minutes or more, ramp-up procedures need to be implemented. Only if the PSO watch has been suspended, a 30-minute clearance of the exclusion zone is required prior to commencing ramp-up. Discontinuation of airgun activity for less than 10 minutes does not require a ramp-up.
- 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 exclusion 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.

•The airgun array shall be immediately powered down whenever a marine mammal is sighted approaching close to or within the applicable exclusion zone of the full array, but is outside the applicable exclusion zone of the single mitigation airgun.

•If a marine mammal is already within the exclusion zone when first detected, the airguns will be powered down immediately.

•Following a power-down, ramp up to the full airgun array will not resume until the marine mammal has cleared the exclusion zone. The animal will be considered to have cleared the exclusion zone if it is visually observed to have left the exclusion zone of the full array, or has not been seen within the zone for 15 minutes (pinnipeds or small toothed whales) or 30 minutes (baleen whales or large toothed whales).

Shutdown Procedures

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

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

Poor Visibility Conditions

BP plans to conduct 24-hour 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 exclusion zone is not visible, the airguns cannot commence a ramp-up procedure from a full shut-down.

•If one or more airguns have been operational before nightfall or before the onset of poor visibility conditions, they can remain operational throughout the night or poor visibility conditions. In this case ramp-up procedures can be initiated, even though the exclusion 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. In addition, NMFS proposes the following additional protective mitigation and monitoring during the periods of darkness or low visibility. Specifically, NMFS does not recommend keeping one airgun (the so called ‘‘mitigation gun’’ in past IHAs) firing for long periods of time with no seismic operation ongoing during darkness or other periods of poor visibility on the previous assumption that marine mammals will be alerted by the sounds from the single airgun so that a cold start with pre-survey monitoring could be avoided, since there is no scientific evidence that such technique works (Tyack 2009). On the contrary, keeping an airgun firing unnecessarily for long periods of time would only introduce more noise into the water. Therefore, for seismic surveys that would start during night time and low visibility, NMFS proposes to require that PSOs use vessel lights, night vision devices (NVDs), and/or forward looking infrared (FLIR) to observe as much as possible for 30 minutes before ramping up the airgun array. PSOs will be called up to observe at nighttime during the 30-min periods prior to ramp-ups as well as during ramp-ups.

Review of the 2010 and 2011 Open Water Seismic Survey Reports

In 2010, NMFS issued two IHAs for the harassment of marine mammals incidental to conducting seismic and/or site clearance and shallow hazards surveys in the Beaufort and Chukchi seas to Shell and Statoil. In 2011, NMFS issued an IHA to Statoil for its site clearance and shallow hazards survey in the Chukchi Sea. NMFS has reviewed the reports submitted by these companies. Based on the results of these studies collectively, NMFS concludes that the monitoring and mitigation measures prescribed in these marine mammal take authorizations were effective. In addition, actual take of marine mammals by Level B harassment was generally lower than expected due to the implementation of monitoring and mitigation measures. No Level A harassment (injuries included) or mortality was observed or suspected as a result of the operations.

Mitigation Conclusions

NMFS has carefully evaluated the applicant’s proposed mitigation measures and considered a range of other measures in the context of ensuring that NMFS prescribes the means of effecting the least practicable impact on the affected marine mammal species and stocks and their habitat. Our evaluation of potential measures included consideration of the following factors in relation to one another: the manner in which, and the degree to which, the successful implementation of the measure is expected to minimize adverse impacts to marine mammals; and the practicability of the measure for applicant implementation.

Based on our evaluation of the applicant’s proposed measures, as well as other measures considered by NMFS, NMFS has preliminarily determined that the proposed mitigation measures provide the means of effecting the least practicable impact on marine mammal species or stocks and their habitat, paying particular attention to rookeries, mating grounds, and areas of similar significance.

Proposed Monitoring and Reporting

In order to issue an IHA for an activity, Section 101(a)(5)(D) of the MMPA states that NMFS must set forth ‘‘requirements pertaining to the monitoring and reporting of such taking’’. The MMPA implementing regulations at 50 CFR 216.104(a)(13) indicate that requests for IHAs must include the suggested means of accomplishing the necessary monitoring and reporting that will result in increased knowledge of the species and of the level of taking or impacts on populations of marine mammals that are expected to be present in the proposed action area.

Proposed Monitoring Measures

The monitoring plan proposed by BP can be found in its IHA application. The plan may be modified or supplemented based on comments or new information received from the public during the public comment period. A summary of the primary components of the plan follows. There will be two vessel-based monitoring programs during the Simpson Lagoon OBC seismic survey. One program involves the presence of protected species observers (PSOs) on the seismic source vessels during the entire seismic survey period. The other vessel-based program involves two PSOs on a monitoring vessel outside the barrier islands after 25 August.

Visual Monitoring From Source Vessels

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

- To implement mitigation measures during seismic operations (e.g. course alteration, airgun power-down, shut- down and ramp-up);
- 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;
- To compare the distance and distribution of marine mammals relative to the source vessel at times with and without seismic activity; and
- To obtain data on the behavior and movement patterns of marine mammals observed and compare those at times with and without seismic activity.

Marine Mammal Observer Protocol

BP intends to work with experienced PSOs that have had previous experience working on seismic survey vessels, which will be especially important for the lead PSO on the source vessels. At least one Alaska Native resident, who is knowledgeable about Arctic marine mammals and the subsistence hunt, is expected to be included as one of the team members aboard the vessels. Before the start of the seismic survey the crew of the seismic source vessels will be briefed on the function of the PSOs, their monitoring protocol, and mitigation measures to be implemented. They will also be aware of the monitoring objectives of the dedicated monitoring vessel, and how their observations can affect the operations. On all source vessels, at least one observer will monitor for marine mammals at any time during daylight hours (there will be no periods of total darkness until mid-August). 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 three source vessels will offer suitable platforms for PSOs. 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 (e.g., 7 × 50 Fujinon) and with the naked eye. Laser range-finding binoculars (Leica LRF 1200 laser rangefinder or equivalent) will be available to assist with distance estimation, using other vessels in the area as targets. Laser range finding binoculars are generally not useful in measuring distances to animals directly.

Communication Procedures

When marine mammals in the water are detected within or about to enter the designated exclusion zones, the airgun(s) power-down or shut-down procedures will be implemented immediately. To assure prompt implementation of power-downs and shut- downs, multiple channels of communication between the PSOs and the airgun technicians will be established. During the power-down and shut-down, 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 exclusion zone, or if the animal(s) were not observed within the exclusion zone for 15 minutes (pinnipeds and small toothed whales) or for 30 minutes (for baleen whales and large toothed whales). Direct communication with the airgun operator will be maintained throughout these procedures.

Data Recording

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

Visual Monitoring Outside the Barrier Islands

The main purpose of the PSOs on the monitoring vessel that will operate outside the barrier islands is to monitor the 120 dB disturbance zone during daylight hours for the presence of four or more bowhead cow/calf pairs. The predicted distances to received levels of 120 dB are 6.4 km for the 640 in^3 array and 5.7 km for the 320 in^3 array. The distance to the 160 dB disturbance zone is small enough (1.8 km for the 640 in^3 and 1.5 km for the 320 in^3 array) to be covered by the PSOs on the source vessels. Of the two PSOs on the monitoring vessel, one will be on watch at all times during daylight hours to monitor the disturbance zones and to communicate any sightings of four bowhead cow/calf pairs to the PSOs on the source vessels. The shift schedule and observer protocol will be similar to that of the PSOs on the source vessels.

Channels of communication between the lead PSOs on the source vessels and the dedicated monitoring vessel will also be established. If four or more bowhead cow/calf pairs are observed within or entering the 120 dB disturbance zone the lead PSO on monitoring vessel will immediately contact the lead PSO on the source vessel, who will ensure prompt implementation of airgun power downs or shutdowns. The lead PSO of the monitoring vessel will continue monitoring the 120 dB zone and notify the PSO on the source vessel when the cow/calf pairs have left the exclusion zone or when they haven’t been observed within the exclusion zone for 30 minutes. Under these conditions ramp-up can be initiated. These vessel based surveys outside the barrier islands will be conducted up to 3 days per week, weather depending. Anticipated start date is August 25, 2012, and these surveys will be continuing until the end of the data acquisition period. During this period data acquisition will take place only inside the barrier islands. The vessel will follow transect lines within the 120 dB zone that are designed in such a way that the area ensonified by 120 dB or more will be covered. The exact start and end point will depend on the area to be covered by the source vessels during that particular day.

2012 Monitoring Plan

NMFS' implementing regulations of the MMPA state, ''Upon receipt of a complete monitoring plan, and at its discretion, [NMFS] will either submit the plan to members of a peer review panel for review or within 60 days of receipt of the proposed monitoring plan, schedule a workshop to review the plan'' (50 CFR 216.108(d)). NMFS convened an independent peer review panel to review BP's mitigation and monitoring plan for this action. The panel met on January 5 and 6, 2012, and provided their final report to NMFS on February 29, 2012. The full panel report can be viewed at: *http://www.nmfs.noaa.gov/pr/permits/incidental.htm#applications.*

The peer review panel's report contains several recommendations regarding vessel-based marine mammal observers, marine mammal monitor training, data recording, data analysis and presentation of data in reports, and acoustic monitoring, which NMFS agrees that BP should incorporate during the 2012 seismic surveys. These recommendations are considered part of the action being analyzed in this opinion.

(1) Vessel-Based Marine Mammal Observers

- Utilize crew members to assist the MMOs. Crew members should not be used as primary MMOs because they have other duties and generally do not have the same level of expertise, experience, or training as MMOs, but they could be stationed on the fantail of the vessel to observe the near field, especially the area around the airgun array and implement a rampdown or shutdown if a marine mammal enters the exclusion zone.

- If crew members are to be used as MMOs, they should go through some basic training consistent with the functions they will be asked to perform. The best approach would be for crew members and MMOs to go through the same training together.

- As BP plans to have a marine mammal survey vessel outside the barrier islands after 25 August, the panel recommends BP use MMOs on the vessel to monitor for the presence and behavior of marine mammals in the offshore area projected to be exposed to seismic sounds.

(2) MMO Training

- BP could improve its MMO training by implementing panel recommendations from previous years (on other seismic survey programs). These recommendations include:

- Observers should be trained using visual aids (e.g., videos, photos), to help them identify the species that they are likely to encounter in the conditions under which the animals will likely be seen.
- Observer teams should include Alaska Natives, and all observers should be trained together. Whenever possible, new observers should be paired with experienced observers to avoid situations where lack of experience impairs the quality of observations.
- Observers should understand the importance of classifying marine mammals as ‘‘unknown’’ or ‘‘unidentified’’ if they cannot identify the animals to species with confidence. In those cases, they should note any information that might aid in the sighted. For example, for an unidentified mysticete whale, the observers should record whether the animal had a dorsal fin.
- Observers should use the best possible positions for observing (e.g., outside and as high on the vessel as possible), taking into account weather and other working conditions.
- BP should train its MMOs to follow a scanning schedule that consistently distributes scanning effort according to the purpose and need for observations. For example, the schedule might call for 60 percent of scanning effort to be directed toward the near field and 40 percent at the far field. All MMOs should follow the same schedule to ensure consistency in their scanning efforts.
- MMOs also need training in documenting the behaviors of marine mammals. MMOs should simply record the primary behavioral state (i.e., traveling, socializing, feeding, resting, approaching or moving away from vessels) and relative location of the observed marine mammals.

(3) Data Recording

- MMOs should record observations of marine mammals hauled out on barrier islands. Because of the location of BP’s proposed survey, most (if not all) of the marine mammals observed in the lagoon will be pinnipeds. It is feasible that the surveys may alter the hauling out patterns of pinnipeds, so observations of them should be recorded.
- BP should work with its observers to develop a means for recording data that does not reduce observation time significantly. Possible options include the use of a voice recorder during observations followed by later transcriptions, or well-designed software programs that minimize the time required to enter data. Other techniques also may be suitable.

(4) Data Analysis and Presentation of Data in Reports

- Estimation of potential takes or exposures should be improved for times with low visibility (such as during fog or darkness) through interpolation or possibly using a probability approach. For instance, for periods of fog or darkness one could use marine mammal observations obtained during a specified period of time before or fter the time when visibility was restricted. Those data could be used to interpolate possible takes during periods of restricted visibility.

- Simpson Lagoon is relatively shallow, and marine mammal distribution likely will be closely linked to water depth. To account for this confounding factor, depth should be continuously recorded by the vessel and for each marine mammal sighting. Water depth should be accounted for in the analysis of take estimates.
- BP should be very clear in their report about what periods are considered ‘‘non-seismic’’ for analyses.
- BP should examine data from BWASP and other such programs to assess possible impacts from their seismic survey.
- The panel states that it believes the best ways to present data and results are described in peer-review reports from previous years. These recommendations include:
    - To better assess impacts to marine mammals, data analysis should be separated into periods when a seismic airgun array (or a single mitigation airgun) is operating and when it is not. Final and comprehensive reports to NMFS should summarize and plot:
        - Data for periods when a seismic array is active and when it is not; and
        - The respective predicted received sound conditions over fairly large areas (tens of km) around operations.
    - To help evaluate the effectiveness of MMOs and more effectively estimate take, reports should include sightability curves (detection functions) for distance-based analyses.
    - To better understand the potential effects of oil and gas activities on marine mammals and to facilitate integration among companies and other researchers, the following data should be obtained and provided electronically in the 90-day report:
        - The location and time of each aerial or vessel-based sighting or acoustic detection;
        - Position of the sighting or acoustic detection relative to ongoing operations (i.e., distance from sightings to seismic operation, drilling ship, support ship, etc.), if known;
        - The nature of activities at the time (e.g., seismic on/off);
        - Any identifiable marine mammal behavioral response (sighting data should be collected in a manner that will not detract from the MMO’s ability to detect marine mammals); and
        - Adjustments made to operating procedures.
    - BP should improve take estimates and statistical inference into effects of the activities by incorporating the following measures:
        - Reported results from all hypothesis tests should include estimates of the associated statistical power.
        - Estimate and report uncertainty in all take estimates. Uncertainty could be expressed by the presentation of confidence limits, a minimum-maximum, posterior probability distribution, etc.; the exact approach would be selected based on the sampling method and data available.

(5) Acoustical Monitoring

- BP should also use the offshore vessel to monitor (periodically) the propagation of airgun sounds from within the lagoon into offshore areas during its marine mammal survey using a dipping hydrophone.
- To help verify the propagation model results, the panel also recommends additional acoustic monitoring with bottom mounted recorders. Recorders should be deployed throughout the seismic survey. One suggestion is to deploy instruments including: one at the cut, or break, between Leavitt and Spy islands at about the 5 m isobath; one north of the center of Leavitt Island at the 10 m isobath; and one off the east end of Pingok Island at the 10m isobaths (Figure 2).

Term of this Opinion

This opinion will be valid upon issuance and remain in force until December 31, 2012.

Action Area

Federal regulations implementing the ESA (50 C.F.R. §402.02) define the action area as follows: "action area means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action."

In order to define the action area for the proposed action, we must have some basic understanding of the zone over which direct and indirect effects of this action might occur. Seismic effects are the principal type of effects of the proposed action on listed species and species proposed for listing. Based on literature on effects from other seismic activities conducted in the Beaufort Sea, the bowhead whale is the most sensitive of the species considered in this opinion. Bowheads may react to noise as low as 120 dB (Richardson, 1999). Based on this metric, we can define the action area for purposes of this Biological Opinion as the area ensonified to at least this level (Figure 13). The direct and indirect effects of this action on bowhead whales and ringed and bearded seals are expected to be confined to the action area.

III. STATUS OF THE SPECIES

NMFS has determined that two listed cetacean species and two pinniped species that have been proposed for listing may occur in the action area, and may be affected by the proposed action. This document constitutes NMFS's biological opinion on the effects of the proposed action on listed species and NMFS's conference opinion on species proposed for listing (Table 2).

Table 2. Listing status and critical habitat designation for species considered in this opinion.

Species	**Common Name**	**Stock**	**Status**	**Listing**	**Critical Habitat**
Balanea mysticetus	Bowhead whale	Western Arctic	Endangered	NMFS 1970, 35 FR 18319	Not designated
Megaptera novaeangliae	Humpback Whale	Alaska	Endangered	NMFS 1970, 35 FR 18319	Not designated
Phoca hispida hispida	Ringed Seals	Arctic sub-species	Proposed for listing	NMFS 2010, 75 FR 77476	Not proposed
Erignathus barbatus barbatus, Beringia DPS	Bearded Seals	Beringia DPS	Proposed for listing	NMFS 2010, 75 FR 77496	Not proposed

Species and Critical Habitat Not Likely to be Adversely Affected

NMFS uses two criteria to identify endangered or threatened species or critical habitat not likely to be adversely affected by the action. The first criterion is *exposure*: whether we may reasonably expect a listed species or designated habitat to be exposed to one or more potential stressors associated with the authorized activities. If there is little likelihood of such exposure, we also conclude that those activities are not likely to affect listed species or designated critical habitat.

The second criterion is the probability of a *response*. For endangered or threatened species, we consider the *susceptibility* of the species to the phenomenon to which they may be exposed. For example, a species may be exposed to sounds produced by active seismic surveys, but if the animals are not likely to have a physical, physiological, or behavioral response to those sounds, we conclude that the species is not likely to be adversely affected by the seismic activity.

We applied these criteria to the species listed at the beginning of this section. This subsection summarizes the results of those evaluations.

Critical Habitat

Critical habitat has not been designated for any of the listed or proposed species considered under this opinion. As a result, we conclude that the proposed activities will not affect any designated critical habitat.

Humpback Whale

BP’s IHA application (2011) requested authorization for the take of listed humpback whales. NMFS’s letter requesting consultation on the issuance of the IHA listed expected Level B harassment take of two humpback whales. Under this consultation, we reviewed pertinent information about the distribution of humpback whales and the potential for adverse effects from this action.

Until 2007, historic and recent information did not indicate that humpback whales inhabit northern portions of the Chukchi Sea or enter the Beaufort Sea. No sightings of humpback whales were reported during aerial surveys of endangered whales in summer (July) and autumn (August, September, and October) of 1979-1987 in the Northern Bering Sea (from north of St. LawrenceIsland), the Chukchi Sea north of lat. 66º N. and east of the International Date Line, and the Alaskan Beaufort Sea from long. 157º01’ W. east to long. 140º W. and offshore to lat. 72º N. (Ljungblad et al., 1988). Humpbacks have not been observed during annual aerial surveys of the Beaufort Sea conducted in September and October from 1982-2007 (e.g., Monnett and Treacy, 2005; Moore et al., 2000; Treacy, 2002; Monnett, 2008, pers. commun.). During a 2003 research cruise in which all marine mammals observed were recorded from July 5 to August 18 in the Chukchi and Beaufort seas, no humpback whales were observed (Bengtson and Cameron, 2003). One observation of one humpback whale was recorded in 2006 by marine mammal observers aboard a vessel in the southern Chukchi Sea outside of the Chukchi Sea Planning Area (Patterson et al., 2007; unpublished MMS marine mammal-observer reports, 2006). Between August 1 and October 16, 2007, humpback whales were observed during seven sequential observations in the western Alaska Beaufort Sea and eastern and southeastern Chukchi Sea (unpublished MMS marine mammal-observer reports, 2007) and one other observation in the southern Chukchi Sea in 2007 (Sekiguchi, In prep.). NMML shows a probable northern distribution boundary for humpback whales extending just east of Point Barrow to Smith Bay. This boundary is still well outside the action area for this analysis.

Based on the extremely small number of observations of humpback whales in the Beaufort Sea and the lack of spatial overlap between their known distribution and the action area, NMFS concludes that any effects to humpback whales are discountable, i.e., that we may discount the probability that a humpback whale will be affected by these seismic surveys.

NMFS has determined that the Simpson Lagoon seismic surveys are not likely to adversely affect humpback whales. As a result, this species will not be considered further in this opinion.

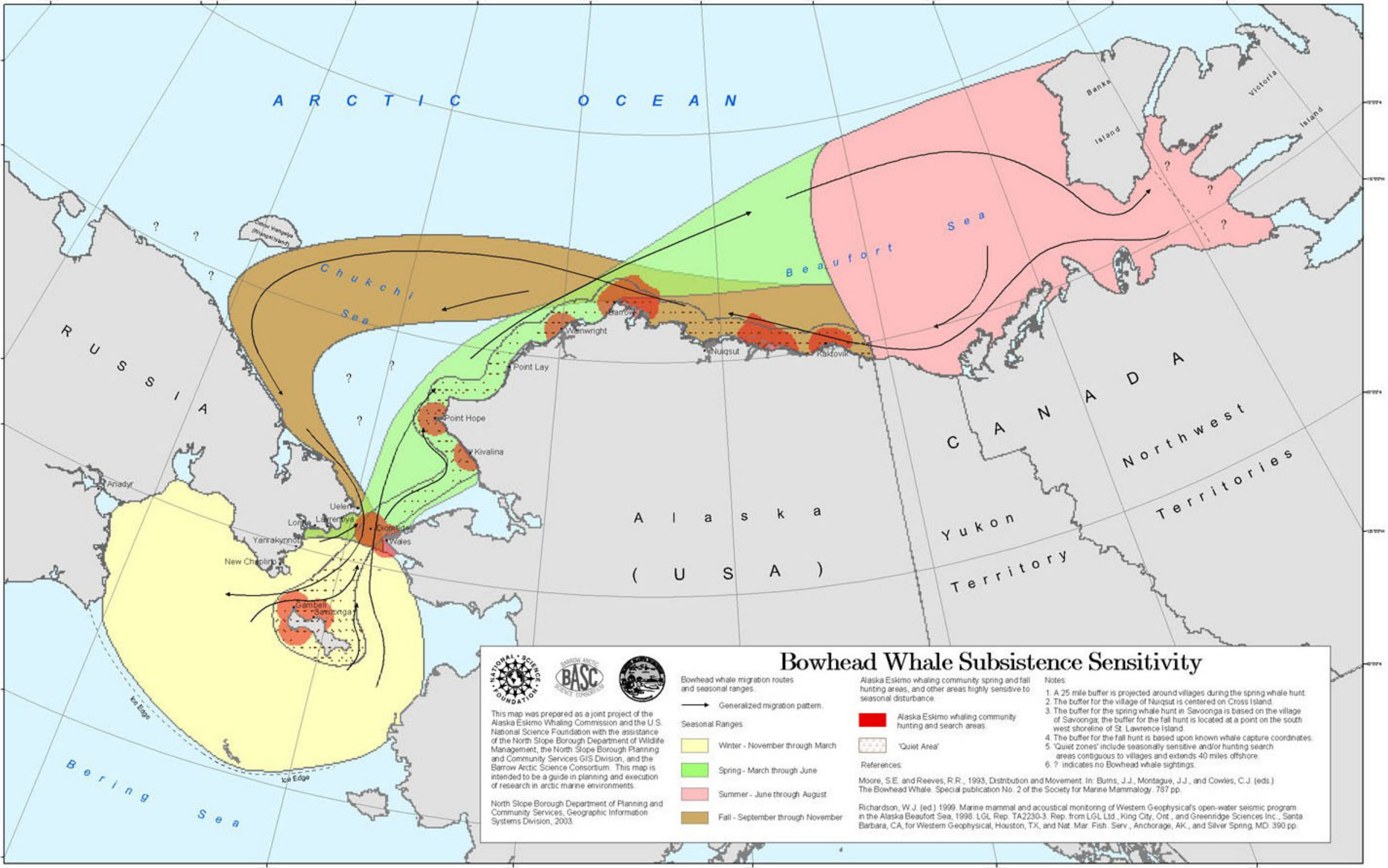
Introduction to Status of Listed Species

Next we review the status of the endangered and proposed listed species that occur in the action area that may be adversely affected by the proposed action. We present a summary of information on the distribution and population structure of each species to provide a foundation for the exposure analyses that appear later in this opinion.

Bowhead whale (*Balaena mysticetus*)

Distribution

Bowhead whales have a circumpolar distribution in high latitudes in the Northern Hemisphere, and range from 54º to 85ºN latitude (Figure 3). They live in pack ice for most of the year, typically wintering at the southern limit of the pack ice, or in polynyas (large, semi-stable open areas of water within the ice), and move north as the sea ice breaks up and recedes during the spring.



Bowhead Whale Subsistence Sensitivity

This map was prepared as a joint project of the Alaska Eskimo Whaling Commission and the U.S. National Science Foundation with the assistance of the North Slope Borough Department of Wildlife Management, the North Slope Borough Planning and Community Services GIS Division, and the Barrow Arctic Science Consortium. This map is intended to be a guide in planning and execution of research in arctic marine environments.

North Slope Borough Department of Planning and Community Services, Geographic Information Systems Division, 2003.

Bowhead whale migration routes and seasonal ranges.

→ Generalized migration pattern.

Seasonal Ranges

🟨 Winter - November through March

🟩 Spring - March through June

▨ Summer - June through August

🟫 Fall - September through November

Alaska Eskimo whaling community spring and fall hunting areas, and other areas highly sensitive to seasonal disturbance.

🟥 Alaska Eskimo whaling community hunting and search areas.

▨ 'Quiet Area'

References:

Moore, S.E. and Reeves, R.R., 1993, Distribution and Movement. In: Burns, J.J., Montague, J.J., and Cowles, C.J. (eds.) The Bowhead Whale. Special publication No. 2 of the Society for Marine Mammalogy. 787 pp.

Richardson, W.J. (ed.) 1999. Marine mammal and acoustical monitoring of Western Geophysical's open-water seismic program in the Alaska Beaufort Sea, 1998. LGL Rep. TA2230-3. Rep. from LGL Ltd., King City, Ont., and Greenridge Sciences Inc., Santa Barbara, CA, for Western Geophysical, Houston, TX, and Nat. Mar. Fish. Serv., Anchorage, AK., and Silver Spring, MD. 390 pp.

Notes:

1. A 25 mile buffer is projected around villages during the spring whale hunt.
2. The buffer for the village of Nuiqsut is centered on Cross Island.
3. The buffer for the spring whale hunt in Savoonga is based on the village of Savoonga; the buffer for the fall hunt is located at a point on the south west shoreline of St. Lawrence Island.
4. The buffer for the fall hunt is based upon known whale capture coordinates.
5. 'Quiet zones' include seasonally sensitive and/or hunting search areas contiguous to villages and extends 40 miles offshore.
6. ? indicates no Bowhead whale sightings.

Figure 3 Bowhead whale migration routes and seasonal ranges in relation to subsistence activities (Adopted from the North Slope Borough Department of Planning and Community Services, Geographic Information Systems Division).

In the North Pacific Ocean, bowhead whales are distributed in seasonally ice-covered waters of the Arctic and near-Arctic, generally north of 60°N and south of 75°N in the western Arctic Basin (Braham 1984, Moore and Reeves 1993). They have an affinity for ice and are associated with relatively heavy ice cover and shallow continental shelf waters for much of the year. The largest population of bowhead whales can be found in the Bering Sea in winter, migrating north into the western Arctic, Beaufort, and Chukchi Seas in the spring.

Population Structure

The International Whaling Commission (IWC) recognizes five stocks of bowhead whales for management purposes. Three of these stocks occur in the North Atlantic: the Spitsbergen, Baffin Bay-Davis Strait, and Hudson Bay-Foxe Basin stocks. The remaining two stocks occur in the North Pacific: the Sea of Okhotsk and Bering-Chukchi-Beaufort stocks. Out of all of the stocks, the Bering-Chukchi-Beaufort stock is the largest, and the only stock to inhabit U.S. waters. NMFS identifies this stock as the Western Arctic stock of bowhead whales, which is how they are referred to in the remainder of this opinion, and which will be the focus of this analysis.

Woodby and Botkin (1993) summarized previous efforts to determine a minimum worldwide population estimate prior to commercial whaling of 50,000, with 10,400-23,000 in the Western Arctic stock (dropping to less than 3,000 at the end of commercial whaling). This stock is currently estimated to be increasing at a rate of 3.2% per year. The most recent abundance estimate, based on surveys conducted in 2001, is 10,545 (Coefficient of Variation (CV) = 0.128) (updated from George *et al*. 2004 by Zeh and Punt 2004). See Table 2 for a summary of population abundance estimates (Allen and Angliss 2010).

George *et al.* (2004) reported that the Western Arctic stock of bowhead whales has increased at a rate of 3.4% from 1978-2001, during which time abundance doubled from approximately 5,000 to approximately 10,000 whales. The count of 121 calves during the 2001 census was the highest yet recorded and was likely caused by a combination of variable recruitment and the large population size (George *et al.* 2004). The calf count provides corroborating evidence for a healthy and increasing population.

Year	Abundance estimate (CV)
Historical estimate	10,400-23,000
End of commercial whaling	1,000-3,000
1978	4,765 (0.305)
1980	3,885 (0.343)
1981	4,467 (0.273)
1982	7,395 (0.281)
1983	6,573 (0.345)
1985	5,762 (0.253)
1986	8,917 (0.215)
1987	5,298 (0.327)
1988	6,928 (0.120)
1993	8,167 (0.017)

2001	10,545 (0.128)

Table 3. Summary of population abundance estimates for the Western Arctic stock of bowhead whales. The historical estimates were made by back-projecting using a simple recruitment model. All other estimates were developed by corrected ice-based census counts. Historical estimates are from Woodby and Botkin (1993); 1978-2001 estimates are from George et al. (2004) and Zeh and Punt (2004).

ESA Listing History and Status

The bowhead whale was listed as a Federal endangered species on June 2, 1970 (35 FR 8495). It is also protected by the Convention on International Trade in Endangered Species of wild flora and fauna and the Marine Mammal Protection Act (MMPA). Critical habitat has not been designated for bowhead whales.

Feeding and Prey Selection

Bowheads are filter feeders, filtering prey from the water through baleen fibers in their mouth. They feed throughout the water column, including bottom feeding as well as surface skim feeding (Würsig *et al.* 1989). Skim feeding can occur when animals are alone or may occur in coordinated echelons of over a dozen animals (Würsig *et al*. 1989). Bowhead whales typically spend a high proportion of time on or near the ocean floor. Even when traveling, bowhead whales visit the bottom on a regular basis (Quakenbush, Small, and Citta 2010). Laidre et al. (2007) and others have identified krill concentrated near the sea bottom and bowhead whales have been observed with mud on heads and bodies and streaming from mouths. Food items most commonly found in the stomachs of harvested bowheads include euphausiids, copepods, mysids, and amphipods (Moore *et al.* 2010; Lowry, Sheffield, and George 2004). Euphausiids and copepods are thought to be their primary prey. Lowry, Sheffield, and George (2004) documented that other crustaceans and fish also were eaten but were minor components in samples consisting mostly of copepods or euphausiids.

Available data indicate that bowhead whales feed in the Beaufort Sea and that this use varies in degree among years, among individuals, and among areas. It is likely that bowheads continue to feed opportunistically where food is available as they move through or about the Alaskan Beaufort Sea, similar to what they are thought to do during the spring migration. Observations from the 1980s documented that some feeding occurs in the spring in the northeastern Chukchi Sea, but this feeding was not consistently seen (e.g., Ljungblad *et al.* 1988a, Carroll *et al.* 1987). Stomach contents from bowheads harvested between St. Lawrence Island and Point Barrow during April into June also indicated it is likely that some whales feed during the spring migration (Carroll *et al*., 1987; Shelden and Rugh, 1995, 2002). Carroll et al. (1987) reported that the region west of Point Barrow seems to be of particular importance for feeding, at least in some years, but whales may feed opportunistically at other locations in the lead system where oceanographic conditions produce locally abundant food. Lowry (1993) reported that the stomachs of 13 out of 36 spring-migrating bowheads harvested near Point Barrow between 1979 through 1988 contained food. Lowry estimated total volumes of contents in stomachs ranged from less than 1 to 60 liters (L.), with an average of 12.2 L. in eight specimens. Shelden and Rugh (1995) concluded that “In years when oceanographic conditions are favorable, the lead system near Barrow may serve as an important feeding ground in the spring." Richardson and Thomson (2002) concluded that some, probably limited, feeding occurs in the spring.

Bowhead whales feed in the Canadian Beaufort in the summer and early fall and in the Alaskan Beaufort in late summer/early fall (Lowry and Frost 1984, Schell and Saupe 1993, Lowry, Sheffield, and George 2004; summarized in Richardson and Thomson 2002). Available information indicates it is likely there is considerable inter-annual variability in the locations where feeding occurs during the summer and fall in the Alaska Beaufort Sea, in the length of time individuals spend feeding, and in the number of individuals feeding in various areas in the Beaufort Sea. Recent satellite tagging data suggest bowhead whales may feed extensively in late fall along the Chukotka coastline (ADFG, 2009).

Social Behavior

The bowhead whale usually travels alone or in groups of three to four individuals. Loose aggregations of 50 or more individuals are sometimes observed on the feeding grounds or when moving through ice leads. Bowhead whale calls might help maintain social cohesion of groups (Würsig and Clark, 1993). Wursig *et al*. (1985) indicated that low-frequency tonal calls, believed to be long distance contact calls by a female and higher frequency calls by calf, have been recorded in an instance where the pair were separated and swimming toward each other.

Bowhead whales sometimes feed cooperatively (Wursig and Clarke, 1993), taking advantage of dense swarms of invertebrates.

Vocalizations and Hearing

Bowhead whales are among the more vocal of the baleen whales. They mainly communicate with low frequency sounds. Most underwater calls are at a fairly low frequency and easily audible to the human ear. Vocalization is made up of moans of varying pitch, intensity and duration, and occasionally higher-frequency screeches. Bowhead calls have been distinguished by Würsing and Clark (1993): pulsed tonal calls, pulsive calls, high frequency calls, low-frequency calls (upsweeps, inflected, downsweeps, and constant frequency calls). However, no direct link between specific bowhead activities and call types was found. Bowhead whales may use low-frequency sounds to provide information about the ocean floor and locations of ice.

Bowhead whales have well-developed capabilities for navigation and survival in sea ice. Bowhead whales are thought to use the reverberations of their calls off the undersides of ice floes to help them orient and navigate (Wursig and Clarke, 1993). This species is well adapted to ice-covered waters and can easily move through extensive areas of nearly solid sea ice cover. Their skull morphology allows them to break through ice up to 18 cm thick to breathe in ice covered waters (Wursig and Clarke, 1993).

Bowhead whales are grouped among low frequency functional hearing baleen whales (Southall *et al*. 2007). Inferring from their vocalizations, bowhead whales should be most sensitive to frequencies between 20 Hz-5 kHz, with maximum sensitivity between 100-500 Hz.

Distribution and Habitat Use of the Western Arctic Stock of Bowhead Whale

The Western Arctic stock of bowheads generally occurs north of 60° N. and south of 75° N. (Angliss and Outlaw, 2005) in the Bering, Chukchi, and Beaufort seas. They have an affinity for ice and are associated with relatively heavy ice cover and shallow continental shelf waters for much of the year. Bowhead whales of the Western Arctic stock overwinter in the central and western Bering Sea. Most mating probably occurs in the Bering Sea. The amount of feeding in the Bering Sea in the winter is unknown as is the amount of feeding in Bering Strait in the fall (Richardson and Thomson, 2002). In the Bering Sea, bowheads frequent the marginal ice zone, regardless of where the zone is, and polynyas. Important winter areas in the Bering Sea include polynyas along the northern Gulf of Anadyr, south of St. Matthew Island, and near St. Lawrence Island. Bowheads congregate in these polynyas before migrating (Moore and Reeves, 1993). During their southward migration in the autumn, bowheads pass through the Bering Strait in late October through December on their way to overwintering areas in the Bering Sea.

Most of the bowheads that winter in the Bering Sea migrate northward through the Bering Strait to the Chukchi Sea and through the Alaskan Beaufort Sea to summer feeding grounds in the Canadian Beaufort Sea. The bowhead northward spring migration appears to coincide with ice breakup and probably begins most years in April (possibly late March depending on ice conditions) and early May. It is thought to occur after the peak of breeding, which is believed to occur in March-April (C. George, cited in IWC, 2004).

The migration past Barrow takes place in pulses in some years (e.g., in 2004) but not in others (e.g., 2003) (IWC, 2004b). At Barrow, the first migratory pulse is typically dominated by juveniles. This pattern gradually reverses and by the end of the migration, there are almost no juveniles. Currently, the whales are first seen at Barrow around April 9-10. In later May (May 15-June), large whales and cow/calf pairs are seen (H. Brower, in USDOC, NOAA and NSB, 2005). Koski et al. (2004b) found that females and calves constituted 31-68% of the total number of whales seen during the last few days of the migration. Their rate of spring migration was slower and more circuitous than other bowheads. Calves had shorter dive duration, surface duration, and blow interval than their mothers. Calf blow rate was nearly 3 times that of their mothers. Most calving probably occurs in the Chukchi Sea. Some subset of the population may summer in the Chukchi Sea.

Bowheads arrive on their summer feeding grounds near Banks Island from mid-May through June-July (IWC, 2004) and remain in the Canadian Beaufort Sea and Amundsen Gulf until late August or early September (Moore and Reeves, 1993). Bowhead whales are seen also in the central Chukchi Sea and along the Chukotka coast in July and August. They may occupy the northeastern Chukchi Sea in late summer more regularly than commonly believed (Moore, 1992), but it is unclear if these are “early-autumn” migrants or whales that have summered nearby (Moore et al., 1995) or elsewhere. Bowhead whales have been observed near Barrow in the mid-summer (e.g., Brower, as cited in MMS, 1995). Moore and DeMaster (2000:61) noted that these observations are consistent with Russian scientist suggestions that “…Barrow Canyon is a focal feeding area for bowheads and that they ‘move on’ from there only when zooplankton concentrations disperse (Mel’nikov et al. 1998)”.

Some biologists conclude that almost the entire Bering Sea bowhead population migrates to the Beaufort Sea each spring and that few whales, if any, summer in the Chukchi Sea. Incidental sightings suggest that bowhead whales may occupy the Chukchi Sea in the summer more regularly than commonly believed. Moore (1992) summarized observations of bowheads in the northeastern Chukchi in late summer. Other scientists maintain that a few bowheads swim northwest along the Chukotka coast in late spring and summer in the Chukchi Sea. Recent satellite tagging studies of Western Arctic bowheads provide support for this (ADFG 2009). Observation by numerous Russian authors (cited in Mel'nikov, Zelensky, and Ainana [1997:8]) indicates that bowheads occur in waters of the Chukchi Sea off the coast of Chukotka in the summer.

Those bowheads that have been summer feeding in the Canadian Beaufort Sea begin moving westward into Alaskan waters in August and September. While few bowheads generally are seen in Alaskan waters until the major portion of the migration takes place (typically mid-September to mid-October), in some years bowheads are present in substantial numbers in early September (Greene and McLennan, 2001; Treacy, 1998). There is some indication that the fall migration, just as the spring migration, takes place in pulses or aggregations of whales (Moore and Reeves, 1993). Eskimo whalers report that smaller whales precede large adults and cow-calf pairs on the fall migration (Braham et al., 1984, as reported in Moore and Reeves, 1993). During the autumn migration Koski and Miller (2004, cited in IWC, 2004) found decreasing proportions of small whales and increasing proportions of large whales as one moved offshore. "Mothers and calves tended to avoid water depths less than (<) 20 m." (Koski and Miller, cited in IWC, 2004). These authors also found that in the Central Beaufort Sea in late August, the vast majority of the whales were subadults and this percentage declined throughout the autumn to about 35% by early October. They reported that mother/calf pairs "arrived in September and were common until early October" (Koski and Miller, 2004, cited in IWC, 2004).

Data are limited on the bowhead fall migration through the Chukchi Sea before the whales move south into the Bering Sea. Bowhead whales commonly are seen from the coast to about 150 km (93 mi) offshore between Point Barrow and Icy Cape, suggesting that most bowheads disperse southwest after passing Point Barrow and cross the central Chukchi Sea near Herald Shoal to the northern coast of the Chukotka Peninsula. However, sightings north of 72° N. latitude suggest that at least some whales migrate across the Chukchi Sea farther to the north. Mel'nikov, Zelensky, and Ainana (1997) argued that data suggest that after rounding Point Barrow, some bowheads head for the northwestern coast of the Chukotka Peninsula and others proceed primarily in the direction of the Bering Strait and into the Bering Sea. Mel'nikov (in USDOC, NOAA, and NSB, 2005) reported that abundance increases along northern Chukotka in September as whales come from the north. More whales are seen along the Chukotka coast in October. J.C. George (cited in IWC 2004) noted that bowheads pass through the Bering Strait into the Bering Sea between October and November on their way to overwintering areas in the Bering Sea.

The timing, duration, and location of the fall migration along the Chukotka Peninsula are highly variable and are linked to the timing of freezeup (Mel'nikov, Zelensky, and Ainana, 1997). Whales migrate in "one short pulse over a month" in years with early freezeup, but when ice formation is late, whales migrate over a period of 1.5-2 months in 2 pulses (Mel'nikov, Zelensky, and Ainana, 1997.

Ringed Seal – Arctic sub species (*Phoca hispida hispida)*

Distribution

Arctic ringed seals have a circumpolar distribution. They occur in all seas of the Arctic Ocean, and range seasonally into adjacent seas including the Bering Sea. In the Chukchi and Beaufort seas, where they are year-round residents, they are the most widespread seal species (Figure 4).

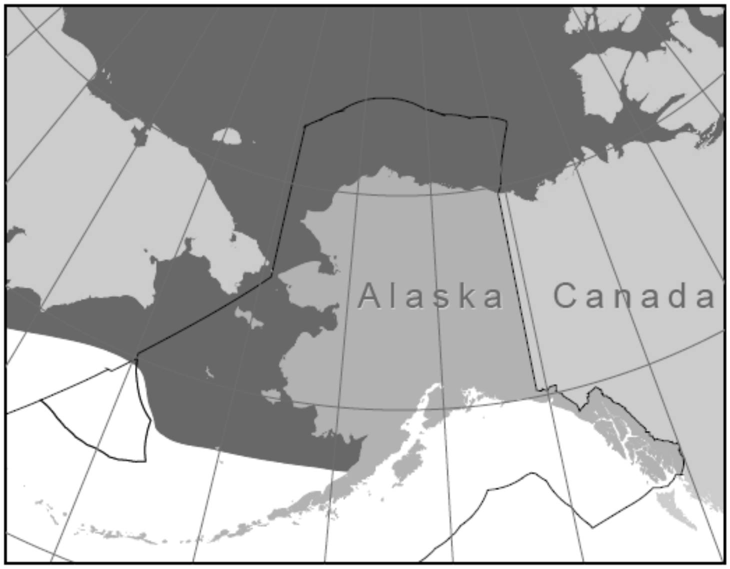


Figure 4. Approximate distribution of ringed seals (shaded area). The combined summer and winter distribution are depicted. (Adopted from Allen and Angliss (2010)).

Arctic ringed seals have an affinity for ice-covered waters and are able to occupy areas of even continuous ice cover by abrading breathing holes in that ice (Hall 1865, Bailey and Hendee 1926, Chapskii 1940, McLaren 1958a). Throughout most of their range, Arctic ringed seals do not come ashore and use sea ice as a substrate for resting, pupping, and molting (Kelly 1988, Kelly *et al*. 2010). Arctic ringed seals use sea ice as a platform for resting throughout the year, and they make and maintain breathing holes in the ice from freeze-up until breakup (Frost *et al.* 2002). They normally give birth in late winter-early spring in subnivean lairs constructed in the snow on the sea ice above breathing holes, and mating takes place typically in May shortly after parturition. In the spring, as day length and temperature increase, ringed seals haul out in large numbers on the surface of the ice near breathing holes or lairs. This behavior is associated with the annual May-July molt.

Outside the breeding and molting seasons, they are distributed in waters of nearly any depth; their distribution is strongly correlated with seasonally and permanently ice-covered waters and food availability (e.g. Simpkins *et al.* 2003, Freitas *et al.* 2008).

The seasonality of ice cover strongly influences ringed seal movements, foraging, reproductive behavior, and vulnerability to predation. Three ecological seasons have been described as important to ringed seals: the "open-water " or "foraging" period when ringed seals forage most intensively, the subnivean period in early winter through spring when seals rest primarily in subnivean lairs on the ice, and the basking period between lair abandonment and ice break-up (Born *et al.* 2004, Kelly *et al.* 2010b).

Overall, the record from satellite tracking indicates that during the foraging period, ringed seals breeding in shorefast ice either forage within 100 km of their shorefast breeding habitat or they make extensive movements of hundreds or thousands of kilometers to forage in highly productive areas and along the pack ice edge. Movements during the foraging period by ringed seals that breed in the pack ice are unknown. During the winter subnivean period, ringed seals excavate lairs in the snow above breathing holes where the snow depth is sufficient. These lairs are occupied for resting, pupping, and nursing young in annual shorefast and pack ice. Movements during the subnivean period are typically limited, especially when ice cover is extensive.

Because Arctic ringed seals are most readily observed during the spring basking period, aerial surveys to assess abundance are conducted during this period. Frost et al. (2004) reported that water depth, location relative to the fast ice edge, and ice deformation showed substantial and consistent effects on ringed seal densities during May and June in their central Beaufort Sea study area—densities were highest in relatively flat ice and near the fast ice edge, as well as at depths between 5 and 35 m. Bengtson *et al.* (2005) found that in their eastern Chukchi Sea study area during May and June, ringed seals were four to ten times more abundant in nearshore fast and pack ice than in offshore pack ice, and that ringed seal preference for nearshore or offshore habitat was independent of water depth. They observed higher densities of ringed seals in the southern region of the study area south of Kivalina and near Kotzebue Sound.

ESA Listing and Status

NMFS received a petition from the Center for Biological Diversity (CBD) to list ringed seals under the ESA on May 28, 2008 due to loss of sea ice habitat caused by climate change in the Arctic (CBD 2008a). NMFS published a *Federal Register* notice (73 FR 51615; September 4, 2008), indicating that there were sufficient data to warrant a review of the species. NMFS proposed to list Arctic ringed seals as threatened under the ESA on December 10, 2010 (75 *FR* 77476). At that time, NMFS determined that critical habitat for the Arctic ringed seal in U.S. waters was not determinable and did not propose to designate critical habitat for the subspecies. The deadline for a final determination regarding the listing proposal has been extended to summer 2012 (76 FR 77466).

Population Structure

A single Alaska stock of ringed seals is currently recognized in U.S. waters. This stock is part of the Arctic ringed seal subspecies. The genetic structuring of the Arctic subspecies has yet to be thoroughly investigated, and Kelly *et al.* (2010) cautioned that it may prove to be composed of multiple distinct populations.

There are no specific estimates of population size available for the Arctic subspecies of the ringed seal, but most experts would postulate that the population numbers in the millions. Based on the available abundance estimates for study areas within the Chukchi-Beaufort Sea region and extrapolations for pack ice areas without survey data, Kelly *et al.* (2010) indicated that a reasonable estimate for the Chukchi and Beaufort Seas is 1 million seals, and for the Alaskan portions of these seas is at least 300,000 seals. Bengtson *et al.* (2005) estimated the abundance of ringed seals from spring aerial surveys conducted along the eastern Chukchi coast from Shishmaref to Barrow at 252,000 seals in 1999 and 208,000 in 2000 (corrected for seals not hauled out). Frost *et al.* (2004) conducted spring aerial surveys along the Beaufort Sea coast from Oliktok Point to Kaktovik in 1996–1999. They reported density estimates for these surveys, but did not derive abundance estimates. Based on the average density reported by Frost *et al.* (2004) for all years and ice types and the size of the survey area, Allen and Angliss (2011) derived an estimate of approximately 18,000 seals hauled out in that survey area (uncorrected for seals not hauled out).

Feeding and Prey Selection

Many studies of the diet of Arctic ringed seals have been conducted and although there is considerable variation in the diet regionally, several patterns emerge. Most ringed seal prey is small, and preferred prey tends to be schooling species that form dense aggregations. Ringed seals rarely prey upon more than 10-15 prey species in any one area, and not more than 2-4 of those species are considered important prey. Fishes are generally more commonly eaten than invertebrate prey, but diet is determined to some extent by availability of various types of prey during particular seasons as well as preference, which in part is guided by energy content of various available prey (Reeves 1998, Wathne *et al*. 2000). Invertebrate prey seem to become more important in the diet of Arctic ringed seals in the open water season and often dominate the diet of young animals (e.g., Lowry *et al.* 1980, Holst *et al.* 2001).

Despite regional and seasonal variations in the diet of Arctic ringed seals, fishes of the cod family tend to dominate the diet from late autumn through early spring in many areas. Arctic cod (*Boreogadus saida*) is often reported to be the most important prey species for ringed seals, especially during the ice-covered periods of the year (Labansen *et al*. 2007). Quakenbush *et al.* (2011) reported evidence that in general, the diet of Alaska ringed seals sampled consisted of cod, amphipods, and shrimp. They found that fish were consumed more frequently in the 2000s than during the 1960s and 1970s, and identified the five dominant species or taxa of fishes in the diet during the 2000s as: Arctic cod, saffron cod, sculpin, rainbow smelt, and walleye pollock. Invertebrate prey were predominantly mysids, amphipods, and shrimp, with shrimp most dominant.

Diving, Hauling out, and Social Behavior

Behavior of ringed seals is poorly understood because both males and females spend much of their time in lairs built in pressure ridges or under snowdrifts for protection from predators and severe weather (ADFG 1994). Figure 5 summarizes the approximate annual timing of reproduction and molting for Arctic ringed seals.

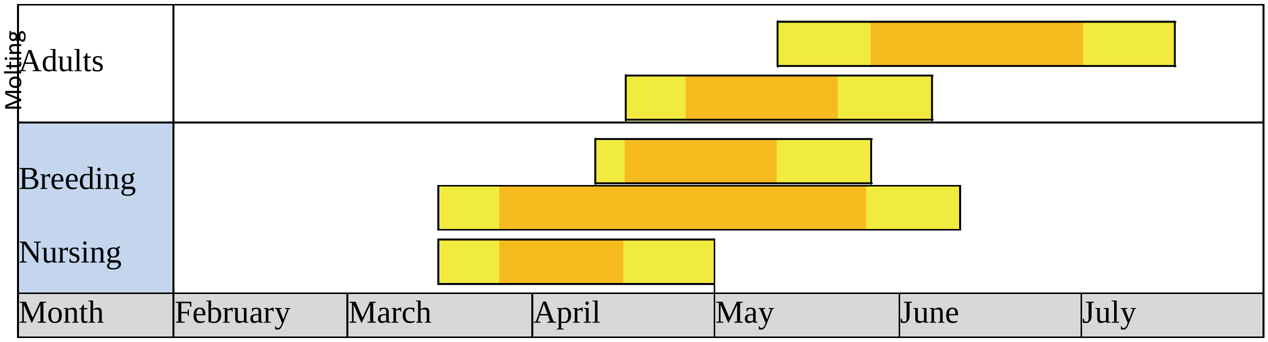


Figure 5. Approximate annual timing of reproduction and molting for Arctic ringed seals. Yellow bars indicate the "normal" range over which each event is reported to occur and orange bars indicated the "peak" timing of each event (from Kelly *et al.* 2010).

Tagging studies revealed that Arctic ringed seals are capable of diving for at least 39 minutes (Teilmann et al. 1999) and to depths of over 500 m (Born et al. 2004), however, most dives reportedly lasted less than 10 minutes and dive depths were highly variable and were often limited by the relative shallowness of the areas in which the studies took place (Lydersen 1991, Kelly and Wartzok 1996, Teilmann et al. 1999, Gjertz et al. 2000). Based on three-dimensional tracking, Simpkins et al. (2001) categorized ringed seal dives as either travel, exploratory, or foraging/social dives. Ringed seals tend to come out of the water during the daytime and dive at night during the spring to early summer breeding and molting periods, while the inverse tended to be true during the late summer, fall, and winter (Kelly and Quakenbush 1990, Lydersen 1991, Teilmann et al. 1999, Carlens et al. 2006, Kelly et al. 2010). Captive diving experiments conducted by Elsner et al. (1989) indicated that ringed seals primarily use vision to locate breathing holes from under the ice, followed by their auditory and vibrissal senses for short-range pilotage.

Vocalizations and Hearing

Ringed seals vocalize underwater in association with territorial and mating behaviors. Underwater audiograms for phocids suggest that they have very little hearing sensitivity below 1 kHz, though they can hear underwater sounds at frequencies up to 60 kHz and make calls between 90 Hz and 16 kHz (Richardson *et al*. 1995). A more recent review suggests that the functional auditory bandwidth for pinnipeds in water is between 75 Hz and 75 kHz, with the greatest sensitivity between approximately 700 Hz and 20 kHz (Southall *et al*. 2007).

Beringia DPS of Bearded Seals (Erignathus barbatus barbatus)

Distribution

The range of the Beringia DPS of the bearded seal is defined as extending from an east-west Eurasian dividing line at Novosibirskiye in the East Siberian Sea, south into the Bering Sea (Kamchatka Peninsula and 157°E division between the Beringia and Okhotsk DOSs), and to a north American dividing line (between the Beringia DPS of the E. b. nauticus subspecies and the E. B. barbatus subspecies) at 122°W (midpoint between the Beaufort Sea and Pelly Bay) (Figure 6).

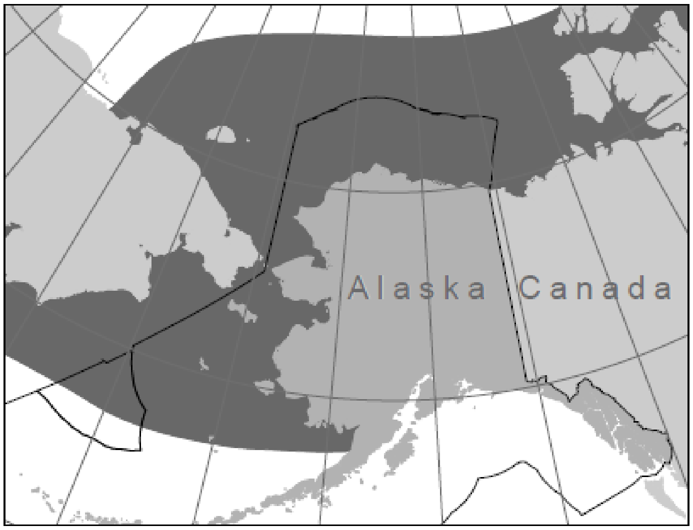


Figure 6. Approximate distribution of bearded seals (shaded area). The combined summer and winter distribution are depicted. (Adopted from Allen and Angliss (2010)).

Bearded seals are closely associated with sea ice – particularly during the critical life history periods related to reproduction and molting – and can be found in a broad range of ice types. They generally prefer ice habitat that is in constant motion and produces natural openings and areas of open water such as leads, fractures, and polynyas, for breathing, hauling out on the ice, and access to water for foraging (Heptner et al. 1976, Fedoseev 1984, Nelson et al. 1984). The bearded seal's effective range is generally restricted to areas where seasonal sea ice occurs over relatively shallow waters. Based on the best available data, Cameron et al. (2010) therefore defined the core distribution of bearded seals as those areas over waters less than 500 m deep.

The region that includes the Bering and Chukchi seas is the largest area of continuous habitat for bearded seals (Burns 1981, Nelson *et al.* 1984). The Bering-Chukchi Platform is a shallow intercontinental shelf that encompasses half of the Bering Sea, spans the Bering Strait, and covers nearly all of the Chukchi Sea. Bearded seals can reach the bottom everywhere along the shallow shelf and so it provides them favorable foraging habitat (Burns 1967). The Bering and Chukchi seas are generally covered by sea ice in late winter and spring and are then mostly ice free in late summer and fall, a process that helps to drive a seasonal pattern in the movements and distribution of bearded seals in this area (Burns 1967, Burns 1981, Nelson *et al.* 1984). During winter, most bearded seals in Alaskan waters are found in the Bering Sea, while smaller numbers of year-round residents remain in the Beaufort and Chukchi Seas, mostly around lead systems, and polynyas. From mid-April to June, as the ice recedes, many bearded seals that overwinter in the Bering Sea migrate northward through the Bering Strait into the Chukchi and

Beaufort Seas, where they spend the summer and early fall at the southern edge of the Chukchi and Beaufort Sea pack ice at the wide, fragmented margins of multiyear ice. A small number of bearded seals, mostly juveniles, remains near the coasts of the Bering and Chukchi seas for the summer and early fall instead of moving with the ice edge. These seals are found in bays, brackish water estuaries, river mouths, and have been observed up some rivers (Burns 1967, Heptner *et al.* 1976, Burns 1981).

Population Structure

There are two recognized subspecies of the bearded seal: *E. b. barbatus,* often described as inhabiting the Atlantic sector (Laptev, Kara, and Barents seas, North Atlantic Ocean, and Hudson Bay; Rice 1998); and *E. b. nauticus*, which inhabits the Pacific sector (remaining portions of the Arctic Ocean and the Bering and Okhotsk seas; Ognev 1935, Scheffer 1958, Manning 1974, Heptner *et al*. 1976). Two distinct population segments (DPS) were identified for the *E. b. nauticus* subspecies–the Okhotsk DPS in the Sea of Okhotsk, and the Beringia DPS, encompassing the remainder of the range of this subspecies. Only the Beringia DPS of bearded seals is found in U.S. waters, and these are of a single recognized Alaska stock.

Harvest

Bearded seals were among those species hunted by early Arctic inhabitants (Krupnik 1984), and today they remain a central nutritional and cultural resource for many northern communities (Hart and Amos 2004, ACIA 2005, Hovelsrud et al. 2008). The solitary nature of bearded seals has made them less suitable for commercial exploitation than many other seal species. Still, within the Beringia DPS they may have been depleted by commercial harvests in the Bering Sea during the mid-20th century. There is currently no significant commercial harvest of bearded seals and significant harvests seem unlikely in the foreseeable future.

Alaska Native hunters mostly take bearded seals of the Beringia DPS during their northward migration in the late spring and early summer, using small boats in open leads among ice floes close to shore (Kelly 1988). Allen and Angliss (2010) reported that based on harvest data maintained by ADF&G primarily for the years 1990 to 1998, the mean estimated annual harvest level in Alaska averaged 6,788 bearded seals as of August 2000 (Coffing et al. 1998, Georgette et al. 1998, Wolfe and Hutchinson-Scarbrough 1999, Allen and Angliss 2010). The estimate of 6,788 bearded seals is considered by Allen and Angliss (2010) to be the best estimate of the subsistence harvest level in Alaska. Cameron et al. (2010) noted that ice cover in hunting locations can dramatically affect the availability of bearded seals and the success of hunters in retrieving seals that have been shot, which can range from 50-75% success in the ice (Burns and Frost 1979, Reeves et al. 1992) to as low as 30% in open water (Burns 1967, Smith and Taylor 1977, Riewe and Amsden 1979, Davis et al. 1980). Using the mean annual harvest reported from 1990-1998, assuming 25 to 50% of seals struck are lost, they estimated the total annual hunt by Alaska Natives would range from 8,485 to 10,182 bearded seals. Assuming contemporary harvest levels in eastern Siberia are similar to Alaska, as was the pattern in the 1970s and 1980s, and a comparable struck-loss rate of 25-50%, the total annual take from the entire Bering and Chukchi Seas would range from 16,970 to 20,364 bearded seals (Cameron et al. 2010). In the western Canadian Beaufort Sea, bearded seal hunting has historically been secondary to ringed seal harvest, and its importance has declined further in recent times (Cleator 1996). Cameron et al. (2010) concluded that although the current subsistence harvest is substantial in some areas, there is little or no evidence that subsistence harvests have or are likely to pose serious risks to the Beringia DPS (Cameron *et al.* 2010).

ESA Listing Status

NMFS received a petition from CBD to list bearded seals under the ESA on May 28, 2008 due to loss of sea ice habitat caused by climate change in the Arctic (CBD 2008a). NMFS published a *Federal Register* notice (73 FR 51615; September 4, 2008) indicating that there were sufficient data to warrant a status review of the species (Allen and Angliss 2010). NMFS proposed to list the Beringia DPS of bearded seals as threatened under the ESA on December 10, 2010 (75 *FR* 77496). At that time, NMFS determined that critical habitat for the Beringia DPS in U.S. waters was not determinable and did not propose to designate critical habitat for the DPS. The deadline for a final determination regarding the listing proposal has been extended to summer 2012 (76 FR 77465).

Although the present population of the Beringia DPS is highly uncertain, it has been estimated to be about 155,000 individuals. Based on extrapolation from existing aerial survey data, Cameron et al. (2010) considered the current population of bearded seals in the Bering Sea to be about double the 63,200 estimate reported by Ver Hoef *et al.* (2010; corrected for seals in the water) for U.S. waters, or approximately 125,000 individuals. In addition, Cameron et al. (2010) derived crude estimates of: 3,150 bearded seals for the Beaufort Sea (uncorrected for seals in the water), which was noted as likely a substantial underestimate given the known subsistence harvest of bearded seals in this region; and about 27,000 seals for the Chukchi Sea based on extrapolation from limited aerial surveys (also uncorrected for seals in the water).

Feeding and Prey Selection

Bearded seals feed primarily on a variety of invertebrates (crabs, shrimp, clams, worms, and snails) and some fishes found on or near the sea bottom (Kelly 1988; Reeves, Stewart, and Leatherwood 1992; ADFG 1994; Cameron *et al*. 2010; Burns 1981; Hjelset *et al*. 1999). They primarily feed on or near the bottom, diving to depths of less than 100 m (though dives of adults have been recorded up to 300 m and young-of-the-year have been recorded diving down to almost 500 m; Gjertz 2000). Satellite tagging indicates that adults, subadults, and to some extent pups, show some level of fidelity to feeding areas, often remaining in the same general area for weeks or months at a time (Cameron 2005; Cameron and Boveng, 2009). Diets may vary with age, location, season, and possible changes in prey availability (Kelly 1988).

Quakenbush *et al.* (2011b) reported that fish consumption appeared to increase between the 1970s and 2000s for Alaska bearded seals sampled in the Bering and Chukchi Seas, although the difference was not statistically significant. Bearded seals also commonly consumed invertebrates, which were found in 95% of the stomachs sampled. In the 2000s, sculpin, cod, and flatfish were the dominant fish taxa consumed (Quakenbush *et al.* 2011b). The majority of invertebrate prey items identified in the 2000s were mysids, isopods, amphipods, and decapods. Decapods were the most dominant class of invertebrates, and were strongly correlated with the occurrence of shrimp and somewhat correlated with the occurrence of crab. Mollusks were also common prey, occurring in more than half of the stomachs examined throughout the years of the study.

Diving, Hauling out, and Social Behavior

Figure 7 summarizes the approximate annual timing of reproduction and molting in the Bering Strait, Central Chukchi, and Western Canadian Arctic. Females give birth to a single pup in the spring on suitable broken pack ice over shallow waters. Pups enter the water within hours of birth and nurse on the ice. Though not specifically studied, the molting period of bearded seals in the Bering and Chukchi seas is reportedly protracted, occurring between April and August with a peak in May and June (Tikhomirov 1964, Kosygin 1966, Burns 1981). Adult and juvenile bearded seals haul out more frequently during this annual molt.

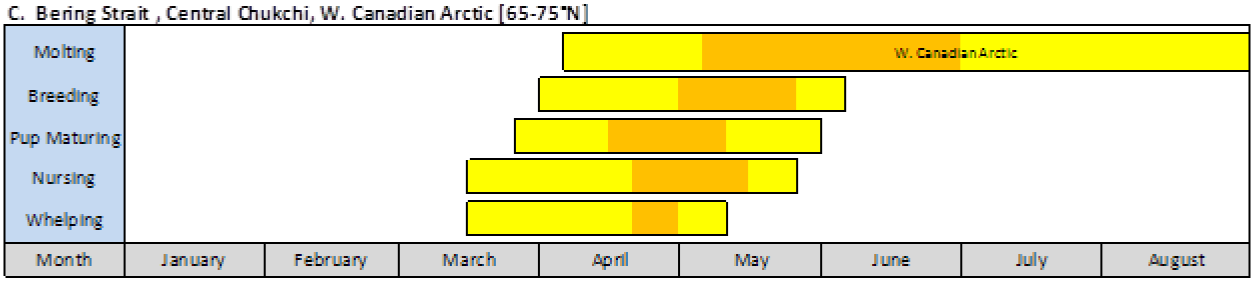


Figure 7. Approximate annual timing of reproduction and molting for the Beringia DPS of bearded seals. Yellow bars indicate the "normal" range over which each event is reported to occur and orange bars indicate the peak timing of each event. For molting, reports for juveniles and adults were combined. "Pup Maturing" refers to the period when weaned pups may remain at least partially dependent on sea ice while they develop proficiency at diving and foraging for themselves. Locations are noted where differences within the region occur (from Cameron *et al.* 2010).

There are only a few quantitative studies concerning the activity patterns of bearded seals. Based on limited observations in the southern Kara Sea and Sea of Okhotsk it has been suggested that from late May to July bearded seals haul out more frequently on ice in the afternoon and early evening (Heptner *et al*. 1976). From July to April, three males (2 subadults and 1 young adult) tagged as part of a study in the Bering and Chukchi Seas rarely hauled out at all, even when occupying ice covered areas. This is similar to both male and female young-of-year bearded seals instrumented in Kotzebue Sound, Alaska (Frost *et al*. 2008); suggesting that, at least in the Bering and Chukchi Seas, bearded seals may not require the presence of sea ice for a significant part of the year. The timing of haulout was different between the age classes in these two studies however, with more of the younger animals hauling out in the late evening (Frost *et al*. 2008) while adults favored afternoon.

The diving behavior of adult bearded seals is closely related to their benthic foraging habits and in the few studies conducted so far, dive depths have largely reflected local bathymetry (Gjertz *et al*. 2000, Krafft *et al*. 2000). The preferred depth range is often defined as less than 200 m, though dives of adults have been recorded up to 300 m and young-of-the-year have been recorded diving down to almost 500 m (Kovacs 2002, Cameron and Boveng 2009). Studies using depth recording devices have until recently focused on lactating mothers and their pups. These studies showed that mothers in the Svalbard Archipelago make relatively shallow dives, generally <100 m in depth, and for short periods, generally less than 10 min in duration. Nursing mothers dived deeper on average than their pups, but by 6 weeks of age most pups had exceeded the maximum dive depth of lactating females (448-480 m versus 168-472 m)(Gjertz *et al*. 2000).

Bearded seals are solitary throughout most of the year except for the breeding season. The social dynamics of mating in bearded seals are not well known because detailed observations of social interactions are rare, especially underwater where copulations are believed to occur. Theories regarding their mating system have centered around serial monogamy and promiscuity, and more specifically on the nature of competition among breeding males to attract and gain access to females (Stirling 1983, Budelsky 1992, Stirling and Thomas 2003). Whichever mating system is favored, sexual selection driven by female choice is predicted to have strongly influenced the evolution of male displays, and possibly size dimorphism, and caused the distinct geographical vocal repertoires recorded from male bearded seals in the Arctic (Stirling, 1983; Atkinson, 1997; Risch *et al*., 2007).

Vocalizations and Hearing

Bearded seals vocalize underwater in association with territorial and mating behaviors. The predominant calls produced by males during breeding, termed trills, are described as frequency-modulated vocalizations. Trills show marked individual and geographical variation, are uniquely identifiable over long periods, can propagate up to 30 km, are up to 60 s in duration, and are usually associated with stereotyped dive displays (Cleator *et al*. 1989, Van Parijs *et al*. 2001, Van Parijs 2003, Van Parijs *et al*. 2003, Van Parijs *et al*. 2004, Van Parijs and Clark 2006).

Underwater audiograms for ice seals suggest that they have very little hearing sensitivity below 1 kHz; but hear underwater sounds at frequencies up to 60 kHz; and make calls between 90 Hz and 16 kHz (Richardson et al., 1995a). A more recent review suggests that the functional auditory bandwidth for pinnipeds in water is between 75 Hz and 75 kHz, with the greatest sensitivity between approximately 700 Hz and 20 kHz (Southall *et al*., 2007). Masking of biologically important sounds by anthropogenic noise could be considered a temporary loss of hearing acuity. Brief, small-scale masking episodes might, in themselves, have few long-term consequences for individual marine mammals. There are few situations or circumstances where low frequency sounds could mask biologically important signals.

IV.ENVIRONMENTAL BASELINE

This section provides the reference condition for the species within the action area. By regulation, the baseline includes the impacts of past and on-going actions (except the effects of the proposed action) on the species. This section also contains summaries of the impacts from stressors that will be ongoing in the same areas and times as the effects of the proposed action (future baseline). This information forms part of the foundation of our exposure, response, and risk analyses. There are several major categories of impacts introduced below: climate change; ocean acidification; subsistence harvest; and noise exposure. After their introduction, major stressors and others are further analyzed specifically for each species.

Climate Change

There is widespread consensus within the scientific community that atmospheric temperatures on earth are increasing and that this will continue for at least the next several decades. The 4th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC 2007) reports that warming will be greatest over land and at most high northern latitudes.

> Eleven of the twelve years (1995-2006) rank among the twelve warmest years in the instrumental record of global surface temperature (since 1850). The 100-year linear trend (1906-2005) of 0.74 [0.56 to 0.92]°C is larger than the corresponding trend of 0.6 [0.4 to 0.8]°C (1901-2000) given in the TAR (Figure 1.1). The linear warming trend over the 50 years from 1956 to 2005 (0.13 [0.10 to 0.16]°C per decade) is nearly twice that for the 100 years from 1906 to 2005. The temperature increase is widespread over the globe and is greater at higher northern latitudes.
>
> Average Arctic temperatures have increased at almost twice the global average rate in the past 100 years. During the 20th century, air temperatures over extensive land areas increased by up to 5°C; sea ice thinned and declined in extent; Atlantic water flowing into the Arctic Ocean warmed; and terrestrial permafrost and Eurasian spring snow decreased in extent. Projected surface temperature changes along the North Slope of Alaska may increase by 6.0-6.5 degrees C for the late 21st century (2090-2099), relative to the period 1980-1999.

The NRC (2001) also concluded that: “The predicted warming is larger over higher latitudes than over low latitudes, especially during winter and spring, and larger over land than over sea.”

For example, the UAF's Scenarios Network for Alaska & Arctic Planning (SNAP) projects October – March average monthly temperatures will increase by 20-25 degrees Farenheit by 2100 near Barrow, Alaska (www.snap.uaf.edu chart tool accessed June 2012).

IPCC 2007 also predict the continuation of recent observed trends such as contraction of snow cover area, increases in thaw depth over most permafrost regions, and decrease in sea ice extent.

> Observed decreases in snow and ice extent are also consistent with warming. Satellite data since 1978 show that annual average Arctic sea ice extent has shrunk by 2.7 [2.1 to 3.3]% per decade, with larger decreases in summer of 7.4 [5.0 to 9.8]% per decade.
>
> Snow cover area is projected to contract. Widespread increases in thaw depth are projected over most permafrost regions. Sea ice is projected to shrink in both the Arctic and Antarctic under all SRES scenarios. In some projections, Arctic late-summer sea ice disappears almost entirely by the latter part of the 21st century.

Climate change associated with Arctic warming may also result in regime change of the Arctic Ocean ecosystem. Sighting of humpback whales in the Chukchi Sea during the 2007 SOI deep seismic surveys (Funk *et al.* 2008) may indicate the expansion of habitat by this species as a result of ecosystem regime shift in the Arctic. These species, in addition to minke and killer whales, and four pinniped species (harp, hooded, ribbon, and spotted seals) that seasonally occupy Arctic and subarctic habitats may be poised to encroach into more northern latitudes and to remain there longer, thereby competing with extant Arctic species (Moore and Huntington 2008).

In the past decade, geographic displacement of marine mammal population distributions has coincided with a reduction in sea ice and an increase in air and ocean temperatures in the Bering Sea (Grebmeier *et al.* 2006). Continued warming is likely to increase the occurrence and resident times of subarctic species such as spotted seals and bearded seals in the Beaufort Sea. The result of global warming would significantly reduce the extent of sea ice in at least some regions of the Arctic (ACIA 2004; Johannessen *et al.* 2004).

Ocean Acidification

The threats posed to marine ecosystems due to ocean acidification are becoming increasingly apparent. A report entitled "Ocean Acidification: A National Strategy to Meet the Challenges of a Changing Ocean," (NRC 2010 available online at http://www.nap.edu/catalog.php?record_id=12904) explained that as carbon dioxide has been released into the atmosphere due to human activities, the ocean has absorbed about 1/3 of the total emissions for the past 200 years. When the oceans uptake this CO_2, decreases to water pH can result (IPCC 2007), leading to other chemical changes which have been termed "ocean acidification." NRC (2010) highlighted the fact that this rate of change in ocean chemistry is greater than any known for at least 800,000 years and is increasing too rapidly for natural processes to maintain the ocean's pH. The potential effects and the specific timeframes for effects of ocean acidification are uncertain. The NRC (2010) concluded that while direct biological effects of this ocean acidification will vary and are not certain, the chemical effects are "well understood" and "…the long-term consequences of ocean acidification are not known but are likely to include serious impacts on ecosystems…."

The IAP (2009) summarized the direction of the likely impacts of ocean acidification:

> "The high CO_2 waters in polar and upwelling regions such as the eastern Pacific and Bering Sea for example, will experience low pH more rapidly than other regions…The ocean chemistry changes projected will exceed the range of natural variability, which is likely to be too rapid for many species to adapt to. Many coastal animals and groups of phytoplankton and zooplankton may be directly affected with implications for fish, marine mammals and the other groups that depend on them for food…The impacts of these changes on oceanic ecosystems…cannot yet be estimated accurately but they are potentially large…Although some species may benefit, most are adapted to current conditions and the impacts on ocean biological diversity and ecosystem functioning will likely be severe."

One of the key effects that is predicted to occur from increasing ocean acidification derives from observations that acidifying seawater negatively affects the ability of species to form and maintain shells and skeletons made of calcium carbonate. This observation indicates that there will likely be adverse effects on organisms such as zooplankton, key elements in many food webs. Based on all of the available information, the ecosystems of Chukchi and Beaufort Seas may be seriously threatened by ocean acidification and climate change in this century.

Arctic Acoustic Environment

The need to understand the marine acoustic environment is critical when assessing the effects of oil and gas exploration and development on humans and wildlife. Sounds generated by oil and gas exploration and development within the marine environment can affect its inhabitants' behavior (e.g., deflection from loud sounds) or ability to effectively live in the marine environment (e.g., masking of sounds that could otherwise be heard). Understanding of the existing environment is necessary to evaluate what the potential effects of oil and gas exploration and development may be.

This section summarizes the various sources of natural ocean sounds and anthropogenic sounds documented in the Arctic sub-region.

Ambient sound levels are the result of numerous natural and anthropogenic sounds that can propagate over large distances and vary greatly on a seasonal and spatial scale (National Research Council [NRC] 2003a). This is especially the case in the dynamic Arctic environment with its highly variable ice, temperature, wind, and snow conditions. Where natural forces dominate, there will be sounds at all frequencies and contributions in ocean sound from a few hundred Hz to 200 kHz (NRC 2003a).

In the Arctic Ocean, the main sources of underwater ambient sound would be associated with:

- Ice, wind, and wave action
- Precipitation
- Subsea earthquake activity
- Vessel and industrial transit
- Sonar and seismic-survey activities
- Biological sounds

The contribution of these sources to the background sound levels differs with their spectral components and local propagation characteristics (e.g., water depth, temperature, salinity, and ocean bottom conditions). In deep water, low-frequency ambient sound from 1–10 Hz mainly comprises turbulent pressure fluctuations from surface waves and the motion of water at the air-water interfaces. At these infrasonic frequencies, sound levels depend only slightly on wind speed. Between 20–300 Hz, distant anthropogenic sound (ship transiting, etc.) dominates wind-related sounds. Above 300 Hz, the ambient sound level depends on weather conditions, with wind- and wave-related effects mostly dominating sounds. Biological sounds arise from a variety of sources (e.g., marine mammals, fish, and shellfish) and range from approximately 12 Hz to over 100 kHz. The relative strength of biological sounds varies greatly; depending on the situation, biological sound can be nearly absent to dominant over narrow or even broad frequency ranges (Richardson *et al.* 1995).

Typical background sound levels within the ocean are shown as a function of frequency (Figure 8 from Wenz 1962). The sound levels are given in underwater dB frequency bands written as dB re 1 $\mu Pa^2/Hz$. Sea State or wind speed is the dominant factor in calculating ambient noise levels above 500 Hz.

Sources of Natural Ocean Sounds

Sources of natural ocean sounds in the Arctic sub-region that contribute to the ambient sound levels are from non-biological and biological origins. Examples of non-biological natural sound sources include movements of sea ice, wind and wave action, surface precipitation, and subsea earthquakes. Biological sources of sound production are fish, marine mammals, and sea birds. The contribution of natural sounds to the overall ambient sound level has been well documented for the Beaufort Sea close to Northstar Island (Blackwell *et al.* 2008).

Non-Biological Sound Sources

Non-biological natural sound sources in the Beaufort Sea include the wind stirring the surface of the ocean, lightning strikes; subsea earthquakes; and ice movements. Burgess and Greene (1999) report that collectively, these sources create an ambient noise range of 63 - 133 dB re 1 µPa.

The presence of ice can contribute significantly to ambient noise levels and affects sound propagation. As noted by the NRC (2001:39), “An ice cover radically alters the ocean noise field…” with factors such as the “…type and degree of ice cover, whether it is shore-fast pack ice, moving pack ice and…floes, or at the marginal ice zone…,” and temperature, all affecting ambient noise levels. The NRC (2001, citing Urick, 1984) reported that variability in air temperature over the course of the day can change received sound levels by 30 dB between 300 and 500 Hz.

Temperature affects the mechanical properties of the ice, and temperature changes can result in cracking. In winter and spring, landfast ice produces significant thermal cracking noise (Milne and Ganton 1964; Lewis and Denner 1987, 1988). In areas characterized by a continuous fast-ice cover, the dominant source of ambient noise is the ice cracking induced by thermal stresses (Milne and Ganton 1964). The spectrum of cracking noise typically displays a broad range from 100 Hz – 1 kHz, and the spectrum level has been observed to vary as much as 15 dB within 24 hours due to the diurnal change of air temperature. Ice deformation occurs primarily from wind and currents and usually produces low frequency noises. Data are limited, but at least in one instance it has been shown that ice-deformation noise produced frequencies of 4 - 200 Hz (Greene 1981). As icebergs melt, they produce additional background noise as the icebergs tumble and collide.

While sea ice can produce significant amounts of background noise, it also can function to dampen ambient noise. Areas of water with 100% sea-ice cover can reduce or completely eliminate noise from waves or surf (Richardson *et al.* 1995). Because ice effectively decreases water depth, industrial sounds may not propagate as well at the lowest frequencies (Blackwell and Greene, 2002). The marginal ice zone, the area near the edge of large sheets of ice, usually is characterized by quite high levels of ambient noise compared to other areas, in large part due to the impact of waves against the ice edge and the breaking up and rafting of ice floes (Milne and Ganton 1964; Diachok and Winokur 1974). In the Arctic, wind and waves (during the open-water season) are important sources of ambient noise with noise levels tending to increase with increased wind and sea state, all other factors being equal (Richardson *et al.* 1995).

Precipitation in the form of rain and snow would be another source of sound. These forms of precipitation can increase ambient sound levels by up to 35 dB across a broad band of frequencies, from 100 Hz to more than 20 kHz (Nystuen and Farmer 1987). In general, it is expected that precipitation in the form of rain would result in greater increases in ambient sound levels than snow. Thus, ocean sounds caused by precipitation are quite variable and transitory.

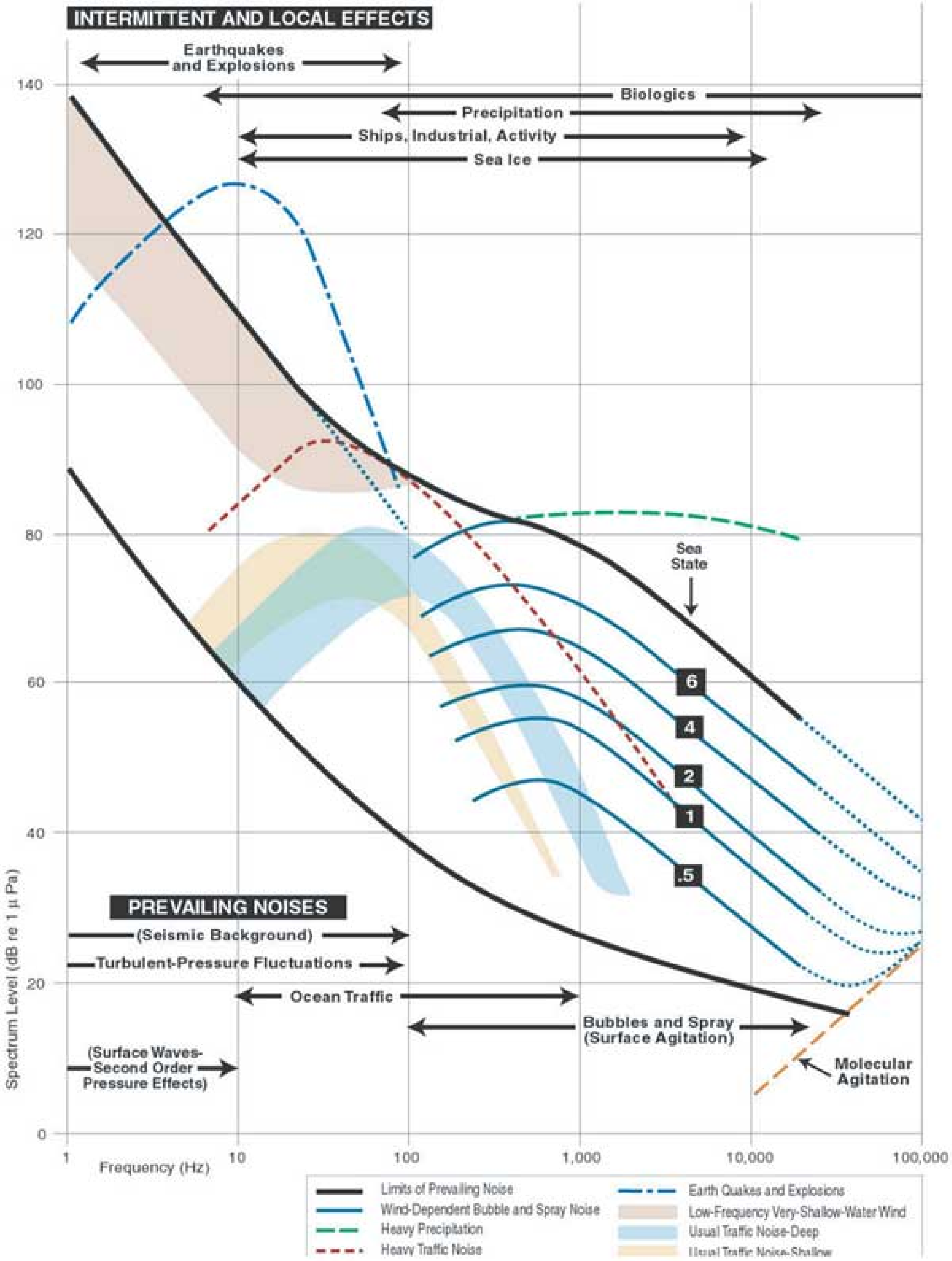


Figure 8. Background sound levels within the ocean (Source: Wenz (1962); adopted from the National Research Council (NRC; 2003a). Ocean Noise and Marine Mammals. National Academy Press. Washington DC).

Seismic events such as earthquakes caused by a sudden shift of tectonic plates, or volcanic events where hydrothermal venting or eruptions occur, can produce a continual source of sound in some areas. This sound can be as much as 30 – 40 dB above background sound and can last from a few seconds to several minutes (Schreiner *et al.* 1995). Shallow hazard surveys conducted in the Alaskan Chukchi Shelf have found that it is generally not seismically active (Fugro 1989).

Biological Sound Sources

The sounds produced by marine life are many and varied. Marine mammals and many fish and marine invertebrates are known to produce sounds (Wenz 1962; Tavolga 1977; Zelick *et al.* 1999).

Fishes produce different types of sounds using different mechanisms and for different reasons. Sounds may be intentionally produced as signals to predators or competitors, to attract mates, or as a fright response. Sounds are also produced unintentionally including those made as a by-product of feeding or swimming. The three main ways fishes produce sounds are by using sonic muscles that are located on or near their swim bladder (drumming); striking or rubbing together skeletal components (stridulation); and by quickly changing speed and direction while swimming (hydrodynamics). The majority of sounds produced by fishes are of low frequency, typically less than 1,000 Hz. However, there is not much information on marine invertebrates and fish sounds in the Arctic region.

Marine mammals can contribute significantly to the ambient sound levels in the acoustic environment of the Beaufort Sea. Frequencies and levels are highly dependent on seasons. For example, source levels of bearded seal songs have been estimated to be up to 178 dB re 1 µPa at 1 m (Cummings *et al.* 1983). Ringed seal calls have a source level of 95 - 130 dB re 1 µPa at 1 m, with the dominant frequency under 5 kHz (Richardson *et al.* 1995). Bowhead whales, which are present in the Arctic region from early spring to mid- to late fall, produce sounds with source levels ranging from 128 - 189 dB re 1 µPa at 1 m in frequency ranges from 20 - 3,500 Hz. Richardson *et al.* (1995) summarized that most bowhead whale calls are “tonal frequency-modulated (FM)” sounds at 50 - 400 Hz. There are many other species of marine mammals in the arctic marine environment whose vocalizations contribute to ambient noise including, but not limited to, the gray whale, walrus, ringed seal, beluga whale, spotted seal, fin whale (in the southwestern areas) and, less likely, the humpback whale. In air, sources of sound will include seabirds (especially in the Chukchi Sea near colonies), walruses, and seals.

Sources of Anthropogenic Sounds

Human sources include noise from vessels (motor boats used for subsistence and local transportation, commercial shipping, research vessels, etc.); navigation and scientific research equipment; airplanes and helicopters; human settlements; military activities; and marine development. Table 5 provides a comparison of manmade sound levels from various sources associated with the marine environment. NMFS has established acoustic thresholds that identify the received sound levels above which hearing impairment or other injury could potentially occur, which are 180 and 190 dB re 1 µPa (rms) for cetaceans and pinnipeds, respectively (NMFS 1995, 2000). The established 180- and 190-dB re 1 µPa (rms) criteria are the received levels above which, in the view of a panel of bioacoustics specialists convened by NMFS before additional TTS measurements for marine mammals became available, one could not be certain that there would be no injurious effects, auditory or otherwise, to marine mammals.

Vessel Activities and Traffic

Shipping is the dominant source of sound in the world's oceans in the range from 5 to a few hundred Hz (National Academy of Sciences 2005). Commercial shipping is the major contributor to sound in the world's oceans and contributes to the 10 – 100 Hz frequency band (NRC 2003a). Some of the more intense anthropogenic sounds come from oceangoing vessels, especially larger ships such as supertankers. Shipping noise, often at source levels of 150 - 190 dB, dominates the low frequency regime of the spectrum. It is estimated that over the past few decades the shipping contribution to ambient noise has increased by as much as 12 dB (Hildebrand 2009).

Table 5. A Comparison of Most Common Anthropogenic Sound Levels from Various Sources (Richardson et al. 1995; and Rober Lemeur).

Source	Activities	dB at source
Vessel Activity		
	Tug Pulling Barge	171
	Fishing Boat	151-158
	Zodiac (outboard)	156
	Supply Ship	181
	Tankers	169-180
	Supertankers	185-190
	Freighter	172
Ice Breaking		
	Ice Management	171-191
	Icebreaking[2]	193
Dredging		
	Clamshell Dredge	150-162
	Aquarius (cutter suction dredge)	185
	Beaver Mackenzie Dredge	172
Drilling		
	Kulluk (conical drillship) – drilling	185
	Explorer II (drillship) – drilling	174
	Artificial Island – drilling	125
	Ice Island (in shallow water) – drilling	86
Seismic and Marine Surveys		
	Airgun Arrays	235-259
	Single Airguns	216-232
	Vibroseis	187-210
	Water Guns	217-245
	Sparker	221
	Boomer	212
	Depth Sounder	180

	Sub-bottom Profiler	200-230
	Side-scan Sonar	220-230
	Military	200-230

In addition, interest in the Arctic has led to several tourist cruise ships spending time in arctic waters during the past few years (Lage 2009). In the Beaufort Sea, vessel transiting and associated sounds presently are limited primarily to late spring, summer, and early autumn, when open waters are unimpeded by broken ice or ice sheets.

Due to the shortness of the open water season, vessel transiting—particularly large vessel transiting—is minimal in arctic marine waters. Richardson *et al.* (1995) described the range of frequencies for shipping activities to be from 20–300 Hz. They note that smaller boats used principally for fishing or whaling generate a frequency of approximately 300 Hz (Richardson *et al.* 1995).

Sound energy in the Arctic is particularly efficient at propagating over large distances, because in these regions the oceanic sound channel reaches the ocean surface and forms the Arctic half-channel (Urick 1983). In shallow water, vessels more than 10 km away from a receiver generally contribute only to background noise (Richardson *et al.* 1995). In deep water, traffic noise up to 4,000 km away may contribute to background-noise levels (Richardson *et al.* 1995). Shipping traffic is most significant at frequencies from 20 - 300 Hz (Richardson *et al.* 1995). Barging associated with activities such as onshore and limited offshore oil and gas activities, fuel and supply shipments, and other activities contributes to overall ambient noise levels in some regions of the Beaufort Sea. The use of aluminum skiffs with outboard motors during fall subsistence whaling in the Alaskan Beaufort Sea also contributes noise. Fishing boats in coastal regions also contribute sound to the overall ambient noise. Sound produced by these smaller boats typically is at a higher frequency, around 300 Hz (Richardson *et al.* 1995).

Icebreaking and ice management vessels used in the Arctic for activities including research and oil and gas activities produce stronger, but also more variable, sounds than those associated with other vessels of similar power and size (Greene 1987; Richardson *et al.* 1995). Even with rapid attenuation of sound in heavy ice conditions, the elevation in noise levels attributed to icebreaking can be substantial out to at least 5 km (Richardson *et al.* 1991). In some instances, icebreaking sounds are detectable from more than 50 km away. In general, spectra of icebreaker noise are wide and highly variable over time (Richardson *et al.* 1995).

Oil and Gas Development and Production Activities

Oil and gas exploration and production activities have occurred on the North Slope since the early 1900s, and production has occurred for more than 50 years. Since the discovery and development of the Prudhoe Bay and Kuparuk oil field, more recent fields generally have been developed not in the nearshore environment, but on land in areas adjacent to existing producing areas. Pioneer Natural Resources Co. is developing its North Slope Oooguruk field, which is in the shallow waters of the Beaufort Sea approximately 8 mi northwest of the Kuparuk River unit.

Much of the production noise from oil and gas operations on gravel islands is substantially attenuated within 4 km and often not detectable at 9.3 km. Typically, noise propagates poorly from artificial islands, as it must pass through gravel into the water (Richardson *et al.* 1995). Richardson *et al.* (1995) reported that during unusually quiet periods, drilling noise from ice-bound islands would be audible at a range of about 10 km, when the usual audible range would be ~2 km. Richardson *et al.* (1995) also reported that broadband noise decayed to ambient levels within ~1.5 km, and low-frequency tones were measurable to ~9.5 km under low ambient-noise conditions, but were essentially undetectable beyond ~1.5 km with high ambient noise.

Richardson and Williams (2004) summarized results from acoustic monitoring of the BP offshore Northstar production facility from 1999 - 2003. Northstar is located on an artificial gravel island in the central Alaskan Beaufort Sea. In the open-water season, in-air broadband measurements reached background levels at 1 - 4 km and were not affected by vessel presence. However, Blackwell and Greene (2004) pointed out that "…an 81 Hz tone, believed to originate at Northstar, was still detectable 37 km from the island." Based on sound measurements from Northstar obtained during March 2001 and February - March 2002 (during the ice-covered season), Blackwell *et al.* (2004) found that background levels were reached underwater at 9.4 km when drilling was occurring and at 3 - 4 km when it was not. Irrespective of drilling, in-air background levels were reached at 5-10 km from Northstar.

During the open-water season, vessels such as tugs, self-propelled barges, and crew boats were the main contributors to Northstar-associated underwater sound levels, with broadband sounds from such vessels often detectable approximately 30 km offshore. In 2002, sound levels were up to 128 dB re 1 μPa at 3.7 km when crew boats or other operating vessels were present (Richardson and William 2003). In the absence of vessel noise, averaged underwater broadband sounds generally reached background levels 2 - 4 km from Northstar. Underwater sound levels from a hovercraft, which BP began using in 2003, were quieter than similarly sized conventional vessels.

BP is currently producing oil from an offshore development in the Northstar Unit, which is located between 3.2 and 12.9 km (2 and 8 mi) offshore from Point Storkersen in the Beaufort Sea. This development is the first in the Beaufort Sea that makes use of a subsea pipeline to transport oil to shore and then into the Trans-Alaska Pipeline System. The Northstar facility was built in State of Alaska waters on the remnants of Seal Island ~9.5 km (6 mi) offshore from Point Storkersen, northwest of the Prudhoe Bay industrial complex, and 5 km (3 mi) seaward of the closest barrier island. The unit is adjacent to Prudhoe Bay, and is approximately 87 km (54 mi) northeast of Nuiqsut, an Inupiat community. To date, it is the only offshore oil production facility north of the barrier islands in the Beaufort Sea.

On November 6, 2009, BP submitted an application requesting NMFS issue regulations and subsequent LOAs governing the taking of marine mammals, by both Level B harassment and serious injury and mortality, incidental to operation of the Northstar development in the Beaufort Sea, Alaska. Construction of Northstar was completed in 2001. The proposed activities for 2012-2017 include a continuation of drilling, production, and emergency training operations but no construction or activities of similar intensity to those conducted between 1999 and 2001. NMFS published a notice of proposed rulemaking in the Federal Register on July 6, 2011, requesting comments and information from the public (76 FR 39706). NMFS is currently working on the final rulemaking governing BP's marine mammal take authorizations for operating its Northstar facility.

In addition, Shell Offshore Inc. (Shell) plans to drill two exploration wells at two drill sites in Camden Bay, Beaufort Sea, Alaska, during the 2012 Arctic open water season . On May 2, 2012, NMFS issued an IHA to Shell Offshore Inc. (Shell) to take 8 species of marine mammals, by harassment, incidental to offshore exploration drilling on Outer Continental Shelf (OCS) leases in the Beaufort Sea, Alaska, from July 1, 2012, through October 31, 2012 (NMFS 2012c).

Geophysical and Seismic Surveys

Shell's zero-offset vertical seismic profile (ZVSP) surveys in Camden Bay between July and October 2012 (NMFS 2012c) are concurrent to the action analyzed in this opinion. These surveys do not overlap with the action area for this opinion.

The most intense sound sources from geophysical and seismic surveys would be impulse sound generated by the airgun arrays. These impulse sounds are created by the venting of high-pressure air from the airguns into the water column and the subsequent production of an air-filled cavity (a bubble) that expands and contracts, creating sound with each oscillation. Airgun output usually is specified in terms of zero-to-peak (0-peak, or 0-p) or peak-to-peak (peak-peak, or p-p) levels.

While the seismic airgun pulses are directed towards the ocean bottom, sound propagates horizontally for several kilometers (Greene and Richardson 1988; Hall *et al.* 1994). In waters 25 - 50 m deep, sound produced by airguns can be detected 50 - 75 km away, and these detection ranges can exceed 100 km in deeper water (Richardson *et al.* 1995) and thousands of kilometres in the open ocean (Nieukirk *et al.* 2004). Typically, an airgun array is towed behind a vessel at 4 - 8 m depth and is fired every 10 - 15 seconds. The ship also may be towing long cables with hydrophones (streamers), which detect the reflected sounds from the seafloor.

Airgun-array sizes are quoted as the sum of their individual airgun volumes (in cubic inches) and can vary greatly. The array output is determined more by the number of guns than by the total array volume. For single airguns the zero-peak acoustic output is proportional to the cube root of the volume. As an example, compare two airgun configurations with the same total volume. The first array consists of one airgun with a total volume of 100 in^3 resulting in a cube root of 4.64. The second array has the same total volume, but consists of five 20-in^3 guns. The second array has an acoustic output nearly three times higher (5 times the cube root of 20 = 13.57) than the single gun, while the gun volumes are equal. The output of a typical 2D/3D array has a theoretical point-source output of ~255 dB + 3 dB (Barger and Hamblen 1980; Johnston and Cain 1981); however, this is not realized in the water column, and maximum real pressure is more on the order of 232 dB + 3 dB and typically only occurs within 1 - 2 m of the airguns.

The depth at which the source is towed has a major impact on the maximum near-field output, and on the shape of its frequency spectrum. The root-mean-square (rms) received levels that are used as impact criteria for marine mammals are not directly comparable to the peak or peak-to-peak values normally used to characterize source levels of airguns. The measurement units used to describe airgun sources, peak or peak-to-peak decibels, are always higher than the rms decibels referred to in much of the biological literature.

Tolstoy *et al.* (2004) collected empirical data concerning 190-, 180-, 170-, and 160-dB (rms) distances in deep (~3,200 m) and shallow (~30 m) water for various airgun-array configurations during the acoustic calibration study conducted by Lamont-Doherty Earth Observatory in the northern Gulf of Mexico. Results demonstrate that received levels in deep water were lower than anticipated based on modeling, while received levels in shallow water were higher.

Seismic sounds vary, but a typical 2D/3D seismic survey with multiple guns would emit energy at about 10 - 120 Hz, and pulses can contain significant energy up to at least 500 - 1,000 Hz (Richardson *et al.* 1995). Goold and Fish (1998) recorded a pulse range of 200 Hz - 22 kHz from a 2D survey using a 2,120-in^3 array.

Richardson *et al.* (1995) summarized that typical signals associated with vibroseis sound source used for on-ice seismic survey sweep from 10 - 70 Hz, but harmonics extend to about 1.5 kHz (Richardson *et al.* 1995). In this activity, hydraulically driven pads mounted beneath a line of trucks are used to vibrate, and thereby energize the ice. Noise incidental to the activity is introduced by the vehicles associated with this activity.

The effects of sounds from airgun pulses might include one or more of the following: masking of natural sounds, behavioral disturbance, temporary or permanent hearing impairment, non-auditory physical effects, and/or stranding and mortality (Richardson et al. 1995). As outlined in previous NMFS documents, the effects of noise on marine mammals are highly variable, and can be categorized as follows (based on Richardson et al. 1995):

(1) Behavioral Disturbance

Marine mammals may behaviorally react to sound when exposed to anthropogenic noise. Currently NMFS uses 160 dB re 1 mPa (rms) at received level for impulse noises (such as airgun pulses) as the threshold for the onset of marine mammal behavioral harassment.
The onset of behavioral disturbance from anthropogenic noise depends on both external factors (characteristics of noise sources and their paths) and the receiving animals (hearing, motivation, experience, demography) and is difficult to predict (Southall et al. 2007). Reactions may include changing durations of surfacing and dives, number of blows per surfacing, or moving direction and/or speed; reduced/increased vocal activities; changing/cessation of certain behavioral activities (such as socializing or feeding); visible startle response or aggressive behavior (such as tail/fluke slapping or jaw clapping); avoidance of areas where noise sources are located; and/or flight responses (e.g., pinnipeds flushing into water from haulouts or rookeries).

The biological significance of many of these behavioral disturbances is difficult to predict, especially if the detected disturbances appear minor. However, the consequences of behavioral modification could be expected to be biologically significant if the change affects growth, survival, and reproduction. Some of these potential significant behavioral modifications include:

- Drastic change in diving/surfacing patterns (such as those thought to be causing beaked whale stranding due to exposure to military mid-frequency tactical sonar);
- Habitat abandonment due to loss of desirable acoustic environment; and
- Cease feeding or social interaction.

Mysticete

Baleen whales generally tend to avoid operating airguns, but avoidance radii are quite variable. Whales are often reported to show no overt reactions to airgun pulses at distances beyond a few kilometers, even though the airgun pulses remain well above ambient noise levels out to much longer distances (reviewed in Richardson et al. 1995; Gordon et al. 2004). However, studies done since the late 1990s of migrating humpback and migrating bowhead whales show reactions, including avoidance, that sometimes extend to greater distances than documented earlier. Therefore, it appears that behavioral disturbance can vary greatly depending on context, and not just received levels alone. Avoidance distances often exceed the distances at which boat-based observers can see whales, so observations from the source vessel can be biased. Observations over broader areas may be needed to determine the range of potential effects of some large-source seismic surveys where effects on cetaceans may extend to considerable distances (Richardson et al. 1999; Moore and Angliss 2006). Longer-range observations, when required, can sometimes be obtained via systematic aerial surveys or aircraft-based observations of behavior (e.g., Richardson et al. 1986, 1999; Miller et al. 1999, 2005; Yazvenko et al. 2007a, 2007b) or by use of observers on one or more support vessels operating in coordination with the seismic vessel (e.g., Smultea et al. 2004; Johnson et al. 2007). However, the presence of other vessels near the source vessel can, at least at times, reduce sightability of cetaceans from the source vessel (Beland et al. 2009), thus complicating interpretation of sighting data.

Some baleen whales show considerable tolerance of seismic pulses. However, when the pulses are strong enough, avoidance or other behavioral changes become evident. Because the responses become less obvious with diminishing received sound level, it has been difficult to determine the maximum distance (or minimum received sound level) at which reactions to seismic activity become evident and, hence, how many whales are affected.

Studies of gray, bowhead, and humpback whales have determined that received levels of pulses in the 160–170 dB re 1 mPa (rms) range seem to cause obvious avoidance behavior in a substantial fraction of the animals exposed (McCauley et al. 1998, 1999, 2000). In many areas, seismic pulses diminish to these levels at distances ranging from 4–15 km from the source. A substantial proportion of the baleen whales within such distances may show avoidance or other strong disturbance reactions to the operating airgun array. Some extreme examples including migrating bowhead whales avoiding considerably larger distances (20–30 km) and lower received sound levels (120–130 dB re 1 mPa (rms)) when exposed to airguns from seismic surveys. Also, even in cases where there is no conspicuous avoidance or change in activity upon exposure to sound pulses from distant seismic operations, there are sometimes subtle changes in behavior (e.g., surfacing–respiration– dive cycles) that are only evident through detailed statistical analysis (e.g., Richardson et al. 1986; Gailey et al. 2007).

Data on short-term reactions by cetaceans to impulsive noises are not necessarily indicative of long-term or biologically significant effects. It is not known whether impulsive sounds affect reproductive rate or distribution and habitat use in subsequent days or years. However, gray whales have continued to migrate annually along the west coast of North America despite intermittent seismic exploration (and much ship traffic) in that area for decades (Appendix A in Malme et al. 1984; Richardson et al. 1995), and there has been a substantial increase in the population over recent decades (Allen and Angliss 2010). The western Pacific gray whale population did not seem affected by a seismic survey in its feeding ground during a prior year (Johnson et al. 2007). Similarly, bowhead whales have continued to travel to the eastern Beaufort Sea each summer despite seismic exploration in their summer and autumn range for many years (Richardson et al. 1987), and their numbers have increased notably (Allen and Angliss 2010). Bowheads also have been observed over periods of days or weeks in areas ensonified repeatedly by seismic pulses (Richardson et al. 1987; Harris et al. 2007). However, it is generally not known whether the same individual bowheads were involved in these repeated observations (within and between years) in strongly ensonified areas.

Pinnipeds

Few studies of the reactions of pinnipeds to noise from open-water seismic exploration have been published (for review of the early literature, see Richardson et al. 1995). However, pinnipeds have been observed during a number of seismic monitoring studies. Monitoring in the Beaufort Sea during 1996–2002 provided a substantial amount of information on avoidance responses (or lack thereof) and associated behavior. Additional monitoring of that type has been done in the Beaufort and Chukchi Seas in 2006–2009. Pinnipeds exposed to seismic surveys have also been observed during seismic surveys along the U.S. west coast. Also, there are data on the reactions of pinnipeds to various other related types of impulsive sounds.

Early observations provided considerable evidence that pinnipeds are often quite tolerant of strong pulsed sounds. During seismic exploration off Nova Scotia, gray seals exposed to noise from airguns and linear explosive charges reportedly did not react strongly (J. Parsons in Greene et al. 1985). An airgun caused an initial startle reaction among South African fur seals but was ineffective in scaring them away from fishing gear. Pinnipeds in both water and air sometimes tolerate strong noise pulses from non-explosive and explosive scaring devices, especially if attracted to the area for feeding or reproduction (Mate and Harvey 1987; Reeves et al. 1996). Thus, pinnipeds are expected to be rather tolerant of, or to habituate to, repeated underwater sounds from distant seismic sources, at least when the animals are strongly attracted to the area.

In summary, visual monitoring from seismic vessels has shown only slight (if any) avoidance of airguns by pinnipeds, and only slight (if any) changes in behavior. These studies show that many pinnipeds do not avoid the area within a few hundred meters of an operating airgun array. However, based on the studies with large sample size, or observations from a separate monitoring vessel, or radio telemetry, it is apparent that some phocid seals do show localized avoidance of operating airguns. The limited nature of this tendency for avoidance is a concern. It suggests that one cannot rely on pinnipeds to move away, or to move very far away, before received levels of sound from an approaching seismic survey vessel approach those that may cause hearing impairment.

(2) Masking

Chronic exposure to excessive, though not high-intensity, noise could cause masking at particular frequencies for marine mammals that utilize sound for vital biological functions. Masking can interfere with detection of acoustic signals such as communication calls, echolocation sounds, and environmental sounds important to marine mammals. Since marine mammals depend on acoustic cues for vital biological functions, such as orientation, communication, finding prey, and avoiding predators, marine mammals that experience severe (intensity and duration) acoustic masking could potentially suffer reduced fitness, which could lead to adverse effects on survival and reproduction.

Masking occurs when noise and signals (that animals utilize) overlap at both spectral and temporal scales. For the airgun noise generated from the proposed marine seismic survey, these are low frequency (under 1 kHz) pulses with extremely short durations (in the scale of milliseconds). Lower frequency man-made noises are more likely to affect detection of communication calls and other potentially important natural sounds such as surf and prey noise. There is little concern regarding masking due to the brief duration of these pulses and relatively longer silence between airgun shots (9–12 seconds) near the noise source, however, at long distances (over tens of kilometers away) in deep water, due to multipath propagation and reverberation, the durations of airgun pulses can be ‘‘stretched’’ to seconds with long decays (Madsen et al. 2006; Clark and Gagnon 2006). Therefore it could affect communication signals used by low frequency mysticetes when they occur near the noise band and thus reduce the communication space of animals (e.g., Clark et al. 2009a, 2009b) and affect their vocal behavior (e.g., Foote et al. 2004; Holt et al. 2009). Further, in areas of shallow water, multipath propagation of airgun pulses could be more profound, thus affecting communication signals from marine mammals even at close distances. Average ambient noise in areas where received seismic noises are heard can be elevated. At long distances, however, the intensity of the noise is greatly reduced. Nevertheless, partial informational and energetic masking of different degrees could affect signal receiving in some marine mammals within the ensonified areas. Additional research is needed to further address these effects.

Although masking effects of pulsed sounds on marine mammal calls and other natural sounds are expected to be limited, there are few specific studies on this. Some whales continue calling in the presence of seismic pulses and whale calls often can be heard between the seismic pulses (e.g., Richardson et al. 1986; McDonald et al. 1995; Greene et al. 1999a, 1999b; Nieukirk et al. 2004; Smultea et al. 2004; Holst et al. 2005a, 2005b, 2006; Dunn and Hernandez 2009).

Among the odontocetes, there has been one report that sperm whales ceased calling when exposed to pulses from a very distant seismic ship (Bowles et al. 1994). However, more recent studies of sperm whales found that they continued calling in the presence of seismic pulses (Madsen et al. 2002; Tyack et al. 2003; Smultea et al. 2004; Holst et al. 2006; Jochens et al. 2008). Madsen et al. (2006) noted that airgun sounds would not be expected to mask sperm whale calls given the intermittent nature of airgun pulses. Dolphins and porpoises are also commonly heard calling while airguns are operating (Gordon et al. 2004; Smultea et al. 2004; Holst et al. 2005a, 2005b; Potter et al. 2007). Masking effects of seismic pulses are expected to be negligible in the case of the smaller odontocetes, given the intermittent nature of seismic pulses plus the fact that sounds important to them are predominantly at much higher frequencies than are the dominant components of airgun sounds.

Pinnipeds have best hearing sensitivity and/or produce most of their sounds at frequencies higher than the dominant components of airgun sound, but there is some overlap in the frequencies of the airgun pulses and the calls. However, the intermittent nature of airgun pulses presumably reduces the potential for masking.

Marine mammals are thought to be able to compensate for masking by adjusting their acoustic behavior such as shifting call frequencies, and increasing call volume and vocalization rates, as discussed earlier (e.g., Miller et al. 2000; Parks et al. 2007; Di Iorio and Clark 2009; Parks et al. 2010); the biological significance of these modifications is still unknown.

(3) Hearing Impairment

Marine mammals exposed to high intensity sound repeatedly or for prolonged periods can experience hearing threshold shift (TS), which is the loss of hearing sensitivity at certain frequency ranges (Kastak et al. 1999; Schlundt et al. 2000; Finneran et al. 2002; 2005). TS can be permanent (PTS), in which case the loss of hearing sensitivity is unrecoverable, or temporary (TTS), in which case the animal's hearing threshold will recover over time (Southall et al. 2007). Marine mammals that experience TTS or PTS will have reduced sensitivity at the frequency band of the TS, which may affect their capability of communication, orientation, or prey detection. The degree of TS depends on the intensity of the received levels the animal is exposed to, and the frequency at which TS occurs depends on the frequency of the received noise. It has been shown that in most cases, TS occurs at the frequencies approximately one-octave above that of the received noise. Repeated noise exposure that leads to TTS could cause PTS. For transient sounds, the sound level necessary to cause TTS is inversely related to the duration of the sound.

TTS

TTS is the mildest form of hearing impairment that can occur during exposure to a strong sound (Kryter 1985). While experiencing TTS, the hearing threshold rises and a sound must be stronger in order to be heard. It is a temporary phenomenon, and (especially when mild) is not considered to represent physical damage or ‘‘injury’’ (Southall et al. 2007). Rather, the onset of TTS is an indicator that, if the animal is exposed to higher levels of that sound, physical damage is ultimately a possibility.

The magnitude of TTS depends on the level and duration of noise exposure, and to some degree on frequency, among other considerations (Kryter 1985; Richardson et al. 1995; Southall et al. 2007). For sound exposures at or somewhat above the TTS threshold, hearing sensitivity recovers rapidly after exposure to the noise ends. In terrestrial mammals, TTS can last from minutes or hours to (in cases of strong TTS) days. Only a few data have been obtained on sound levels and durations necessary to elicit mild TTS in marine mammals (none in mysticetes), and none of the published data concern TTS elicited by exposure to multiple pulses of sound during operational seismic surveys (Southall et al. 2007).

For toothed whales, experiments on a bottlenose dolphin (Tursiops truncates) and beluga whale showed that exposure to a single watergun impulse at a received level of 207 kPa (or 30 psi) peak-to-peak (p-p), which is equivalent to 228 dB re 1 mPa (p-p), resulted in a 7 and 6 dB TTS in the beluga whale at 0.4 and 30 kHz, respectively. Thresholds returned to within 2 dB of the pre-exposure level within 4 minutes of the exposure (Finneran et al. 2002). No TTS was observed in the bottlenose dolphin.

Finneran et al. (2005) further examined the effects of tone duration on TTS in bottlenose dolphins. Bottlenose dolphins were exposed to 3 kHz tones (non-impulsive) for periods of 1, 2, 4 or 8 seconds (s), with hearing tested at 4.5 kHz. For 1-s exposures, TTS occurred with SELs of 197 dB, and for exposures >1 s, SEL >195 dB resulted in TTS (SEL is equivalent to energy flux, in dB re 1 mPa2-s). At an SEL of 195 dB, the mean TTS (4 min after exposure) was 2.8 dB. Finneran et al. (2005) suggested that an SEL of 195 dB is the likely threshold for the onset of TTS in dolphins and belugas exposed to tones of durations 1–8 s (i.e., TTS onset occurs at a near- constant SEL, independent of exposure duration). That implies that, at least for non-impulsive tones, a doubling of exposure time results in a 3 dB lower TTS threshold.

However, the assumption that, in marine mammals, the occurrence and magnitude of TTS is a function of cumulative acoustic energy (SEL) is probably an oversimplification. Kastak et al. (2005) reported preliminary evidence from pinnipeds that, for prolonged non-impulse noise, higher SELs were required to elicit a given TTS if exposure duration was short than if it was longer, i.e., the results were not fully consistent with an equal-energy model to predict TTS onset. Mooney et al. (2009a) showed this in a bottlenose dolphin exposed to octave-band non-impulse noise ranging from 4 to 8 kHz at SPLs of 130 to 178 dB re 1 mPa for periods of 1.88 to 30 minutes (min). Higher SELs were required to induce a given TTS if exposure duration was short than if it was longer. Exposure of the aforementioned bottlenose dolphin to a sequence of brief sonar signals showed that, with those brief (but non- impulse) sounds, the received energy (SEL) necessary to elicit TTS was higher than was the case with exposure to the more prolonged octave-band noise (Mooney et al. 2009b). Those authors concluded that, when using (non-impulse) acoustic signals of duration ~0.5 s, SEL must be at least 210–214 dB re 1 mPa2-s to induce TTS in the bottlenose dolphin. The most recent studies conducted by Finneran et al. also support the notion that exposure duration has a more significant influence compared to SPL as the duration increases, and that TTS growth data are better represented as functions of SPL and duration rather than SEL alone (Finneran et al. 2010a, 2010b). In addition, Finneran et al. (2010b) conclude that when animals are exposed to intermittent noises, there is recovery of hearing during the quiet intervals between exposures through the accumulation of TTS across multiple exposures. Such findings suggest that when exposed to multiple seismic pulses, partial hearing recovery also occurs during the seismic pulse intervals.

For baleen whales, there are no data, direct or indirect, on levels or properties of sound that are required to induce TTS. The frequencies to which baleen whales are most sensitive are lower than those to which odontocetes are most sensitive, and natural ambient noise levels at those low frequencies tend to be higher (Urick 1983). As a result, auditory thresholds of baleen whales within their frequency band of best hearing are believed to be higher (less sensitive) than are those of odontocetes at their best frequencies (Clark and Ellison 2004). From this, it is suspected that received levels causing TTS onset may also be higher in baleen whales. However, no cases of TTS are expected given the small size of the airguns proposed to be used and the strong likelihood that baleen whales (especially migrating bowheads) would avoid the approaching airguns (or vessel) before being exposed to levels high enough for there to be any possibility of TTS.

In pinnipeds, TTS thresholds associated with exposure to brief pulses (single or multiple) of underwater sound have not been measured. Initial evidence from prolonged exposures suggested that some pinnipeds may incur TTS at somewhat lower received levels than do small odontocetes exposed for similar durations (Kastak et al. 1999; 2005). However, more recent indications are that TTS onset in the most sensitive pinniped species studied (harbor seal, which is closely related to the ringed seal) may occur at a similar SEL as in odontocetes (Kastak et al. 2004).

Most cetaceans show some degree of avoidance of seismic vessels operating an airgun array (see above). It is unlikely that these cetaceans would be exposed to airgun pulses at a sufficiently high level for a sufficiently long period to cause more than mild TTS, given the relative movement of the vessel and the marine mammal. TTS would be more likely in any odontocetes that bow- or wake-ride or otherwise linger near the airguns. However, while bow- or wake-riding, odontocetes would be at the surface and thus not exposed to strong sound pulses given the pressure release and Lloyd Mirror effects at the surface. But if bow- or wake-riding animals were to dive intermittently near airguns, they would be exposed to strong sound pulses, possibly repeatedly.

If some cetaceans did incur mild or moderate TTS through exposure to airgun sounds in this manner, this would very likely be a temporary and reversible phenomenon. However, even a temporary reduction in hearing sensitivity could be deleterious in the event that, during that period of reduced sensitivity, a marine mammal needed its full hearing sensitivity to detect approaching predators, or for some other reason.

Some pinnipeds show avoidance reactions to airguns, but their avoidance reactions are generally not as strong or consistent as those of cetaceans. Pinnipeds occasionally seem to be attracted to operating seismic vessels. There are no specific data on TTS thresholds of pinnipeds exposed to single or multiple low-frequency pulses. However, given the indirect indications of a lower TTS threshold for the harbor seal than for odontocetes exposed to impulse sound (see above), it is possible that some pinnipeds close to a large airgun array could incur TTS.

NMFS currently typically includes mitigation requirements to ensure that cetaceans and pinnipeds are not exposed to pulsed underwater noise at received levels exceeding, respectively, 180 and 190 dB re 1 mPa (rms). The 180/ 190 dB acoustic criteria were taken from recommendations by an expert panel of the High Energy Seismic Survey (HESS) Team that performed an assessment on noise impacts by seismic airguns to marine mammals in 1997, although the HESS Team recommended a 180-dB limit for pinnipeds in California (HESS 1999). The 180 and 190 dB re 1 mPa (rms) levels have not been considered to be the levels above which TTS might occur. Rather, they were the received levels above which, in the view of a panel of bioacoustics specialists convened by NMFS before TTS measurements for marine mammals started to become available, one could not be certain that there would be no injurious effects, auditory or otherwise, to marine mammals. As summarized above, data that are now available imply that TTS is unlikely to occur in various odontocetes (and probably mysticetes as well) unless they are exposed to a sequence of several airgun pulses stronger than 190 dB re 1 mPa (rms). On the other hand, for the harbor seal, harbor porpoise, and perhaps some other species, TTS may occur upon exposure to one or more airgun pulses whose received level equals 190 dB re 1 mPa (rms). That criterion corresponds to a single-pulse SEL of 175–180 dB re 1 mPa2-s in typical conditions, whereas TTS is suspected to be possible in harbor seals and harbor porpoises with a cumulative SEL of ∼171 and ∼164 dB re 1 mPa2-s, respectively.

It has been shown that most large whales and many smaller odontocetes (especially the harbor porpoise) show at least localized avoidance of ships and/ or seismic operations. Even when avoidance is limited to the area within a few hundred meters of an airgun array, that should usually be sufficient to avoid TTS based on what is currently known about thresholds for TTS onset in cetaceans. In addition, ramping up airgun arrays, which is standard operational protocol for many seismic operators, may allow cetaceans near the airguns at the time of startup (if the sounds are aversive) to move away from the seismic source and to avoid being exposed to the full acoustic output of the airgun array. Thus, most baleen whales likely will not be exposed to high levels of airgun sounds provided the ramp- up procedure is applied. Likewise, many odontocetes close to the trackline are likely to move away before the sounds from an approaching seismic vessel become sufficiently strong for there to be any potential for TTS or other hearing impairment. Hence, there is little potential for baleen whales or odontocetes that show avoidance of ships or airguns to be close enough to an airgun array to experience TTS. Nevertheless, even if marine mammals were to experience TTS, the magnitude of the TTS is expected to be mild and brief, only a few decibels for minutes.

PTS

When PTS occurs, there is physical damage to the sound receptors in the ear. In some cases, there can be total or partial deafness, whereas in other cases, the animal has an impaired ability to hear sounds in specific frequency ranges (Kryter 1985). Physical damage to a mammal’s hearing apparatus can occur if it is exposed to sound impulses that have very high peak pressures, especially if they have very short rise times. (Rise time is the interval required for sound pressure to increase from the baseline pressure to peak pressure.)

There is no specific evidence that exposure to pulses of airgun sound can cause PTS in any marine mammal, even with large arrays of airguns. However, given the likelihood that some mammals close to an airgun array might incur at least mild TTS (see above), there has been further speculation about the possibility that some individuals occurring very close to airguns might incur PTS (e.g., Richardson et al. 1995; Gedamke et al. 2008). Single or occasional occurrences of mild TTS are not indicative of permanent auditory damage, but repeated or (in some cases) single exposures to a level well above that causing TTS onset might elicit PTS.

Relationships between TTS and PTS thresholds have not been studied in marine mammals, but are assumed to be similar to those in humans and other terrestrial mammals (Southall et al. 2007). Based on data from terrestrial mammals, a precautionary assumption is that the PTS threshold for impulse sounds (such as airgun pulses as received close to the source) is at least 6 dB higher than the TTS threshold on a peak-pressure basis, and probably >6 dB higher (Southall et al. 2007). The low-to-moderate levels of TTS that have been induced in captive odontocetes and pinnipeds during controlled studies of TTS have been confirmed to be temporary, with no measurable residual PTS (Kastak et al. 1999; Schlundt et al. 2000; Finneran et al. 2002; 2005; Nachtigall et al. 2003; 2004). However, very prolonged exposure to sound strong enough to elicit TTS, or shorter- term exposure to sound levels well above the TTS threshold, can cause PTS, at least in terrestrial mammals (Kryter 1985). In terrestrial mammals, the received sound level from a single non-impulsive sound exposure must be far above the TTS threshold for any risk of permanent hearing damage (Kryter 1994; Richardson et al. 1995; Southall et al. 2007). However, there is special concern about strong sounds whose pulses have very rapid rise times. In terrestrial mammals, there are situations when pulses with rapid rise times (e.g., from explosions) can result in PTS even though their peak levels are only a few dB higher than the level causing slight TTS. The rise time of airgun pulses is fast, but not as fast as that of an explosion.

Some factors that contribute to onset of PTS, at least in terrestrial mammals, are as follows:
- Exposure to a single very intense sound,
- Fast rise time from baseline to peak pressure,
- Repetitive exposure to intense sounds that individually cause TTS but not PTS, and
- Recurrent ear infections or (in captive animals) exposure to certain drugs.

Cavanagh (2000) reviewed the thresholds used to define TTS and PTS. Based on this review and SACLANT (1998), it is reasonable to assume that PTS might occur at a received sound level 20 dB or more above that inducing mild TTS. However, for PTS to occur at a received level only 20 dB above the TTS threshold, the animal probably would have to be exposed to a strong sound for an extended period, or to a strong sound with a rather rapid rise time.

More recently, Southall et al. (2007) estimated that received levels would need to exceed the TTS threshold by at least 15 dB, on an SEL basis, for there to be risk of PTS. Thus, for cetaceans exposed to a sequence of sound pulses, they estimate that the PTS threshold might be an M-weighted SEL (for the sequence of received pulses) of ~198 dB re 1 mPa2-s. Additional assumptions had to be made to derive a corresponding estimate for pinnipeds, as the only available data on TTS-thresholds in pinnipeds pertained to nonimpulse sound (see above). Southall et al. (2007) estimated that the PTS threshold could be a cumulative SEL of ~186 dB re 1 mPa2-s in the case of a harbor seal exposed to impulse sound. The PTS threshold for the California sea lion and northern elephant seal would probably be higher given the higher TTS thresholds in those species. Southall et al. (2007) also note that, regardless of the SEL, there is concern about the possibility of PTS if a cetacean or pinniped received one or more pulses with peak pressure exceeding 230 or 218 dB re 1 mPa, respectively. Thus, PTS might be expected upon exposure of cetaceans to either SEL ≥198 dB re 1 mPa2-s or peak pressure ≥230 dB re 1 mPa. Corresponding proposed dual criteria for pinnipeds (at least harbor seals) are ≥186 dB SEL and ≥ 218 dB peak pressure (Southall et al. 2007). These estimates are all first approximations, given the limited underlying data, assumptions, species differences, and evidence that the ‘‘equal energy’’ model may not be entirely correct.

Sound impulse duration, peak amplitude, rise time, number of pulses, and inter-pulse interval are the main factors thought to determine the onset and extent of PTS. Ketten (1994) has noted that the criteria for differentiating the sound pressure levels that result in PTS (or TTS) are location and species specific. PTS effects may also be influenced strongly by the health of the receiver’s ear.

As described above for TTS, in estimating the amount of sound energy required to elicit the onset of TTS (and PTS), it is assumed that the auditory effect of a given cumulative SEL from a series of pulses is the same as if that amount of sound energy were received as a single strong sound. There are no data from marine mammals concerning the occurrence or magnitude of a potential partial recovery effect between pulses. In deriving the estimates of PTS (and TTS) thresholds quoted here, Southall et al. (2007) made the precautionary assumption that no recovery would occur between pulses.

It is unlikely that an odontocete would remain close enough to a large airgun array for sufficiently long to incur PTS. There is some concern about bowriding odontocetes, but for animals at or near the surface, auditory effects are reduced by Lloyd’s mirror and surface release effects. The presence of the vessel between the airgun array and bow-riding odontocetes could also, in some but probably not all cases, reduce the levels received by bow-riding animals (e.g., Gabriele and Kipple 2009). The TTS (and thus PTS) thresholds of baleen whales are unknown but, as an interim measure, assumed to be no lower than those of odontocetes. Also, baleen whales generally avoid the immediate area around operating seismic vessels, so it is unlikely that a baleen whale could incur PTS from exposure to airgun pulses. The TTS (and thus PTS) thresholds of some pinnipeds (e.g., harbor seal) as well as the harbor porpoise may be lower (Kastak et al. 2005; Southall et al. 2007; Lucke et al. 2009). If so, TTS and potentially PTS may extend to a somewhat greater distance for those animals. Again, Lloyd’s mirror and surface release effects will ameliorate the effects for animals at or near the surface.

(4) Non-Auditory Physical Effects

Non-auditory physical effects might occur in marine mammals exposed to strong underwater pulsed sound. Possible types of non-auditory physiological effects or injuries that theoretically might occur in mammals close to a strong sound source include neurological effects, bubble formation, and other types of organ or tissue damage. Some marine mammal species (i.e., beaked whales) may be especially susceptible to injury and/or stranding when exposed to intense sounds. However, there is no definitive evidence that any of these effects occur even for marine mammals in close proximity to large arrays of airguns, and beaked whales do not occur in the proposed project area. In addition, marine mammals that show behavioral avoidance of seismic vessels, including most baleen whales, some odontocetes (including belugas), and some pinnipeds, are especially unlikely to incur non- auditory impairment or other physical effects.

Therefore, it is unlikely that such effects would occur during BP's proposed surveys given the brief duration of exposure and the planned monitoring and mitigation measures described later in this document.

Additional non-auditory effects include elevated levels of stress response (Wright et al. 2007; Wright and Highfill 2007). Although not many studies have been done on noise- induced stress in marine mammals, extrapolation of information regarding stress responses in other species seems applicable because the responses are highly consistent among all species in which they have been examined to date (Wright et al. 2007). Therefore, it is reasonable to conclude that noise acts as a stressor to marine mammals. Furthermore, given that marine mammals will likely respond in a manner consistent with other species studied, repeated and prolonged exposures to stressors (including or induced by noise) could potentially be problematic for marine mammals of all ages. Wright et al. (2007) state that a range of issues may arise from an extended stress response including, but not limited to, suppression of reproduction (physiologically and behaviorally), accelerated aging and sickness-like symptoms. However, as mentioned above, BP's proposed activity is not expected to result in these severe effects due to the nature of the potential sound exposure.

(5) Stranding and Mortality

Marine mammals close to underwater detonations can be killed or severely injured, and the auditory organs are especially susceptible to injury (Ketten et al. 1993; Ketten 1995). Airgun pulses are less energetic and their peak amplitudes have slower rise times, while stranding and mortality events would include other energy sources (acoustical or shock wave) far beyond just seismic airguns. To date, there is no evidence that serious injury, death, or stranding by marine mammals can occur from exposure to airgun pulses, even in the case of large airgun arrays.

However, in numerous past IHA notices for seismic surveys, commenters have referenced two stranding events allegedly associated with seismic activities, one off Baja California and a second off Brazil. NMFS has addressed this concern several times, and, without new information, does not believe that this issue warrants further discussion. For information relevant to strandings of marine mammals, readers are encouraged to review NMFS's response to comments on this matter found in 69 FR 74906 (December 14, 2004), 71 FR 43112 (July 31, 2006), 71 FR 50027 (August 24, 2006), and 71 FR 49418 (August 23, 2006).

Strandings related to sound exposure have not been recorded for marine mammal species in the Beaufort Sea. NMFS notes that in the Beaufort Sea, aerial surveys have been conducted by MMS and industry during periods of industrial activity (and by MMS during times with no activity). No strandings or marine mammals in distress have been observed during these surveys and none have been reported by North Slope Borough inhabitants. In addition, there are very few instances that seismic surveys in general have been linked to marine mammal strandings, other than those mentioned above. As a result, NMFS does not expect any marine mammals will incur serious injury or mortality in the Arctic Ocean or strand as a result of the proposed seismic surveys.

Miscellaneous Sources

Acoustical systems are associated with some research, military, commercial, or other vessel use of the Beaufort or Chukchi seas. Such systems include multibeam sonar, sub-bottom profilers, and acoustic Doppler current profilers. Active sonar is used for the detection of objects underwater. These range from depth-finding sonar, found on most ships and boats, to powerful and sophisticated units used by the military. Sonar emits transient, and often intense, sounds that vary widely in intensity and frequency. Acoustic pingers used for locating and positioning oceanographic and geophysical equipment also generate noise at high frequencies. LGL, Ltd. (2005) describes many examples of acoustic navigational equipment.

Specific effects of the past, present, and future acoustic arctic environment are discussed under each species below. However, the effects of the proposed action are discussed in section 4 – Effects of the Action. Also, under the ESA, projected future federal activities that have not undergone completed consultation are not included in the baseline nor in the cumulative effects analyses because those actions would require separate consultation.

Subsistence Harvest

Indigenous peoples of the arctic and subarctic of what is now Alaska have been hunting marine mammals including bowhead whales for at least 2,000 years (Stoker and Krupnik, 1993). The species regularly harvested by subsistence hunters in and around the Beaufort Sea are bowhead and beluga whales, ice seals, walrus, and polar bears. The importance of each of the subsistence species varies among the communities and is mainly based on availability and season.

Under the authority of the IWC, the subsistence take of bowhead whales has been regulated by a quota system since 1977. The IWC renewed catch limits in 2007 for 2008 – 2012 and grants an annual quota of 77 strikes to the US AEWC (NMFS 2008). Federal authority for cooperative management of the Eskimo subsistence hunt is shared with the Alaska Eskimo Whaling Commission (AEWC) through a cooperative agreement between the AEWC and NOAA. The current agreement runs through 2012 (NMFS 2008).

Alaskan Native hunters from 10 villages harvest bowheads for subsistence and cultural purposes under a quota authorized by the IWC: Gambell, Savoonga, Wales, Little Diomede, Kivalina, Point Hope, Wainwright, Barrow, Nuiqsut, and Kaktovik (Figure 12). Their traditional hunting grounds are shown in Figure 3. Chukotkan Native whalers from Russia also are authorized to harvest bowhead whales under the same authorized quota. The status of the bowhead population is closely monitored, and these activities are closely regulated. Strike limits are established by the IWC and set at a 5-year quota of 280 landings. The continued growth of the Western Arctic bowhead population indicates that the level of subsistence take has been sustainable. Because the quota for the hunt is tied to the population size and population parameters, it is unlikely this source of mortality will contribute to a significant adverse effect on the recovery and long-term viability of this population.

Status of the Species within the Action Area

Here we present information on the status of endangered species and species proposed for listing under the ESA within the action area and discuss any threats that are relevant to our determinations about effects to the species as a result of the action being analyzed.

Bowhead Whale

Bowhead whales travel through the central Beaufort Sea and the action area during their spring and fall migrations. Generally, the spring migration occurs between late April and June in waters offshore of the Alaska coast. The returning fall migration, beginning sometime in mid to late August, brings these whales closer to shore, often in waters less than 20 meters, but sometimes extending over deeper waters to 200 meters. The axis of the fall migration is variable, and may depend on the sea ice conditions. The traditional knowledge of Native whale hunters and recent research suggests some segregation within the migration, with smaller whales preceding large adults and cow-calf pairs (Moore and Reeves, 1995).

Residence time for fall-migrant whales in the action area is variable, but averages ~ 4 days (USDOI, 2002). Some whales may be found in the Beaufort Sea and action area during the summer, being detected both visually in aerial surveys and acoustically by several underwater hydrophone arrays along the coast. In addition to migrational movements, bowheads in the action area are also known to display other behaviors, including feeding, socializing, and resting (Figure 13).

In at least some years, some bowheads apparently take their time returning westward during the fall migration, sometimes barely moving at all, with some localities being used as staging areas due to abundant food resources or social reasons (Akootchook, 1995, as reported in NMFS 2001). The Inupiat believe that whales follow the ocean currents carrying food organisms (e.g., Napageak 1996, as reported in NMFS 2001). Bowheads have been observed feeding not more than 1,500 feet (ft) offshore in about 15-20 ft of water (Rexford, 1979, as reported in NMFS, 2001). Nuiqsut Mayor Nukapigak testified at the Nuiqsut Public Hearing on March 19, 2001, that he and others saw a hundred or so bowhead whales and gray whales feeding near Northstar Island (USDOI, MMS 2002). Some bowheads appear to feed east of Barter Island as they migrate westward (Thomson and Richardson, 1987).

The Bowhead Whale Aerial Survey Project (BWASP) reports bowhead sightings and associated data from 2000-2009 in comparison to historical data (Clarke *et al.*, 2009). The annual surveys have been conducted in the fall since 1979. In this study, the BP Simpson Lagoon is located in the “eastern Beaufort Sea” area, and in Survey Block 1 (Prudhoe Bay area) just east of the line dividing areas 3 and 2(Figure 9 and 10).

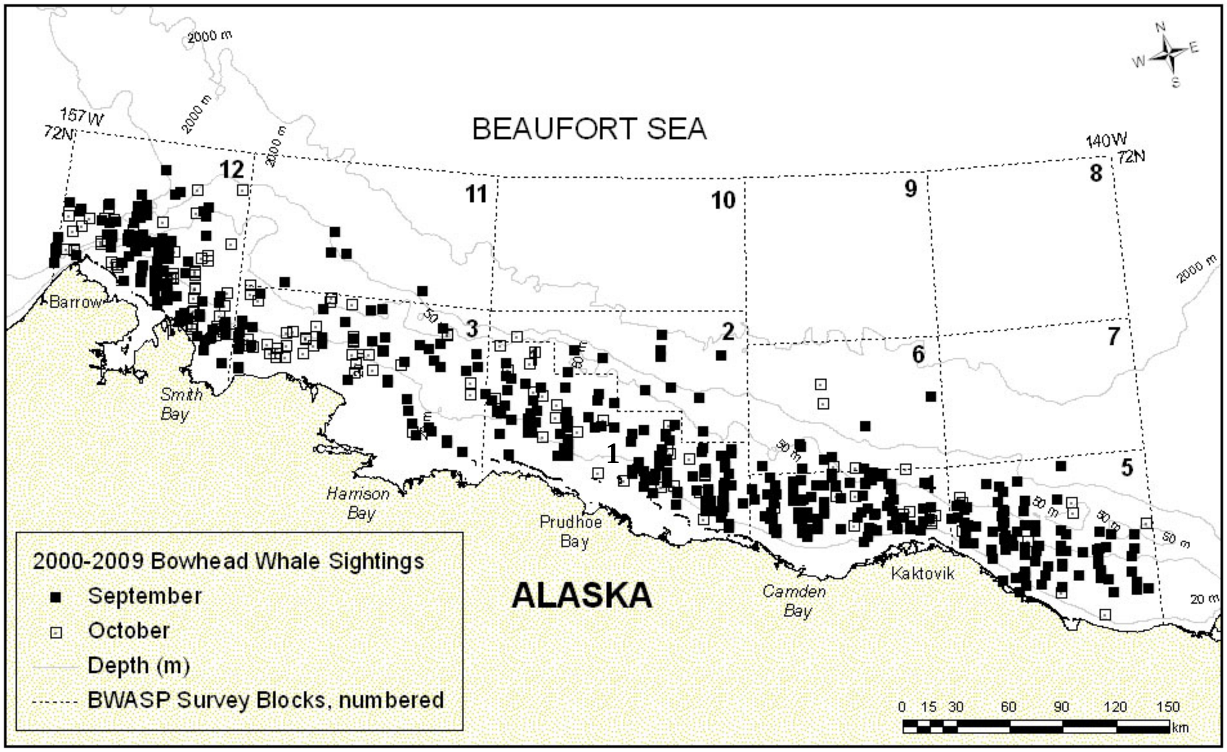


Figure 9. Bowhead whale sightings on transect, 2000-2009. (Clarke et al, 2009).

BWASP documents feeding and milling as 11% of sightings in September/October most heavily east of Kaktovik and west of Smith Bay (Figure 11). Clarke and Ferguson (undated) also note that the incidence of feeding bowheads in the eastern Alaskan Beaufort Sea has decreased since the early 1980s.

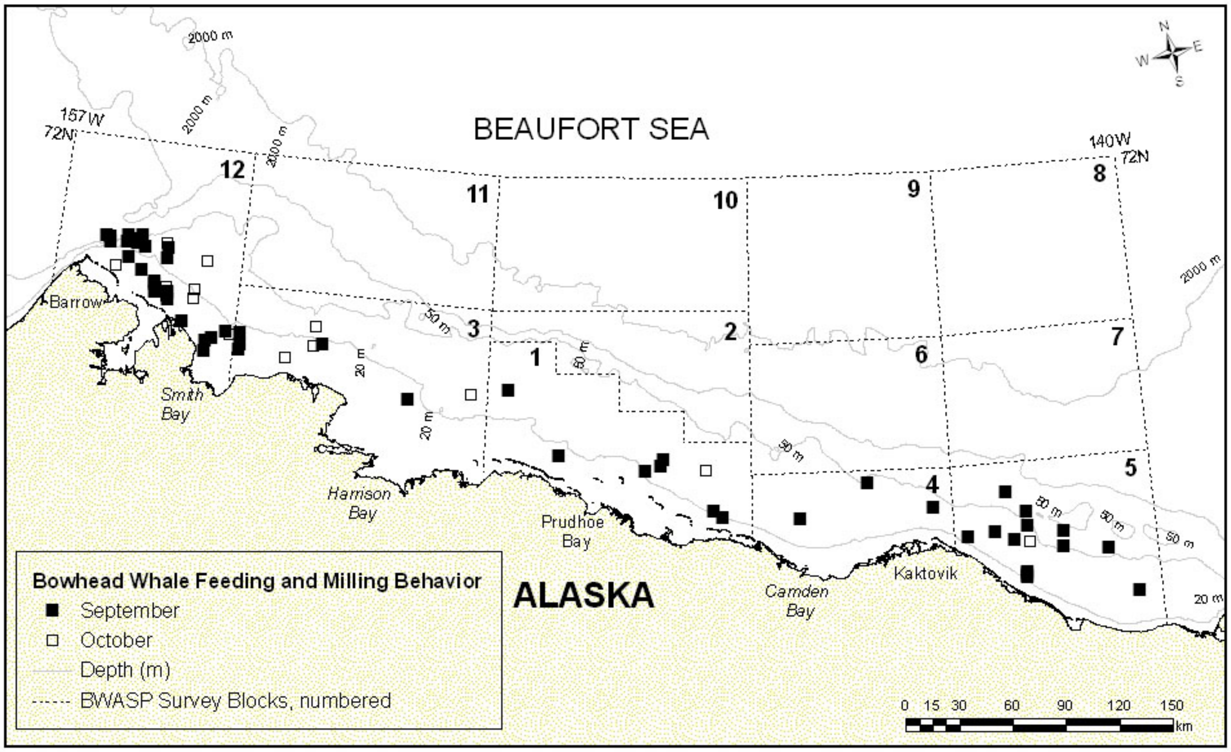


Figure 10. Feeding and milling behavior of bowhead whales sighted on transect, 2000-2009 (Clarke et al 2009).

The nutritional benefit of this feeding has also been considered. Stable isotope measurements (Lee and Schell, 2002) have indicated the majority of carbon intake by these bowheads is of Bering Sea origin, rather than Beaufort origin and that only a minority of the feeding by either subadults or adults is in the eastern Beaufort Sea (the BP Simpson Lagoon project site is within the central Beaufort Sea). Based on stable isotope evidence, bowhead whales likely consume only 10 to 26 per cent of their food in the eastern and central Beaufort Sea. Sub adults appear to derive >10 per cent of annual food requirements there (Lee and Schell, 2002). An MMS study of bowhead feeding in the Beaufort Sea concluded that, in an average year, these whales derive an estimated 2.4 per cent of annual energetic requirements in the eastern Beaufort Sea (MMS, 2002).

Other Factors Affecting the Bowhead Whale within the Action Area

Commercial Hunting

There are no data available that indicate that, other than historic commercial whaling, any previous human activity has had a significant population-level adverse impact on the current status of the Western Arctic stock of bowheads or their recovery. It is clear that commercial whaling between 1848 and 1915 was the human activity that had the greatest adverse effect on this population. Commercial whaling severely depleted bowhead whales. Woody and Botkin (1993) estimated that the historic abundance of bowheads in this population was between 10,400 and 23,000 whales in 1848, before the advent of commercial whaling. Woody and Botkin

(1993) estimated between 1,000 and 3,000 animals remained in 1914, near the end of the commercial-whaling period. Commercial whaling also may have caused the extinction of some subpopulations and some temporary changes in distribution. Following protection from whaling, this population (but not some other bowhead populations) has shown marked progress toward recovery. Population estimates for 2001 range between 10,470 (SE = 1,351) with a 95% confidence interval of 8,100–13,500 (George et al., 2004) and 10,545 CV(N) =0,128 (Zeh and Punt, 2004, cited in Angliss and Outlaw, 2005. Thus estimated population size is within the lower bounds of estimates of the historic population size. Shelden *et al.* (2001, 2003) concluded that this population should be removed from the list of species designated as endangered under the ESA.

Subsistence Hunting

The communities closest to the project area are, from west to east, the villages of Barrow, Nuiqsut, and Kaktovik (see Figures 3, 5, and 11).

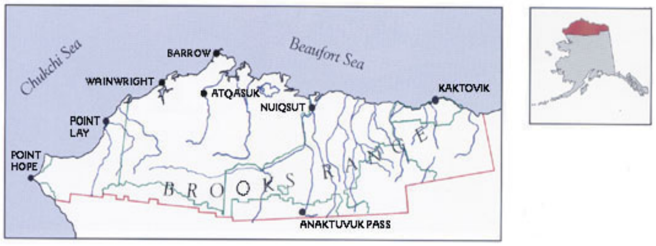


Figure 11. Map showing villages of North Slope Borough.

Barrow is located about 180 miles west from the survey area. It is the largest community on the Alaska's Beaufort Sea coast with a population of 4,351 in 2004 (DCED 2005). Bowhead harvesting in Barrow occurs both during the spring (April–May) and fall (September–October) when the whales migrate relatively close to shore (ADNR 2009). During spring bowheads migrate through open ice leads close to shore. The hunt takes place from the ice using umiaks (bearded seal skin boats). During the fall, whaling is shore-based and boats may travel up to 30 miles a day (EDAW/AECOM 2007). Although in Barrow historically most whales were taken during spring whaling, the efficiency of the spring harvest tends to be lower than the autumn harvest due to ice and weather conditions as well as struck whales escaping under the ice (Suydam et al. 2010). In the past few years the bowhead fall hunt has become increasingly important. Between 1993—2010, Barrow landed an average of 22 bowhead whales per year.

Nuiqsut is located near the mouth of the Colville River, about 35 miles southwest of the project area and had a population of 430 in 2004 (DCED 2005). 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. Nuiqsut whalers hunt near Prudhoe Bay and landed 2 whales in 2009 and 4 whales in 2010. In Nuiqsut, whaling takes place from early September through mid-to-late September as the whales migrate west (EDAW/AECOM 2007). Three to five whaling crews base themselves at Cross Island, a barrier island approximately 35 miles east of the Simpson Lagoon survey area. Nuiqsut whalers harvest an average of 3 bowheads each year.

Kaktovik is located on Barter Island, about 150 miles east of the project area and had a population of 284 in 2004 (DCED 2005). Major marine subsistence resources include bowhead and beluga whales, seals, and polar bears. Approximately 50% of Kaktovik households participate in fall whaling (Fuller and George 1999). Whaling from Kaktovik also occurs in the fall, primarily from late August through late September or early October (EDAW/AECOM 2007). Kaktovik whalers hunt from the Okpilak and Hulahula rivers east to Tapkaurak Point (ADNR 2009). Whaling activities are staged from the community rather than remote camps; most whaling takes place within 12 miles of the community (ADNR 2009). They landed 3 bowhead whales in both 2009 and 2010 during the fall migration (AEWC 2011).

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). 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.

Subsistence hunting is not a new contributor to cumulative effects on this population. There is no indication that, prior to commercial whaling, subsistence whaling caused significant adverse effects at the population level, but the sustainable take of bowhead whales by indigenous hunters does represent the largest known human-related cause of mortality in this population at the present time. Available information suggests that it is likely to remain so for the foreseeable future. While other potential effectors primarily have the potential to cause, or to be related to, behavioral or sublethal adverse effects to this population, or to cause the deaths of a small number of individuals, little or no evidence exists of other common human-related causes of mortality. Subsistence take, which all available evidence indicates is sustainable, monitored, managed, and regulated, helps to determine the resilience of the population to other impacts that could potentially cause lethal takes.

There are adverse impacts of the hunting to bowhead whales in addition to the death of animals that are successfully hunted and the serious injury of animals that are struck but not immediately killed. Available evidence indicates that subsistence hunting causes disturbance to the other whales, changes in their behavior, and sometimes temporary effects on habitat use, including migration paths. Modern subsistence hunting represents a source of noise and disturbance to the whales. Whales in the vicinity of a struck whale could be disturbed by the sound of the explosive used in the hunt, the boat motors, and any sounds made by the injured whale. NMFS (2003a) pointed out that whales that are not struck or killed may be disturbed by noise associated with the approaching hunters, their vessels, and the sound of bombs detonating: "…the sound of one or more bombs detonations during a strike is audible for some distance. Acousticians, listening to bowhead whale calls as part of the census, report that calling rates drop after such a strike …" (NMFS, 2003). We are not aware of data indicating how far hunting-related sounds (for example, the sounds of vessels and/or bombs) can propagate in areas where hunting typically occurs, but this is likely to vary with environmental conditions. It is not known if whales issue an “alarm call” or a “distress call” after they, or another whale, are struck.

NMFS (2003) reported that “…whales may act skittish” and wary after a bomb detonates, or may be displaced further offshore (E. Brower, pers. com.). However, disturbances to migration as a result of a strike are temporary (J. George, 1996), as evidenced when several whales may be landed at Barrow in a single day. There is some potential that migrating whales, particularly calves, could be forced into thicker offshore ice as they avoid these noise sources. The experience of Native hunters suggests that the whales would be more likely to temporarily halt their migrations, turn 180 degrees away…(i.e., move back through the lead systems), or become highly sensitized as they continue moving (E. Brower, pers. com.).

Because evidence indicates that bowhead whales are long-lived, some bowhead whales may have been in the vicinity where hunting was occurring on multiple, perhaps dozens or more, occasions. Thus, some whales may have cumulative exposure to hunting activities. This form of noise and disturbance adds to noise and disturbance from other sources, such as shipping and oil and gas-related activities. To the extent such activities occur in the same habitats during the period of whale migration, even if the activities (e.g., hunting and shipping) themselves do not occur simultaneously, cumulative effects from all noise and disturbance could affect whale habitat use. However, we are not aware of information indicating long-term habitat avoidance has occurred with present levels of activity. Additionally, if whales become more “skittish” and more highly sensitized following a hunt, it may be that their subsequent reactions, over the short-term, to other forms of noise and disturbance are heightened by such activity. Data are not available that permit evaluation of this possible, speculative interaction.

Commercial-Fishing Marine Vessel Traffic

Based on available data, previous incidental take of bowhead whales apparently has occurred only rarely. The bowhead’s association with sea ice limits the amount of fisheries activity occurring in bowhead habitat. However, the frequency of such interactions in the future would be expected to increase if commercial fishing activities expand northward. There is some uncertainty about whether such expansion will occur. The Arctic Fisheries Management Plan of the North Pacific Fishery Management Council bans commercial fishing in federal waters north of the Bering Strait (Figure 12). The Canadian government has established a similar ban for the Canadian Beaufort (NMFS 2009).

Nonetheless, commercial fishing does occur in other portions of the range of the Western Arctic bowhead, and interaction with commercial fishing gear has been documented. There have been two confirmed occurrences of entanglement in crab-pot gear, one in 1993 and one in 1999 (Angliss and Lodge, 2008). Citing a personal communication from Craig George of the North Slope Borough, Department of Wildlife Management, Angliss and Lodge (2008) suggest that there may be more than 20 cases indicating entanglements or scarring attributable to ropes in the bowhead harvest records.

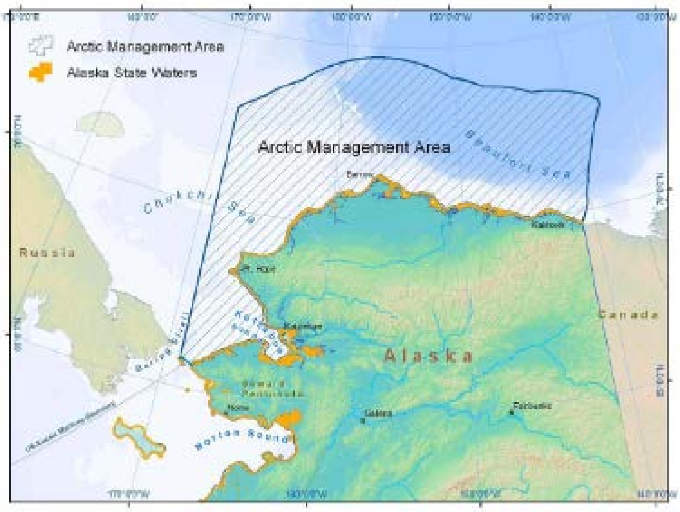


Figure 12. Map showing the Arctic Management Area. (Adopted from NPFMC (2009)).

Potential effects on bowhead whales from commercial-fishing activities include incidental take in the fisheries and/or entanglement in derelict fishing gear resulting in death, injury, or effects on the behavior of individual whales; disturbance resulting in temporary avoidance of areas; and whales being struck and injured or killed by vessels. Bowheads have been entangled in ropes from crab pots, harpoon lines, or fishing nets; however, the frequency of occurrence is not known.

Marine vessel traffic, in general, can pose a threat to bowheads because of the risk of ship strikes. Shipping and vessel traffic is expected to increase in the Arctic if warming continues. Additionally, noise associated with ships or other boats potentially could cause bowheads to alter their movement patterns or make other changes in habitat use. Pollution from marine vessel traffic, especially from large vessels such as large cruise ships, also could cause degradation of the marine environment and increase the risk of the whales' exposure to contaminants and disease vectors. The frequency of observations of vessel-inflicted injuries suggests that the incidence of ship collisions with bowhead whales is low but may be increasing. Between 1976 and 1992, only three ship-strike injuries were documented out of a total of 236 bowhead whales examined from the Alaskan subsistence harvest (George et al. 1994). The low number of observations of ship-strike injuries suggests that bowheads either do not often encounter vessels, or they avoid interactions with vessels, or that interactions usually result in the animals' death.

Pollution and Contaminants

Initial studies of bowhead tissues collected from whales landed at Barrow in 1992 (Becker et al., 1995) indicate that bowhead whales have very low levels of mercury, PCBs, and chlorinated hydrocarbons, but they have fairly high concentrations of cadmium in their liver and kidneys. The study concluded that the high concentration of cadmium in the liver and kidney tissues of bowheads warrants further investigation. Becker (2000) noted that concentration levels of chlorinated hydrocarbons in bowhead whale blubber generally are an order of magnitude less than what has been reported for beluga whales in the Arctic. This probably reflects the difference in the trophic levels of these two species; the bowhead being a baleen whale feeding on copepods and euphausiids, while the beluga whale being toothed whale feeding at a level higher in the food web. The concentration of total mercury in the liver also is much higher in beluga whales than in bowhead whales.

Bratton et al. (1993) measured organic arsenic in the liver tissue of one bowhead whale and found that about 98% of the total arsenic was arsenobetaine. Bratton et al. (1997) looked at eight metals (arsenic, cadmium, copper, iron, mercury, lead, selenium, and zinc) in the kidneys, liver, muscle, blubber, and visceral fat from bowheads harvested from 1983-1990. They observed considerable variation in tissue metal concentration among the whales tested. Metal concentrations evaluated did not appear to increase over time between 1983 and 1990. Based on metal levels reported in the literature for other baleen whales, the metal levels observed in all tissues of the bowhead are similar to levels in other baleen whales. The bowhead whale has little metal contamination as compared to other Arctic marine mammals, except for cadmium, which requires further investigation as to its role in human and bowhead whale health. The study recommended limiting the consumption of kidney from large bowhead whales pending further evaluation.

Cooper et al. (2000) analyzed anthropogenic radioisotopes in the epidermis, blubber, muscle, kidney, and liver of marine mammals harvested for subsistence food in northern Alaska and in the Resolute, Canada region. The majority of samples analyzed had detectable levels of ^{137}Cs. Among tissues of all species of marine mammals analyzed, ^{137}Cs was almost always undetectable in the blubber and significantly higher in epidermis and muscle tissue than in the liver and kidney tissue. The levels of anthropogenic radioisotopes measured were orders of magnitude below levels that would merit public health concern. The study noted there were no obvious geographical differences in ^{137}Cs levels between marine mammals harvested in Resolute, Canada and those from Alaska. However, the ^{137}Cs levels in marine mammals were two to three orders of magnitude lower than the levels reported in caribou in northern Canada and Alaska.

In its Beaufort Sea multiple-sale EIS in 2003, the Minerals Management Service concluded that the levels of metals and other contaminants measured in bowhead whales appear to be relatively low, with the exception of cadmium. Since the finalization of the multiple-sale EIS, additional information (included in the review presented above) on contaminants in Western Arctic bowheads has become available. This information supports this same general conclusion.

Offshore Oil and Gas Related Activities and other Industrial Activities

Offshore petroleum exploration, development, and production activities have been conducted in Alaska State waters or on the Alaska OCS in the Beaufort and Chukchi seas as a result of previous lease sales since 1979. Extensive 2D seismic surveying has occurred in both program areas. MMS-permitted seismic surveys have been conducted in the Chukchi and Beaufort seas since the late 1960s and early 1970s. Much more seismic activity has occurred in the Beaufort Sea OCS than in the Chukchi Sea OCS. The 2D marine seismic surveys in the Beaufort Sea began with two exploration geophysical permits issued in 1968 and four in 1969. Both over-ice (29 permits) and marine 2D (43 permits) seismic surveys were conducted in the 1970s. With one exception, all 80 marine and 43 over-ice surveys permitted in the Beaufort Sea OCS by MMS in the 1980s were 2D. In the Beaufort Sea, 23 MMS G&G permits were issued in 1982 (11 marine and 12 over-ice 2D surveys) and 24 MMS G&G permits were issued in 1983 (1, 3D over-ice survey; 14, 2-D over-ice surveys; and, 9, 2D marine surveys). The first 3-D on-ice survey occurred in the Beaufort Sea OCS in 1983. In the 1990s, both 2D (2 on-ice and 21 marine) and 3D (11 over-ice and 7 marine OBC) seismic surveys were conducted in the Beaufort Sea. The first marine 3D seismic survey in the Beaufort Sea OCS occurred in 1996.

Thirty exploratory wells have been drilled in the Beaufort Sea OCS over a 20+ year period between 1981 and 2002. This drilling occurred from a variety of drilling platforms (e.g., gravel islands, SSDC, drillships, etc.) and, during different seasons of the year, including the open water period. The last exploration well drilled in the Beaufort Sea OCS was drilled in the winter of 2002 at the McCovey prospect. There are currently three offshore exploratory drilling operations occurring on state lands from ice islands.

Many of these offshore activities also required ice management (icebreaking), helicopter traffic, fixed wing monitoring, other support vessels, and, in some cases stand-by barges.

Available information does not indicate that oil and gas related activity (or any recent activity) has had detectable long-term adverse population-level effects on the overall health, current status, or recovery of the Western Arctic population. Data indicate that the Western Arctic population has continued to increase over the timeframe that oil and gas activities has occurred. There is no evidence of long-term displacement from habitat. However, there are no long-term oil and gas developments in the offshore within bowhead high use areas. Northstar is at the southern end of the migratory corridor and Endicott is within the barrier islands. Past behavioral (primarily, but not exclusively, avoidance) effects on bowhead whales from oil and gas activity have been documented in many studies. Inupiat whalers have stated that noise from seismic surveys and some other activities at least temporarily displaces whales farther offshore, especially if the operations are conducted in the main migration corridor.

Data on past drilling in both federal and state waters is relatively complete, especially since 1990. Data on other activities, such as hunting activity, barge traffic, and shipping noise are incomplete. Thus, while it is clear there have been multiple noise and disturbance sources in the Beaufort Sea over the past 30 years, because of the incompleteness of data, even for the 1990s, for many types of activities, we cannot evaluate the totality of past effects on bowhead whales resulting from multiple noise and disturbance sources (e.g., 2D seismic in state and federal waters, drilling, ice-management, high-resolution acoustic surveys, vessel traffic, construction, geotechnical bore-hole drilling, aircraft surveys, and hunting).

Climate Change

There will be more open water and longer ice-free seasons in the arctic seas which may allow bowhead whales to expand their range as the population continues to recover from commercial whaling. However, this potential for beneficial effects on bowheads and other whales will depend on their ability to locate sufficient concentrations of planktonic crustaceans to allow efficient foraging. Conceptual models by Moore and Laidre (2006) suggested that overall reductions in sea ice cover should increase the Western Arctic stock of bowhead whale prey availability. This theory may be substantiated by the steady increase in the population during the nearly 20 years of sea ice reductions (Walsh 2008). Since phytoplankton blooms may occur earlier or at different times of the season, or in different locations, the timing of zooplankton availability may also change from past patterns (Arrigo and van Dijken 2004). Hence, the ability of bowheads to use these food sources may depend on their flexibility to adjust the timing of their own movements and to find food sources in different places (ACIA 2004). Moore and Huntington (2008) anticipate that bowhead whales will alter migration routes and occupy new feeding areas in response to climate related environmental change. Sheldon et al. (2003) notes that there is a high probability that bowhead abundance will increase under a warming global climate.

In addition, it is hypothesized that some of the indirect effects of climate change on marine mammal health would likely include alterations in pathogen transmission due to a variety of factors, effects on body condition due to shifts in the prey base/food web, changes in toxicant exposures, and factors associated with increased human habitation in the Arctic (Burek *et al.* 2008).

Ringed Seal

We have little information on the numbers of ringed seals within the action area. Extensive surveys of ringed and bearded seals have been conducted in the Beaufort Sea, but most surveys have been conducted over the landfast ice, and few seal surveys have occurred in open water or in the pack ice. These surveys provide the most relevant information on densities of ringed seals in the ice margin zone of the Beaufort Sea. The density estimate in Kingsley (1986) was used as the average density of ringed seals that may be encountered in the ice margin. The average ringed seal density in the nearshore zone of the Alaskan Beaufort Sea was estimated from results of ship–based surveys at times without seismic operations reported by Moulton and Lawson (2002). WesternGeco conducted marine mammal monitoring during its open-water seismic program in the Alaskan Beaufort Sea from 1996 to 2001. Operations were conducted in nearshore waters, and of a total 454 seals that were identified to species while no airguns were operating, 4.4% were bearded seals, 94.1% were ringed seals and 1.5% were spotted seals (Moulton and Lawson 2002).

Ringed seals construct lairs for pupping in the Beaufort Sea. However, this species typically does not construct lairs until late winter/early spring on the landfast ice. Tracking seals in Alaska and the western Canadian Arctic, Kelly et al. (2010) referred to the open-water period when ringed seals forage most intensively as the “foraging period”, early winter through late

May to early June when seals rested primarily in subnivean lairs on the ice as the "subnivean period", and the period between abandonment of the lairs (May or June) and ice break-up (typically June or July) as the "basking period." Foraging would be the most common behavior by ringed seals in the action area during the proposed seismic surveys.

Overall, the record from satellite tracking indicates that ringed seals breeding in shorefast ice practice one of two strategies during the open water foraging period (Freitas *et al.*, 2008). Some forage within 100 km of their shorefast ice breeding habitat while others make extensive movements of 100s or 1,000s of kilometers to forage in highly productive areas (e.g., Viscount Melville Sound) and along the pack-ice edge. Just prior to freeze up, large groups of ringed seals frequently feed on dense schools of cod in near shore areas of Amundsen Gulf and Prince Albert Sound, Beaufort Sea (Smith 1987). In offshore areas of the Beaufort Sea and Amundsen Gulf, large, loose feeding aggregations of ringed seals have also been documented in the late summer and early fall (Harwood and Stirling 1992). High quality, abundant food is important to the annual energy budgets of ringed seals. Fall and early winter periods, prior to the occupation of breeding sites, are important in allowing ringed seals to accumulate enough fat stores to support estrus and lactation. However, we are not aware of any information regarding the relative value of the action area for foraging by ringed seals.

Other factors affecting ringed seals within the Action Area

Predation

Polar bears are the main predator of ringed seals, but other predators include Arctic and red foxes, walruses, wolves, wolverines, killer whales, and ravens (Burns and Eley 1976, Heptner *et al.* 1976, Fay *et al.* 1990, Sipliä 2003, Derocher *et al.* 2004, Melnikov and Zagrebin 2005). Ringed seals and bearded seals are the primary prey of polar bears. Polar bear predation on ringed seals is most successful in moving offshore ice, often along flow edges and rarely in ice-free waters. Hammill and Smith (1991) further noted that polar bear predation on ringed seal pups increased 4-fold in a year when average snow depths in their study area decreased from 23 to 10 cm. We conclude that the threat posed to ringed seals by predation is currently moderate, but predation risk is expected to increase as snow and sea ice conditions change with a warming climate.

Destruction, modification, or curtailment of habitat

The main concern about the conservation status of ringed seals stems from the likelihood that their sea ice habitat has been modified by the warming climate and, more so, that the scientific consensus projections are for continued and perhaps accelerated warming in the foreseeable future. A second concern related by the common driver of carbon dioxide emissions, is the modification of habitat by ocean acidification, which may alter prey populations and other important aspects of the marine ecosystem.

Climate Change

Diminishing ice and snow cover are the greatest challenges to persistence of all of the ringed seal subspecies. Ringed seals depend on ice as a platform for resting, whelping, nursing, and molting, and they depend on snow cover to provide protection from cold and predators. Ice and snow cover are changing and will continue to do so as the climate warms.

In most areas of the Arctic Ocean, snow melt advanced 1-6 weeks from 1979 to 2007 (Kelly *et al.* 2010). Throughout most of the ringed seal's range, snow melt occurred within a couple of weeks of weaning. Thus, in the past three decades, snow melts in many areas have been predating weaning. The southern edge of the ringed seal's range may shift north, because ringed seals stay with the ice as it annually advances and retreats (Tynan and DeMaster 1997). Whether ringed seals will continue to move north with retreating ice over the deeper, less productive Arctic Basin waters and whether forage fishes that they prey on will also move north is uncertain. Changes in the phenology and extent of ice extent will alter community composition, presenting ringed seals with new competitors, predators, and prey (Grebmeier *et al*. 2006b).

Harwood et al. (2000) reported that an early spring break-up negatively impacted the growth, condition, and apparent survival of nursing ringed seal pups. Early break-up was believed to have interrupted lactation in adult females, which in turn, negatively affected the condition and growth of pups. Earlier ice break-ups similar to those documented by Harwood et al. (2000) and Ferguson *et al*. (2005) are predicted to occur more frequently with warming temperatures and result in a predicted decrease in productivity and numbers of ringed seals (Kelly 2001, Ferguson *et al*. 2005). Additionally, high fidelity to birthing sites exhibited by ringed seals makes them more susceptible to localized degradation of snow cover (Kelly *et al*. 2010). Warming temperatures that melt snow-covered birth lairs can result in pups being exposed to ambient conditions and suffering from hypothermia (Stirling and Smith 2004). Others have noted that when lack of snow cover has forced birthing to occur in the open, nearly 100% of pups died from predation (Kumlien 1879, Lydersen *et al*. 1987, Lydersen and Smith 1989, Smith *et a*l. 1991, Smith and Lydersen 1991). However, Allen and Angliss write that there are insufficient data to make reliable predictions of the effects of Arctic climate change on the Alaska ringed seal stock (2010).

Ocean Acidification

Although no scientific studies have directly addressed the impacts of ocean acidification on ringed seals, the effects would likely be through their ability to find food. Most pinniped species are high trophic predators that live in regions with high productivity at least seasonally (e.g., Bowen and Siniff 1999). Ringed seals consume most of their annual energy in a period from late summer through to early winter (Ryg and Øritsland 1991), focusing on lipid rich, large zooplankton, Arctic cod, and polar cod. Climate warming, however, has been credited with global declines in phytoplankton concentrations (Boyce et al. 2010) and shifts in community organization and productivity in the Bering Sea, Aleutian Islands, and Gulf of Alaska (Anderson and Piatt 1999, Ciannelli *et al*. 2005, Grebmeier *et al*. 2006b, Litzow *et al*. 2006, Litzow and Ciannelli 2007, Mueter and Litzow 2008). Ocean acidification is likely to have increasingly profound impacts on the ecosystem structure in the ringed seal habitats. The exact nature of these impacts cannot be predicted, and some likely will amplify more than others. For example, populations of upper trophic level pelagic species may decline if their early life stages consume prey items (e.g., pteropods; Comeau *et al*. 2009) that cannot survive the added stress of ocean acidification. Pteropods are important food sources for larval and juvenile walleye pollock (*Theragra chalcogramma*), Pacific herring (*Clupea pallasii*), and cod. The ringed seals depend on cod, particularly juvenile cod that are less than 20 cm in length (Lowry *et al*. 1980). The loss of calcifying species like pteropods from the ecosystem could have a cascading effect on ringed seals.

Harvest

Ringed seals were harvested commercially in large numbers during the 20th century, which led to the depletion of their stocks in many parts of their range. Commercial harvests in the Sea of Okhotsk and predator-control harvests in the Baltic Sea, Lake Ladoga, and Lake Saimaa caused population declines in the past, but have since been restricted.

Ringed seals have been hunted by humans for millennia and remain a fundamental subsistence resource for many northern coastal communities today. Ringed seals are an important subsistence species for Alaskan Native hunters. The number of seals taken annually varies considerably between years due to ice and wind conditions, which impact hunter access to seals. The best estimate of the statewide annual ringed seal subsistence harvest is 9,567 (Allen and Angliss 2010). Although subsistence harvest of the Arctic subspecies is currently substantial in some regions, harvest levels appear to be sustainable.

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. Harvest of bearded seals usually takes place during the spring and summer open water season from Barrow (AECOM 2011) 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).

Ringed seals are by far the most important seal species for human consumption and utilization in the Canadian Arctic (ACIA 2005). Reeves et al. (1998) reviewed the catch history of ringed seals in Canada and concluded that harvest levels were probably highest (likely exceeding 100,000 ringed seals per year) during the 1960s and 1970s when both the value of sealskins and the local demand for seal products were particularly high. Ringed seals may have been locally depleted within the vicinity of some communities where exploitation was most intensive (Mansfield 1970 cited in Reeves et al. 1998). Catches of ringed seals declined substantially during the 1980s following a European ban on pup skins and the subsequent decline in sealskin prices (Reeves et al. 1998). Reeves et al. (1998) estimated that the total catch in Canada ranged between about 50,000 and 65,000 ringed seals per year during the 1980s and early 1990s, with the total kill (accounting for hunting losses) ranging between about 60,000 and 80,000 ringed seals per year.

Commercial Fisheries Interactions

Commercial fisheries may impact ringed seals through direct interactions (i.e., incidental take or bycatch) and indirectly through competition for prey resources and other impacts on prey populations. Based on data from 2002–2006, there has been an annual average of 0.46 mortalities of Arctic ringed seals incidental to commercial fishing operations in Alaskan waters (Allen and Angliss, 2010).

Drowning in fishing gear has been reported as one of the most significant mortality factors for seals in the Baltic Sea, especially for young seals, which are prone to getting trapped in fishing nets. There are no reliable estimates of seal bycatch in this sea, and existing estimates are known to be low in many areas, making risk assessment difficult.

Shipping

Current shipping activities in the Arctic pose varying levels of threats to ringed seals depending on the type and intensity of the shipping activity and its degree of spatial and temporal overlap with ringed seal habitats. These factors are inherently difficult to know or predict, making threat assessment highly uncertain. Most ships in the Arctic purposefully avoid areas of ice and thus prefer periods and areas which minimize the chance of encountering ice. This necessarily mitigates many of the risks of shipping to populations of ringed seals, since they are closely associated with ice throughout the year. Icebreakers pose special risks to ringed seals because they are capable of operating year-round in all but the heaviest ice conditions and are often used to escort other types of vessels (*e.g.,* tankers and bulk carriers) through ice-covered areas.

Contaminants

Contaminants research on ringed seals is very extensive and has been conducted in most parts of the species' range (with the exception of the Sea of Okhotsk), particularly throughout the Arctic environment where ringed seals are an important diet item in coastal human communities. Pollutants such as organochlorine (OC) compounds and heavy metals have been found in all of the subspecies of ringed seal (with the exception of the Okhotsk ringed seal). Reduced productivity in the Baltic Sea ringed seal in recent decades resulted from impaired fertility that was associated with pollutants. We do not have any information to conclude that there are currently population-level effects on Baltic ringed seals from contaminant exposure.

Oil and gas activities have the potential to impact ringed seals primarily through noise, physical disturbance, and pollution, particularly in the event of a large oil spill or blowout. Offshore oil and gas exploration occurs within the action area, including the seismic surveys associated with this action.

Although planning, management, and use of best practices can help reduce risks and impacts, the history of oil and gas activities, including recent events, indicates that accidents cannot be eliminated. Tanker spills, pipeline leaks, and oil blowouts are likely to occur in the future, even under the most stringent regulatory and safety systems. To date, there have been no large spills in the Arctic marine environment from oil and gas activities.

Demographic Threats

The Arctic subspecies may number well over one million or more seals and is not believed to be currently at risk from the effects of demographic stochasticity, inbreeding, loss of genetic diversity, or depensation.

Parasitism and Disease

Exposures to two phocid herpesviruses have been detected in phocid seals in Alaska; phocid herpesvirus-1 (PhHV-1), an alpha herpesvirus, and herpesvirus-2 (PhHV-2), a gamma herpesvirus. Zarnke et al. (1997) tested marine mammals from Alaska and Russia for antibodies to PhHV-1 and PhHV-2. In ringed seals, serum antibody prevalence for PhHV-1 and PhHV-2 were both 50%, and antibody prevalence for neither virus was 25%. Antibody prevalence for PhHV-1 was higher than for PhHV-2 in most of the species examined, and the highest prevalence of antibodies to PhHV-1 was found in phocid seals. Zarnke et al. (1997) suggested that serum antibody prevalences found in this study indicate that marine mammals off the coasts of Alaska and Russia are regularly exposed to PhHV-1 and PhHV-2 and possibly to other related herpesviruses.

A variety of parasites are recorded within ringed seals in the Arctic. A complete discussion on this subject may be found in Kelly *et al.*, 2010.

Recently, an outbreak of disease has been observed in pinnipeds within Alaska waters, including the Beaufort Sea. This disease manifests in ulcerated lesions, hair loss, and emaciated body condition. NMFS has declared this as an unusual mortality event (UME) and is currently working to describe this disease's type and origin. During December 2011 and January 2012, 20-30 adult ringed seals were harvested from leads in the sea ice in the North Slope Borough. Based on local reports, these seals had neither hair loss nor lesions. However, during late February, a young ringed seal with nodular and eroded flipper lesions but no hair loss was harvested. Additionally, necropsy results of the internal organs were consistent with animals with this disease that continues to affect ice seals in the North Slope Borough and Bering Strait regions. The underlying cause of the Alaska UME disease remains a mystery. Testing has ruled out numerous bacteria and viruses known to affect marine mammals, including Phocine distemper, influenza, Leptospirosis, Calicivirus, orthopoxvirus, and poxvirus. Foreign animal diseases and some domestic animal diseases tested for and found negative include foot and mouth disease, VES, pan picornavirus, Rickettsial agents. Last month, preliminary radiation testing results were announced which indicate radiation exposure is likely not a factor in the illness. Further quantitative radionuclide testing is occurring this spring. Results will be made publicly available as soon as the analyses are completed (NMFS news release March 19, 2012).

Bearded Seal

Bearded seals will be present in the action area during the time of the BP surveys, although there are no reliable abundance estimates for bearded seals within the action area during summer months. Their presence may reflect their affinity for sea ice which generally retreats northward during spring and summer, or may be due to feeding in this general area. These seals feed primarily on benthic organisms such as clams, crabs, and shrimp, but their diet may also include fish such as sculpin and cod (Cameron et al., 2010). We have found no information to describe the relative value of feeding habitat of the Beaufort Sea, but no exceptional bearded seal feeding habitat is known within the action area.

Other factors affecting bearded seals within the Action Area

Predation

A reduction in suitable sea ice habitat would likely increase the overlap in the distribution of bearded seals and walrus (*Odobenus rosmarus*), another ice-associated benthic feeder with similar habitat preferences and diet (Lowry *et al*. 1980). The walrus is also a predator of bearded seal, though seemingly infrequent. Hauling out closer to shore or on land could also increase the risks of predation from polar bears, and terrestrial carnivores (75 FR 77505). Polar bears are the primary predators of bearded seals, but other predators include brown bears, killer whales, sharks, and walruses. Predation under the future scenario of reduced sea ice is difficult to assess; polar bear predation may decrease, but predation by killer whales, sharks and walrus may increase (Cameron 2010).

Bearded seal adaptations that may have evolved because of polar bear predation include large, highly aquatic and mobile pups and female preference for small, drifting ice floes for nursing. These adaptations might afford mothers and pups some protection against polar bear predation (Burns and Frost 1979, Burns 1981, Kovacs and Lavigne 1986, Lydersen and Kovacs 1999, Kovacs 2002).

Destruction or Modification of Habitat

The main concern about the conservation status of bearded seals stems from the likelihood that their sea ice habitat has been modified by the warming climate and, more so, that the scientific consensus projections are for continued and perhaps accelerated warming in the foreseeable future. A second concern related by the common driver of carbon dioxide emissions, is the modification of habitat by ocean acidification, which may alter prey populations and other important aspects of the marine ecosystem.

Climate Change

For at least some part of the year, bearded seals rely on the presence of sea ice over the productive and shallow waters of the continental shelves where they have access to food–primarily benthic and epibenthic organisms–as a platform for hauling out of the water.

For bearded seals, the presence of sea ice in April and May is considered a requirement for whelping and nursing young (Reeves et al. 1992, Kovacs et al. 1996). Similarly, the molt in phocid seals is believed to be promoted by elevated skin temperatures that, in polar regions, can only be achieved when seals haul out of the water (Feltz and Fay 1966, Boily 1995). Thus, if suitable ice cover is absent from shallow feeding areas during times of peak whelping and nursing (April/May), or molting (May/June and sometimes through August), bearded seals would be forced to seek either sea-ice habitat over deeper waters (perhaps with poor access to food) or coastal regions in the vicinity of haul-out sites on shore (perhaps with increased risks of disturbance, predation, and competition). Both scenarios would require bearded seals to adapt to novel (i.e., suboptimal) conditions, and to exploit habitats to which they may not be well adapted, likely compromising their reproduction and survival rates. Further, the spring and summer ice edge may retreat to deep waters of the Arctic Ocean basin, which could separate sea ice suitable for pup maturation and molting from benthic feeding areas.

Ocean Acidification

Ocean acidification may impact bearded seal survival and recruitment through changes in the demography or distribution of prey populations, particularly prey that are calcifying or that feed on calcifying prey. Bearded seals of different age classes are thought to feed at different trophic levels, so any ecosystem change could be expected to impact bearded seals in a variety of ways. Changes in bearded seal prey, anticipated in response to ocean warming and loss of sea ice and, potentially, ocean acidification, have the potential for negative impacts, but the possibilities are complex. These ecosystem responses may have very long lags as they propagate through trophic webs. Because of bearded seals' apparent dietary flexibility, these threats are of less concern than the direct effects of potential sea ice degradation.

Ocean acidification may also impact bearded seals by affecting the propagation of sound in the marine environment. Researchers have suggested that effects of ocean acidification will cause low-frequency sounds to propagate more than 1.5X as far (Hester et al. 2008, Brewer and Hester 2009), which, while potentially extending the range bearded seals can communicate under quiet conditions, will increase the potential for masking when man-made noise is present.

Harvest

Evidence of seal hunting by Native villages in the Arctic goes back at least 5,000 years (Riewe 1991). Bearded seals were among those species hunted by the early Arctic inhabitants (Krupnik 1984), and today they remain a central nutritional and cultural resource for many northern communities (Hart and Amos 2004, ACIA 2005, Hovelsrud et al. 2008). By about the late 19th century, bearded seals were harvested commercially in large numbers causing local depletions. Though commercial operations were primarily interested in seal oil and skins, Native hunters have traditionally used all parts of bearded seals: their meat has been used as food for people, sled dogs, and livestock; their durable skins used for foot gear, umiaks (whaling boats), lines, and harnesses, traded for goods, or sold for cash; their blubber rendered into oil for food and fuel; and their flippers, bones, and viscera used for many household, industrial, or medicinal purposes (Krylov et al. 1964, Stewart et al. 1986).

Hunters mostly take seals during their northward migration in the late spring and early summer, using small boats in open leads among ice floes close to shore (Kelly 1988). Alaskan villages harvested about 1,700 bearded seals annually from 1966 to 1979, with reported takes remaining fairly constant except in 1977 when an estimated range of 4,750-6,308 were taken (Matthews 1978, Burns 1981). About a decade later, in 1986, curtailed monitoring from just five Alaska villages in the Bering Strait area reported 791 bearded seals taken (Kelly 1988). More recently in Alaska, under more comprehensive subsistence monitoring, the estimated harvest peaked from 1990 to 1998 at mean levels of 6,788 bearded seals per year (Coffing et al. 1998, Georgette et al. 1998, Wolfe and Hutchinson-Scarbrough 1999, Allen and Angliss 2010). The most recent harvest estimates (from 2003) cover only villages in the North Slope Borough and suggest that a minimum of 1545 bearded seal are taken from just the eastern Chukchi and western Beaufort Seas (Bacon et al. 2009). The 1990-1998 harvest estimates are the most comprehensive and thus considered the most current for the subsistence hunt in Alaska (Allen and Angliss 2010). It is unclear if variations in the harvest, especially the dramatic shifts, are real or reflect changes in survey methodology, coverage, or reporting. Ice cover in hunting locations can dramatically affect the availability of seals and the success of hunters in retrieving seals that have been shot, which can range from 50-75% success in the ice (Burns and Frost 1979, Reeves et al. 1992) to as low as 30% in open water (Burns 1967, Smith and Taylor 1977, Riewe and Amsden 1979, Davis et al. 1980). Using the mean annual harvest reported from 1990-1998, assuming 25 to 50% of seals struck are lost, the total annual hunt by Alaska Natives would range from 8,485 to 10,182 bearded seals.

The current subsistence harvest is substantial in some areas, but there is little evidence that subsistence harvests have or are likely to pose population-level risk to the species.

Commercial Fisheries Interactions

Commercial fisheries may impact bearded seals through direct interactions (i.e., incidental take or bycatch) and indirectly through competition for prey resources and other impacts on prey populations. Estimates of bearded seal bycatch could only be found for commercial fisheries that operate in Alaska waters. Based on data from 2002–2006, there has been an annual average of 1.0 mortalities of bearded seals incidental to commercial fishing operations (Allen and Angliss 2010). Although no information could be found regarding bearded seal bycatch in the Sea of Okhotsk, given the intensive levels of commercial fishing that occur in this sea, bycatch of bearded seals likely occurs there as well. For indirect impacts, we note that commercial fisheries target a number of known bearded seal prey species, such as walleye pollock (*Theragra chalcogramma*) and cod. These fisheries may affect bearded seals indirectly through reduction in prey biomass and through other fishing mediated changes in their prey species. Bottom trawl fisheries also have the potential to indirectly affect bearded seals through destruction or modification of benthic prey and/or their habitat.

Shipping

Current shipping activities in the Arctic pose varying levels of threats to bearded seals depending on the type and intensity of the shipping activity and its degree of spatial and temporal overlap with bearded seal habitats. These factors are inherently difficult to know or predict, making threat assessment highly uncertain. Most ships in the Arctic purposefully avoid areas of ice and thus prefer periods and areas which minimize the chance of encountering ice. This necessarily mitigates many of the risks of shipping to populations of bearded seals, since they are closely associated with ice throughout the year. Icebreakers pose special risks to bearded seals because they are capable of operating year-round in all but the heaviest ice conditions and are often used to escort other types of vessels (*e.g.*, tankers and bulk carriers) through ice-covered areas.

Contaminants

Research on contaminants and bearded seals is limited compared to the extensive information available for ringed seals. Pollutants such as organochlorine compounds (OC) and heavy metals have been found in most bearded seal populations. The variety, sources, and transport mechanisms of the contaminants vary across the bearded seal's range, but these compounds appear to be ubiquitous in the Arctic marine food chain. Statistical analysis of OCs in marine mammals has shown that, for most OCs, the European Arctic is more contaminated than the Canadian and U.S. Arctic. Present and future impacts of contaminants on bearded seal populations should remain a high priority issue. Climate change has the potential to increase the transport of pollutants from lower latitudes to the Arctic, highlighting the importance of continued monitoring of bearded seal contaminant levels.

Oil and Gas

Within the action area, oil and gas exploration, development, and production activities include, but are not limited to: seismic surveys; exploratory, delineation, and production drilling operations; construction of artificial islands, causeways, ice roads, shore-based facilities, and pipelines; and vessel and aircraft operations. These activities have the potential to impact bearded seals, primarily through noise, physical disturbance, and pollution, particularly in the event of a large oil spill or blowout. Oil and gas activities have been conducted off the coast of Alaska since the 1970s, with most of the activity occurring in the Beaufort Sea.

Demographic Threats

The Beringia DPS is not believed to be currently at risk from the effects of demographic stochasticity, inbreeding, loss of genetic diversity, or depensation (Cameron *et al.* 2010).

Parasitism and Disease

Exposures to two phocid herpesviruses have been detected in phocid seals in Alaska; phocid herpesvirus-1 (PhHV-1), an alpha herpesvirus, and herpesvirus-2 (PhHV-2), a gamma herpesvirus. Zarnke et al. (1997) tested marine mammals from Alaska and Russia for antibodies to PhHV-1 and PhHV-2. In bearded seals, serum antibody prevalence for PhHV-1 and PhHV-2 were 61% and 17%, and antibody prevalence for neither virus was 33%. Antibody prevalence for PhHV-1 was higher than for PhHV-2 in most of the species examined, and the three highest prevalence of antibodies to PhHV-1 were found in phocid seals. Zarnke et al. (1997) suggested that serum antibody prevalences found in this study indicate that marine mammals off the coasts of Alaska and Russia are regularly exposed to PhHV-1 and PhHV-2 and possibly to other related herpesviruses.

Quakenbush et al. (2010) collected serum from bearded seals harvested along the coast near Point Hope, Kotzebue, Shishmaref, and Little Diomede Island in 1998 and 2002-2008 and tested for several viruses, including PhHV-1, PhHV-2, phocine distemper virus (PDV), and canine distemper virus (CDV). PDV is a morbillivirus that causes respiratory distress and pneumonia and has been responsible for large die-offs of harbor seals in Europe (Kennedy et al. 1988). PDV has been identified in harbor seals from Alaska as well (Zarnke et al. 1997). Quakenbush *et al.* (2010) found antibodies for only one of the viruses tested; 29.5% (18 of 61) of bearded seals were positive for PhHV-1 antibodies; however, they did not identify antibodies for PhHV-2, PDV, or CDV in seals they examined. Six bearded seals collected from the native harvest around Gambell on St. Lawrence Island, Alaska were also negative for antibodies to PDV (Calle et al. 2008). Calle *et al.* (2008) also tested for influenza A virus, and all seals were negative for antibodies.

Quakenbush *et al.* (2010) examined bearded seals from the native Alaskan harvest for several bacterial diseases. Quakenbush *et al.* (2010) also examined the stomach and intestinal contents from 19 bearded seals collected from the Bering and Chukchi Seas and tested them for domoic acid and saxitoxin. They found domoic acid or saxitoxin in four bearded seals, but only one seal was positive for both domoic acid and saxitoxin. Levels of both domoic acid and saxitoxin were low in all animals (Quakenbush *et al*. 2010).

Quakenbush *et al.* (2010) examined 43 bearded seals collected from the Alaska Native harvest in the Chukchi and Bering Seas for antibodies to *Toxoplamsa* spp., and dentified one seal positive for these antibodies. Fecal samples from 22 bearded seals collected from near Barrow, Alaska, were all negative for both *Giardia spp*. and *Cryptosporidium spp*. (Hughes-Hanks *et al.* 2005). Hughes-Hanks *et al*. (2005) found *Giardia spp*. and *Cryptosporidium spp*. in ringed seals, bowhead whales, and North Atlantic right whales from near Barrow, indicating that these protozoans are present in the marine environment; however, they have only been found in a few bearded seals (Dixon *et al*. 2008).

Many helminth parasites have been found in bearded seals throughout their circumpolar range, including the Kara and Barents Seas, northwest Atlantic, Gulf of St. Lawrence, Bering, Chukchi, and Okhotsk Seas (Cameron *et al*., 2010).

Additionally, bearded seals could be subject to the same UME disease discussed above under ringed seals.

V. EFFECTS OF THE ACTION

Active acoustic sources and vessel activities have the potential for adverse effects on marine mammals. The most significant effect of the proposed action on these species would be associated with increased levels of in-water noise, which may cause these animals to alter their behavior.

The ambient noise environment in the Arctic is complex and variable due to the seasonal changes in ice cover and sea state. Much research has been conducted in characterizing ambient noise in relation to sea ice coverage in the Arctic (e.g., Milne and Ganton, 1964; Diachok and Winoker, 1974; Lewis and Denner, 1987, 1988), however, none of these studies provide the broadband ambient noise levels in time and space that can be used in comparison to the broadband received noise levels from the proposed activities. Nevertheless, frequency band specific analysis showed that ambient levels reach to about 90 dB re 1 μPa at certain 1/3-octave band under 100 Hz near the ice edge (Diachok and Winoker 1974; Lewis and Denner 1987, 1988). Therefore, it is possible that at certain times and/or locations, such as near the ice margins or in open ocean with high sea state, natural ambient noise levels in the Arctic could reach or exceed 120 dB re 1 μPa, although the extent of these situations is unknown.

The potential effects of the surveys to increase noise levels in the marine acoustic environment include sound generated by airgun arrays, pinger signals, and vessels. The most intense sources from the proposed open water seismic surveys would be impulse sound generated by seismic airgun arrays. However, these effects are expected to be localized to the project areas and temporary, occurring only during marine and seismic data acquisition.These specific sources of in-water noise associated with the proposed surveys are discussed below.

Under current NMFS guidelines, the "exclusion zone" for marine mammal exposure to impulse sources is customarily defined as the area within which received sound levels are ≥180 dB re 1 μPa (rms) for cetaceans and ≥190 dB re 1 μPa (rms) for pinnipeds. These safety criteria are based on an assumption that SPL received at levels lower than these will not injure these animals or impair their hearing abilities, but that at higher levels might have some such effects. Disturbance or behavioral effects to marine mammals from underwater sound may occur after exposure to sound at distances greater than the exclusion zones (Richarcdson *et al.* 1995).

This information is discussed in more detail in BP's IHA application (BP, 2011), the proposed rule for the IHA (NMFS 2012a) and in the NEPA environmental analysis (NMFS 2012b). A summary is presented below.

Potential Effects from Airguns and Pingers on Bowhead Whales in the Action Area

A total of three seismic source vessels (two main source vessels and one mini source vessel) would be used during the proposed survey. The sources would be arrays of sleeve airguns. Each main source vessel would carry an array that consists of two sub-arrays. Each sub-array contains eight 40 in^3 airguns, totaling 16 guns per main source vessel with a total discharge volume of 2 × 320 in^3, or 640 in^3. This 640 in^3 array has an estimated source level of ~223 dB re 1 μPa (rms). The mini source vessel would contain one array with eight 40 in^3 airguns for a total discharge volume of 320 in^3. The estimated source level of this 320 in^3 array is 212 dB re 1 μPa (rms).

An acoustic propagation model, i.e., JASCO's Marine Operations Noise Model (MONM), was used to estimate the distances to received sound levels of 190, 180, 170, 160, and 120 dB re 1μPa (rms) for pulsed sounds from the 640 in^3 and 320 in^3 airgun arrays. Modeling methodology and results are described in detail in the appendix of the BP's IHA application (Warner and Hipsey 2011). Table 6 summarizes the distances from the source to specific received sound levels based on MONM modeling.

Table 6. Estimated distances to specified received SPL (rms) from airgun arrays with a total discharge volume of 640 in^3, 320 in^3, and 40 in^3.

Received Levels (dB re 1 μPa rms)	Distance in meters (inside barrier islands)			Distance in meters (outside barrier islands)	
	640 in^3	320 in^3	40 in^3	640 in^3	40 in^3
190	310	160	16	120	< 50
180	750	480	59	950	<50
170	1,200	930	300	2,500	120
160	1,800	1,500	700	5,500	810
120	6,400	5,700	3,700	44,000	16,000
Note: Values are based on 2 m tow depth for the 640 in^3 and 40 in^3 array, and a 1 m tow depth for the 320 in^3 array.					

Figure 13 depicts approximate areas that would be ensonified to 120dB and 160dB during the proposed seismic surveys. It should be noted that the barrier islands will limit propagation of sound both originating inside (between barrier islands and shore) and outside (open ocean) and will change the ensonified area to some extent. Figure 13 is an approximation. More detailed modeling was done in BP (2011).

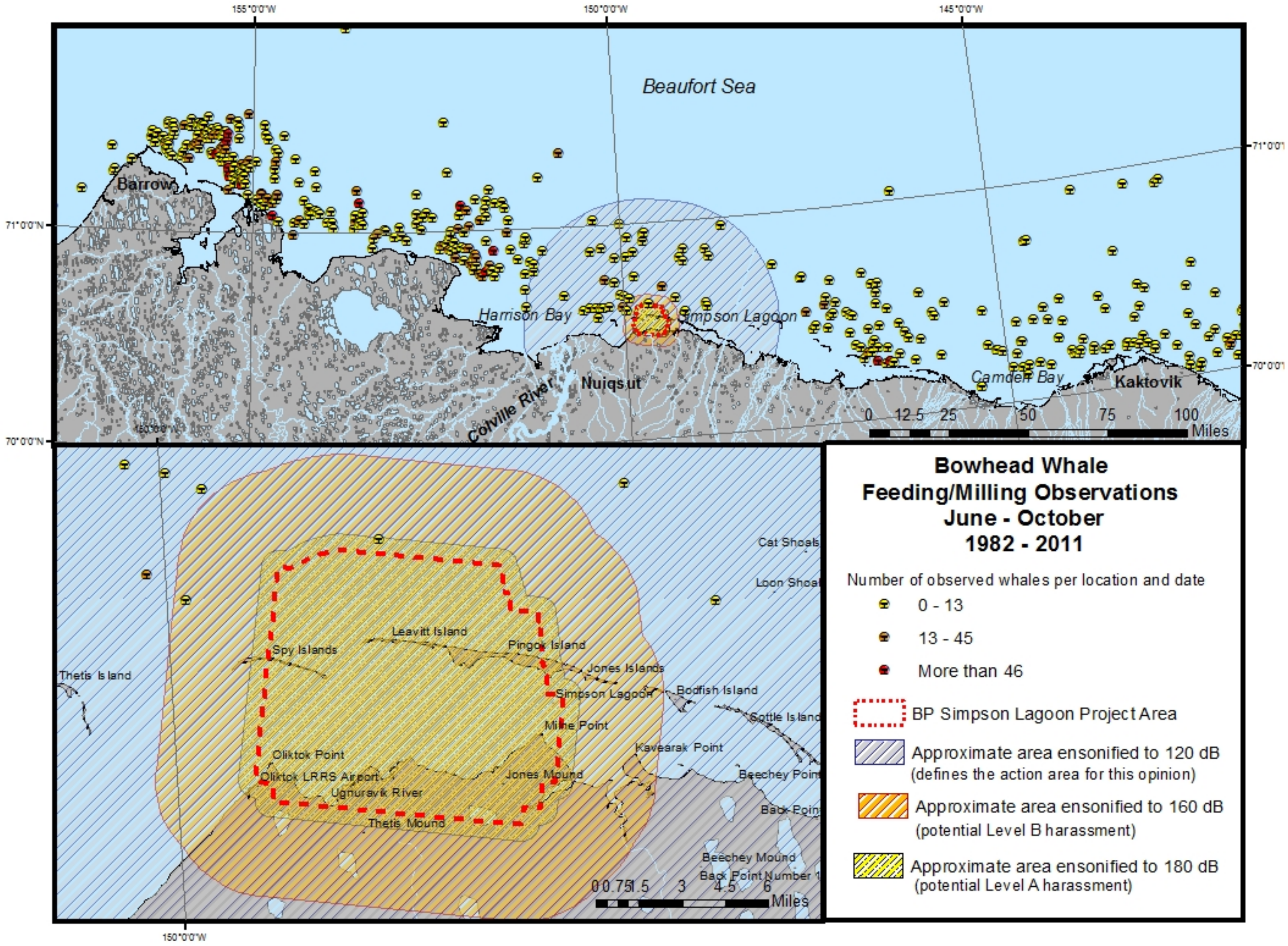


Figure 13. Clarke et al (2012) present bowhead whale observations as part of the BWASP project. Approximate ensonified areas were mapped using distances presented in Table 6. More detailed modeling of ensonified areas is done in BP (2012). Propogation of sound is greatly influenced by the barrier islands.

Since 1996, many of the open water seismic surveys in State of Alaska waters and adjacent nearshore federal waters of the central Alaskan Beaufort Sea have been ocean-bottom cable surveys. These surveys were 3D seismic programs. The area to be surveyed is divided into patches, each patch being approximately 5.9 by 4.0 km in size. Within each patch, several receiving cables are laid parallel to each other on the seafloor. Seismic data are acquired by towing the airguns along a series of source lines oriented perpendicular to the receiving cables. While seismic data acquisition is ongoing on one patch, vessels are deploying cable on the next patch to be surveyed and/or retrieving cables from a patch where seismic surveys have been completed. Airgun arrays varied in size each year from 1996-1998 with the smallest, a 560 in^3 array with 8 airguns, and the largest, a 1,500 in^3 array with 16 airguns. A marine mammal and acoustical monitoring program was conducted in conjunction with the seismic program each year in accordance with provisions of the NMFS Incidental Harassment Authorization. Based on 1996-1998 data, there was little or no evidence that bowhead headings, general activities, or swimming speeds were affected by seismic exploration. Bowheads approaching from the northeast and east showed similar headings at times with and without seismic operations. Miller et al. (1999) stated that the lack of any statistically significant differences in headings should be interpreted cautiously. Changes in headings must have occurred given the avoidance by most bowheads of the area within 20 or even 30 km of active seismic operations. Miller et al. (1999) noted that the distance at which deflection began cannot be determined precisely, but they stated that considering times with operations on offshore patches, deflection may have begun about 35 km to the east. However, some bowheads approached within 19-21 km of the airguns when they were operating on the offshore patches. It appears that in 1998, the offshore deflection might have persisted for at least 40-50 km west of the area of seismic operations. In contrast, during 1996-1997, there were several sightings in areas 25-40 km west of the most recent shotpoint, indicating the deflection in 1996-1997, may not have persisted as far to the west.

LGL Ltd.; Environmental Research Assocs., Inc.; and Greeneridge Sciences Inc. conducted a marine mammal monitoring program for a seismic survey near the Northstar Development Project in 1996 (Miller et al., 1997). The marine mammal monitoring program was continued for subsequent seismic surveys in nearshore waters of the Beaufort Sea in 1997 and 1998 (Miller, Elliot, and Richardson, 1998; Miller et al., 1999). Details of these studies are provided in the Beaufort Sea multiple-sale final EIS. These studies indicated that the bowhead whale migration corridor in the central Alaskan Beaufort Sea during 1998 was similar to the corridor in many prior years, although not 1997. In 1997, nearly all bowheads sighted were in relatively nearshore waters. The results of the 1996-1998 studies indicated a tendency for the general bowhead whale-migration corridor to be farther offshore on days with seismic airguns operating compared to days without seismic airguns operating, although the distances of bowheads from shore during airgun operations overlapped with those in the absence of airgun operations. Aerial-survey results indicated that bowheads tended to avoid the area around the operating source, perhaps to a radius of about 20-30 km. Sighting rates within a radius of 20 km of seismic operations were significantly lower during seismic operations than when no seismic operations were happening. Within 12-24 hours after seismic operations ended, the sighting rate within 20 km was similar to the sighting rate beyond 20 km. There was little or no evidence of differences in headings, general activities, and swimming speeds of bowheads with and without seismic operations. Overall, the 1996-1998 results show that most bowheads avoided the area

within about 20-30 km of the operating airguns. Within 12-24 hours after seismic operations ended, the sighting rate within 20 km was similar to the sighting rate beyond 20 km.
The observed 20-30 km area of avoidance is a larger avoidance radius than documented by previous scientific studies in the 1980s and smaller than the 30 mi suggested by subsistence whalers, based on their experience with the types of seismic operations that occurred in the Beaufort Sea before 1996 (Richardson 2000). The seismic activities in the 1980s were 2D in deeper water. Recent seismic activities were 3D OBC concentrated in shallow water.
Based on recordings of bowhead whale calls made during these same studies, Greene et al. (1999), summarized that results for the 3 years of study indicated that: (1) bowhead whales call frequently during the autumn migration through the study area; (2) calling continued at times when whales were exposed to airgun pulses; and (3) call-detection rates at some locations differed significantly when airguns were detectable versus not detectable. However, there was no significant tendency for the call-detection rate to change in a consistent way at times when airguns started or stopped.

Richardson provided a brief comparison between observations from seismic studies conducted in the 1980s and the 1996 seismic survey at the Arctic Seismic Synthesis Workshop in Barrow (USDOI, MMS 1997). Observations from earlier seismic studies during the summer and early autumn show that most bowhead whales interrupt their previous activities and swim strongly away when a seismic ship approaches within about 7.5-8 km. At the distances where this strong avoidance occurs, received levels of seismic pulses typically are high, about 150-180 dB re 1 µPa. The surfacing, respiration, and dive cycles of bowheads engaged in strong avoidance also change in a consistent pattern involving unusually short surfacing and diving and unusually few blows per surfacing. These avoidance and behavioral effects among bowheads close to seismic vessels are strong, reasonably consistent, and relatively easy to document. Less consistent and weaker disturbance effects probably extend to longer distances and lower received sound levels at least some of the time. Bowheads often tolerate much seismic noise and, at least in summer, continue to use areas where seismic exploration is common. However, at least one case of strong avoidance has been reported as far as 24 km from an approaching seismic boat (Koski and Johnson 1987) and, as noted above, the aerial survey data (Miller et al. 1999) indicated that bowheads tended to avoid the area around the operating source, perhaps to a radius of about 20-30 km. Richardson noted that many of the observations involved bowheads that were not actively migrating. Actively migrating bowheads may react somewhat differently than bowheads engaged in feeding or socializing. Migrating bowheads, for instance, may react by deflecting their migration corridor away from the seismic vessel. Monitoring of the bowhead migration past a nearshore seismic operation in September 1996 provided evidence consistent with the possibility that the closest whales may have been displaced several miles seaward during periods with seismic activity.

With respect to these studies conducted in the Beaufort Sea from 1996-1998, the peer-review group at the Arctic Open-Water Noise Peer Review Workshop in Seattle from June 5-6, 2001, prepared a summary statement supporting the methods and results reported in Richardson (1999) concerning avoidance of seismic sounds by bowhead whales:
"Monitoring studies of 3-D seismic exploration (8-16 airguns totaling 560-1,500 in^3) in the nearshore Beaufort Sea during 1996-1998 have demonstrated that nearly all bowhead whales will avoid an area within 20 km of an active seismic source, while deflection may begin at

distances up to 35 km. Sound levels received by bowhead whales at 20 km ranged from 117-135 dB re 1 µPa rms and 107-126 dB re 1 µPa rms at 30 km. The received sound levels at 20-30 km are considerably lower levels than have previously been shown to elicit avoidance in bowhead or other baleen whales exposed to seismic pulses."

A study in Canada provides information on the behavioral response of bowhead whales to seismic surveys (Miller and Davis, 2002). Bowheads were sighted at similar rates with and without seismic, although the no feeding-seismic sample was too small for meaningful comparisons. Bowheads were seen regularly within 20 km of the operations area at times influenced by airgun pulses. Aerial surveys were unable to document bowhead avoidance of the seismic operations area. The area of avoidance around the seismic operations area was apparently too small to be evident from the broadscale aerial surveys that were flown, especially considering the small amount of surveying done when seismic was not being conducted. General activities of bowheads during times when seismic operations were conducted were similar to times without seismic.

The bowheads that surfaced closest to the vessel (323-614 m) would have been exposed to sound levels of about 180 dB re 1 µPa rms before the immediate shutdown of the array (Miller *et al.* 2002). There were seven shutdowns of the airgun array in response to sightings of bowheads within 1 km of the seismic vessel. Bowheads at the average vessel-based sighting distance (1,957 m) during line seismic would have been exposed to sound levels of about 170 dB re 1 µPa rms. The many aerial sightings of bowheads at distances from the vessel ranging from 5.3-19.9 km would have been exposed to sound levels ranging from approximately 150-130 dB re 1 µPa rms, respectively.

The results from the study in summer 2001 are markedly different from those obtained during similar studies during the autumn migration of bowheads through the Alaskan Beaufort Sea (Miller *et al*. 2002). For example, during the Alaskan studies only 1 bowhead whale was observed from the seismic vessel(s) during six seasons (1996-2001) of vessel-based observations compared with 262 seen in 2001. The zone of avoidance for bowhead whales around the airgun operations in 2001 was clearly much smaller (~2 km) than that observed for migrating bowhead whales in recent autumn studies in Alaskan waters (up to 20-30 km). Davis (1987) concluded that migrating bowheads during the fall migration may be more sensitive to industrial disturbance than bowheads on their summering grounds, where they may be engaged in feeding activities.

Inupiat subsistence whalers have stated that industrial noise, especially noise due to seismic exploration, has displaced the fall bowhead migration seaward and, thereby, is interfering with the subsistence hunt at Barrow (Ahmaogak 1989). Whalers have reported reaction distances, where whales begin to divert from their migratory path, on the order of 10 mi (T. Albert cited in USDOI, MMS 1995) to 35 mi (F. Kanayurak in USDOI, MMS 1997). Kanayurak stated that the bowheads "…are displaced from their normal migratory path by as much as 30 miles."

Data available from MMS' BWASP surveys over about a 27 year period indicate that, at least during the primary open water period during the autumn (when open water seismic activities are most likely to occur), there are areas where bowheads are much more likely to be encountered and where aggregations, including feeding aggregations and/or aggregations with large numbers of females and calves, are more likely to occur in the Beaufort. Such areas include the areas north of Dease Inlet to Smith Bay, northeast of Smith Bay, and Northeast of Cape Halkett, as well as areas near Brownlow Point. Such aggregations have been observed in multiple years during BWASP surveys. However, in some years no large aggregations of bowheads were seen anywhere within the study area. In their Biological Evaluation, the MMS voiced particular concern for the potential for seismic to impact significant life history stages of bowhead whales. If 2D/3D seismic surveys occurred in these areas when large aggregations were present, and particularly if multiple 2D/3D seismic surveys occurred concurrently in these areas, MMS concluded either hundreds of whales could be excluded (through avoidance) from a large area for a relatively long portion of the season, or many more individuals would likely avoid the area as they sequentially came in to use the area.

The extent of avoidance will vary due to the actual noise level radii around each seismic vessel, the context in which it is heard, and the motivation of the animal to stay within the area. It also may vary depending on the age, and most likely, the sex and reproductive status of the whale. It may be related to whether subsistence hunting has begun and/or is ongoing. Because the areas where large aggregations of whales have been observed during the autumn also are areas used, at least in some years, for feeding, it may be that the whales would show avoidance more similar to that observed in studies of whales on their summer feeding grounds. However, Figure 13 shows the observed feeding behavior in the action area as less than in other areas of the Beaufort Sea. And, it is not clear that reduced avoidance should be interpreted as a reduction in impact. It may be that bowheads are so highly motivated to stay on a feeding ground that they remain at noise levels that could, with long term exposure, cause adverse effects.

Seismic activity should have little effect on bowhead prey species (mainly zooplankton). Bowheads feed on concentrations of zooplankton. Zooplanktons that are very close to the seismic source may react to the shock wave, but little or no mortality is expected (LGL Ltd. 2001). A reaction by zooplankton to a seismic impulse would be relevant only if it caused a concentration of zooplankton to scatter. Pressure changes of sufficient magnitude to cause zooplankton to scatter probably would occur only if they were very close to the source. Impacts on zooplankton behavior are predicted to be negligible and would have negligible effects on feeding bowheads (LGL Ltd. 2001).

Data on short-term reactions (or lack of reactions) of cetaceans to impulsive noises do not necessarily provide information about long-term effects. It is not known whether impulsive noises affect reproductive rate or distribution and habitat use in subsequent days or years. Gray whales continued to migrate annually along the west coast of North America despite intermittent seismic exploration and much ship traffic in that area for decades. Bowhead whales continued to travel to the eastern Beaufort Sea each summer despite seismic exploration in their summer and autumn range for many years (Richardson et al. 1987). Populations of both gray whales and bowhead whales grew substantially during this time.

Potential Effects of Pinger Signals

A pinger system (Sonardyne Acoustical Pingers) and acoustic releases/transponders would be used during seismic operations to position the receivers and locate and retrieve the batteries. Sounds transmitted by these pingers are characterized by very short pulses. The Sonardyne pinger has a source level ranging from ~188–193 dB re 1 mPa at 1 m in a frequency range of 19–36 kHz and the transponder has source levels ~192 dB re 1 mPa at 1 m in a frequency range of 7–15 kHz. Pulses are emitted on command from the operator aboard the source vessel. The pinger produces sounds within the frequency range that could be detected by some seals (functional sensitivity from few tens of Hz to ~10 kHz), 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.

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 (within tens of meters) to the source. The maximum reaction that might be expected would be a startle reaction or other short-term response. 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.

Summary of Effect of Airguns and Pingers on Bowhead Whales in the Action Area

The OBC seismic surveys are expected to elicit short term behavioral reactions similar to those described for other seismic surveys in the Beaufort Sea. The impacts to bowhead whales would be expected to result in short term behavioral effects without significant consequence to the whales. Here again we note any possible long-term effects of this exposure are not presently fully known. However, the Western Artic population of bowhead whales has continued to grow over the last several decades despite oil and gas exploration activity, shipping, and subsistence harvests under a quota of 280 whales landed within five year blocks.

Potential Effects of Airguns and Pingers on Ringed and Bearded Seals in the Action Area

Ringed and bearded seals are not likely to show a strong avoidance reaction to the airgun sources proposed for use. Visual monitoring from seismic vessels has shown only slight (if any) avoidance of airguns by pinnipeds and only slight (if any) changes in behavior. Ringed seals frequently do not avoid the area within a few hundred meters of operating airgun arrays (Harris *et al*., 2001; Moulton and Lawson, 2002; Miller *et al.*, 2005). Monitoring work in the Alaskan Beaufort Sea during 1996–2001 provided considerable information regarding the behavior of seals exposed to seismic pulses (Harris *et al.*, 2001; Moulton and Lawson, 2002). These seismic projects usually involved arrays of 6 to 16 airguns with total volumes of 560 to 1,500 in^3. The combined results suggest that some seals avoid the immediate area around seismic vessels. In most survey years, ringed seal sightings tended to be farther away from the seismic vessel when the airguns were operating than when they were not (Moulton and Lawson, 2002). However, these avoidance movements were relatively small, on the order of 328 ft (100 m) to a few hundreds of meters, and many seals remained within 328–656 ft (100–200 m) of the trackline as the operating airgun array passed by. Seal sighting rates at the water surface were lower during airgun array operations than during no-airgun periods in each survey year except 1997. Similarly, seals are often very tolerant of pulsed sounds from seal-scaring devices (Mate and Harvey, 1987; Jefferson and Curry, 1994; Richardson *et al.*, 1995a). However, initial telemetry work suggests that avoidance and other behavioral reactions by two other species of seals to small airgun sources may at times be stronger than evident to date from visual studies of pinniped reactions to airguns (Thompson *et al.*, 1998). Even if reactions of the species occurring in the action area are as strong as those evident in the telemetry study, reactions are expected to be confined to relatively small distances and durations, with no long-term effects on individuals or populations.

Systematic studies of temporary hearing threshold shift (TTS) on captive pinnipeds have been conducted (Bowles et al., 1999; Kastak et al., 1999, 2005, 2007; Schusterman et al., 2000; Finneran et al., 2003; Southall et al., 2007). The TTS threshold for pulsed sounds has been indirectly estimated as being a sound exposure level (SEL) of approximately 171 dB re 1 $\mu Pa^2 \cdot s$ (Southall et al., 2007) which would be equivalent to a single pulse with a received level of approximately 181 to 186 dB re 1 µPa (rms), or a series of pulses for which the highest rms values are a few dB lower. The sound level necessary to cause TTS in pinnipeds depends on exposure duration, as in other mammals; with longer exposure, the level necessary to elicit TTS is reduced (Schusterman et al., 2000; Kastak et al., 2005, 2007). For very short exposures (e.g., to a single sound pulse), the level necessary to cause TTS is very high (Finneran et al., 2003).

Summary of Effect of Airguns and Pingers on Ringed and Bearded Seals in the Action Area

TTS is not expected to occur in any ringed or bearded seals in the proposed action area. While the source level of the airgun is higher than the 190-dB threshold level, an animal would have to be in very close proximity to be exposed to such levels. Because BP will cease operations by October 31, they will not be in the area during the ringed seal pupping season. Because of the mitigation and monitoring measures described earlier in this document, it is highly unlikely that any type of hearing impairment to ringed or bearded seals, temporary or permanent, would occur as a result of the seismic surveys.

Vessel Sounds

In addition to the noise generated from seismic airguns, various types of vessels will be used in the operations, including source vessels, recorder/cable vessels, and various support vessels (Table 1). Sounds from boats and vessels have been reported extensively (Greene and Moore 1995; Blackwell and Greene 2002; 2005; 2006). Numerous measurements of underwater vessel sound have been performed in support of recent industry activity in the Chukchi and Beaufort Seas. Results of these measurements have been reported in various 90-day and comprehensive reports since 2007 (e.g., Aerts et al. 2008; Hauser et al. 2008; Brueggeman 2009; Ireland et al. 2009; Hartin et al. 2011). For example, Garner and Hannay (2009) estimated sound pressure levels of 100 dB at distances ranging from approximately 1.5 to 2.3 mi (2.4 to 3.7 km) from various types of barges. MacDonald et al. (2008) estimated higher underwater SPLs from the seismic vessel Gilavar of 120 dB at approximately 13 mi (21 km) from the source, although the sound level was only 150 dB at 85 ft (26 m) from the vessel. Compared to airgun pulses, underwater sound from vessels is generally at relatively low frequencies.

The primary sources of sounds from all vessel classes are propeller cavitation, propeller singing, and propulsion or other machinery. Propeller cavitation is usually the dominant noise source for vessels (Ross 1976). Propeller cavitation and singing are produced outside the hull, whereas propulsion or other machinery noise originates inside the hull. There are additional sounds produced by vessel activity, such as pumps, generators, flow noise from water passing over the hull, and bubbles breaking in the wake.

The ambient noise environment in the Arctic is complex and variable due to the seasonal changes in ice cover and sea state. Much research has been conducted in characterizing ambient noise in relation to sea ice coverage in the Arctic (e.g., Milne and Ganton 1964; Diachok and Winoker 1974; Lewis and Denner 1987, 1988), however, none of these studies provides the broadband ambient noise levels in time and space that can be used in comparison to the broadband received noise levels from the proposed activities. Nevertheless, frequency band specific analysis showed that ambient levels reach to about 90 dB re 1 μPa at certain 1/3-octav band under 100 Hz near the ice edge (Diachok and Winoker 1974; Lewis and Denner 1987, 1988). Therefore, it is possible that at certain times and/or locations, such as near the ice margins or in open ocean with high sea state, natural ambient noise levels in the Arctic could reach or exceed 120 dB re 1 μPa, although the extent of these situations is unknown.

Source levels from various vessels would be empirically measured before the start of marine surveys (see mitigation measures).

Potential Effects of Vessel Traffic on Bowhead Whales in the Action Area

Bowheads react to the approach of vessels at greater distances than they react to most other industrial activities. According to Richardson and Malme (1993), most bowheads begin to swim rapidly away when vessels approach rapidly and directly. This avoidance may be related to the fact that bowheads have been commercially hunted within the lifetimes of some individuals within the population and they continue to be hunted for subsistence throughout many parts of their range. Avoidance usually begins when a rapidly approaching vessel is 1-4 km (0.62-2.5 mi) away. A few whales may react at distances from 5-7 km (3-4 mi), and a few whales may not react until the vessel is less than 1 km (less than 0.62 mi) away. Received noise levels as low as 84 dB re 1 µPa or 6 dB above ambient may elicit strong avoidance of an approaching vessel at a distance of 4 km (2.5 mi) (Richardson and Malme 1993).

In the Canadian Beaufort Sea, bowheads observed in vessel-disturbance experiments began to orient away from an oncoming vessel at a range of 2-4 km (1.2-2.5 mi) and to move away at increased speeds when approached closer than 2 km (1.2 mi) (Richardson and Malme 1993). Vessel disturbance during these experimental conditions temporarily disrupted activities and sometimes disrupted social groups, when groups of whales scattered as a vessel approached. Reactions to slow-moving vessels, especially if they do not approach directly, are much less dramatic. Bowheads often are more tolerant of vessels moving slowly or in directions other than toward the whales. Fleeing from a vessel generally stopped within minutes after the vessel passed, but scattering may persist for a longer period. After some disturbance incidents, at least some bowheads returned to their original locations (Richardson and Malme 1993). Some whales may exhibit subtle changes in their surfacing and blow cycles, while others appear to be unaffected. Bowheads actively engaged in social interactions or mating may be less responsive to vessels. Data are not sufficient to determine sex, age, or reproductive characteristics of response to vessels. We are not aware of data that would allow us to determine whether females with calves tend to show avoidance and scattering at a greater, lesser, or at the same distances as other segments of the population.

Noise, rather than the simple presence of vessels, seems the likeliest mechanism for vessels to alter whale behavior. It is perhaps unsurprising that cetaceans have been shown to shorten their feeding bouts and initiate fewer of them in the presence of ships and boats. For marine mammals, it is reasonable to assume that larger and noisier vessels, such as seismic and ice-breaking ships, would have greater and more dramatic impacts upon behavior than would smaller vessels.

Nevertheless, the proposed open water seismic survey by BP is of small scale during a limited period. Seismic and support vessels involved in the survey operation are fewer in number when compared to regular shipping. Seismic vessels, which will be moving at speeds of 3 – 5 knots, would not be expected to cause “takes” of marine mammals if not for their intense active sources. All vessels involved in the proposed seismic surveys are small in tonnage compared to large container ships, therefore, their source levels are expected to be much lower than vessels used in commercial shipping. Specific vessels and their actions are described in section 2 of this document.

In addition to acting as a source of noise and disturbance, marine vessels could potentially strike bowhead whales, causing injury or death. As noted in the baseline section of this evaluation, available information indicates that current rates of vessel strikes of bowheads are low. At present, available data do not indicate that strikes of bowheads by oil and gas-related vessels will become an important source of injury or mortality in the Beaufort Sea Planning Area.

Vessel activities associated with the 2012 BP seismic surveys are not expected to disrupt the bowhead migration, and small deflections in individual bowhead swimming paths and a reduction in use of possible bowhead feeding in the Simpson Lagoon area should not result in significant adverse effects on individual whales.

Potential Effects of Vessel Traffic to Bearded and Ringed Seals in the Action Area

The mere presence and movements of ships in the vicinity of seals can cause disturbance of their normal behaviors (Jansen et al. 2010) and potentially cause ringed seals to abandon their preferred breeding habitats in areas with high traffic (Smiley and Milne 1979, Mansfield 1983). The timing of the seismic surveys is such that no disruption of breeding or pupping would occur due to vessel operations. Seals appear quite tolerant of vessels that do not alter course or operate at relatively slow speeds, such as would occur here. As observed in Richardson *et al*. (1995): “In general, evidence about reactions of seals to vessels is meager.” The limited data, plus the responses of seals to other noisy human activities, suggest that seals often show considerable tolerance of vessels. In monitoring seismic work in the Beaufort Sea in 2007, the most commonly observed reaction by seals to passing vessels (not active seismic) was no reaction, followed by looking, splashing, and changing direction (Ireland *et al*., 2009). Similar monitoring of seismic work in the Beaufort during 1998 found 252 seals were sighted from the seismic source vessel (98.5% of which were ringed seals). They found the operation of the airgun array affected the distribution of seals within a few hundred meters of the array. However, seals were observed in the general areas where seismic operations were occurring throughout the season (Richardson, 1999). We are not aware of any abandonment of open water habitat by ringed or bearded seals due to vessel activity.

Aircraft Sounds

Helicopters may be used for personnel and equipment transport. Under calm conditions, rotor and engine sounds are coupled into the water within a 26º cone beneath the aircraft. Some of the sound will transmit beyond the immediate area, and some sound will enter the water outside the 26º area when the sea surface is rough. However, scattering and absorption will limit lateral propagation in the shallow water.

Dominant tones in noise spectra from helicopters are generally below 500 Hz (Greene and Moore, 1995). Helicopter sounds contain numerous prominent tones at frequencies up to about 350 Hz, with the strongest measured tone at 20–22 Hz. Received peak sound levels of a Bell 212 passing over a hydrophone at an altitude of approximately 1,000 ft (300 m), which is the minimum allowed altitude for the Northstar helicopter under normal operating conditions, varied between 106 and 111 dB re 1 µPa at 30 and 59 ft (9 and 18 m) water depth (Greene, 1982, 1985). Harmonics of the main rotor and tail rotor usually dominate the sound from helicopters; however, many additional tones associated with the engines and other rotating parts are sometimes present (Patenaude et al., 2002).

Because of doppler shift effects, the frequencies of tones received at a stationary site diminish when an aircraft passes overhead. The apparent frequency is increased while the aircraft approaches and is reduced while it moves away. Aircraft flyovers are not heard underwater for very long, especially when compared to how long they are heard in air as the aircraft approaches an observer.

Potential Effects from Aircraft Traffic on Bowhead Whales in the Action Area

Most offshore aircraft traffic in support of the oil industry involves turbine helicopters flying along straight lines. Underwater sounds from aircraft are transient. According to Richardson et al. (1995a), the angle at which a line from the aircraft to the receiver intersects the water’s surface is important. At angles greater than 13 degrees from the vertical, much of the incident sound is reflected and does not penetrate into the water. Therefore, strong underwater sounds are detectable while the aircraft is within a 26-degree cone above the receiver. An aircraft usually can be heard in the air well before and after the brief period while it passes overhead and is heard underwater.

Data on reactions of bowheads to helicopters are limited. Most bowheads are unlikely to react significantly to occasional single passes by low-flying helicopters ferrying personnel and equipment to offshore operations. Observations of bowhead whales exposed to helicopter overflights indicate that most bowheads exhibited no obvious response to helicopter overflights at altitudes above 150 m (500 ft). At altitudes below 150 m (500 ft), some bowheads probably would dive quickly in response to the aircraft noise (Richardson and Malme 1993). This noise generally is audible for only a brief time (tens of seconds) if the aircraft remains on a direct course, and the whales should resume their normal activities within minutes. Patenaude et al. (1997) found that most reactions by bowheads to a Bell 212 helicopter occurred when the helicopter was at altitudes of 150 m or less and lateral distances of 250 m or less. The most common reactions were abrupt dives and shortened surface time and most, if not all, reactions seemed brief. However, the majority of bowheads showed no obvious reaction to single passes, even at those distances. The helicopter sounds measured underwater at depths of 3 and 18 m showed that sound consisted mainly of main-rotor tones ahead of the aircraft and tail-rotor sounds behind the aircraft; more sound pressure was received at 3 m than at 18 m; and peak sound levels received underwater diminished with increasing aircraft altitude. Sound levels received underwater at 3 m from a Bell 212 flying overhead at 150 m ranged from 117-120 dB re 1 µPa in the 10-500-Hz band. Underwater sound levels at 18 m from a Bell 212 flying overhead at 150 m ranged from 112-116 dB re 1 µPa in the 10-500-Hz band.

The mitigation measures associate with this action include the 2 following provisions:

- Under no circumstances, other than an emergency, shall aircraft be operated at an altitude lower than 1,000 feet above sea level (ASL) when within 0.3 mile (0.5 km) of groups of whales, and
- Helicopters shall not hover or circle above or within 0.3 mile (0.5 km) of groups of whales.

Potential Effects from Aircraft Traffic to Ringed and Bearded Seals in the Action Area

Potential effects to pinnipeds from aircraft activity could involve both acoustic and non-acoustic effects. It is uncertain if the seals react to the sound of the helicopter or to its physical presence flying overhead. Typical reactions of hauled out pinnipeds to aircraft that have been observed include looking up at the aircraft, moving on the ice or land, entering a breathing hole or crack in the ice, or entering the water. Ice seals hauled out on the ice have been observed diving into the water when approached by a low-flying aircraft or helicopter (Burns and Harbo, 1972, cited in Richardson *et al.*, 1995a; Burns and Frost, 1979, cited in Richardson *et al.*, 1995a). Richardson *et al.* (1995a) note that responses can vary based on differences in aircraft type, altitude, and flight pattern. Additionally, a study conducted by Born *et al.* (1999) found that wind chill was also a factor in level of response of ringed seals hauled out on ice, as well as time of day and relative wind direction.

Blackwell *et al.* (2004a) observed 12 ringed seals during low-altitude overflights of a Bell 212 helicopter at Northstar in June and July 2000 (9 observations took place concurrent with pipe-driving activities). One seal showed no reaction to the aircraft while the remaining 11 (92%) reacted, either by looking at the helicopter (n=10) or by departing from their basking site (n=1). Blackwell et al. (2004a) concluded that none of the reactions to helicopters were strong or long lasting, and that seals near Northstar in June and July 2000 probably had habituated to industrial sounds and visible activities that had occurred often during the preceding winter and spring. There have been few systematic studies of pinniped reactions to aircraft overflights, and most of the available data concern pinnipeds hauled out on land or ice rather than pinnipeds in the water (Richardson *et al.* 1995a; Born *et al.*, 1999).

Born *et al.* (1999) determined that 49% of ringed seals escaped (i.e., left the ice) as a response to a helicopter flying at 492 ft (150 m) altitude. Seals entered the water when the helicopter was 4,101 ft (1,250 m) away if the seal was in front of the helicopter and at 1,640 ft (500 m) away if the seal was to the side of the helicopter. The authors noted that more seals reacted to helicopters than to fixed-wing aircraft. The study concluded that the risk of scaring ringed seals by small-type helicopters could be substantially reduced if they do not approach closer than 4,921 ft (1,500 m). Overall, no significant effect to seals due to this aircraft traffic is expected.

Non-auditory Physiological Effects – Stress

Stress may be induced by the proposed surveys on the species considered in this opinion. This section provides information on the relative exposure to stress, expected responses, and consequences.

Exposure to the surveys associated with the issuance of this IHA has the potential to cause certain physiological effects to marine mammals other than those directly impacting their hearing. The combination of both the psychological stressor and the physiological stressor may have detrimental consequences (Wright et al., 2008). Classic stress responses begin when an animal’s central nervous system perceives a potential threat to its homeostasis. That perception triggers stress responses regardless of whether a stimulus actually threatens the animal; the mere perception of a threat is sufficient to trigger a stress response (Moberg, 2000; Sapolsky et al., 2000; Seyle, 1950). Once an animal’s central nervous system perceives a threat, it mounts a biological response or defense that consists of a combination of the four general biological defense responses: behavioral responses; autonomic nervous system responses; neuroendocrine responses; or immune responses.

In the case of many stressors, an animal’s first and most economical (in terms of biotic costs) response is behavioral avoidance of the potential stressor or avoidance of continued exposure to a stressor.

An animal’s second line of defense to stressors involves the sympathetic part of the autonomic nervous system and the classical “fight or flight” response which includes the cardiovascular system, the gastrointestinal system, the exocrine glands, and the adrenal medulla to produce changes in heart rate, blood pressure, and gastrointestinal activity that humans commonly associate with “stress.”

An animal's third line of defense to stressors involves its neuroendocrine or sympathetic nervous systems; the system that has received the most study has been the hypothalmus-pituitary-adrenal system (also known as the HPA axis in mammals or the hypothalamus-pituitary-interrenal axis in fish and some reptiles). Unlike stress responses associated with the autonomic nervous system, virtually all neuro-endocrine functions that are affected by stress – including immune competence, reproduction, metabolism, and behavior – are regulated by pituitary hormones. Stress-induced changes in the secretion of pituitary hormones have been implicated in failed reproduction (Moberg, 1987; Rivier, 1995), altered metabolism (Elasser et al., 2000), reduced immune competence (Blecha, 2000), and behavioral disturbance.There are times during an animal's life when they have lower reserves and are more vulnerable to impacts from stressors. For example, if a mammal is stressed at the end of a feeding season just prior to a long distance migration, it may have sufficient energy reserves to cope with the stress. If stress occurs at the end of a long migration or fasting period, energy reserves may not be sufficient to adequately cope with the stress (Tyack, 2008; McEwen and Wingfield, 2003; Romano et al., 2004).

Although no information has been collected on the physiological responses of marine mammals to anthropogenic sound exposure, studies of other marine animals and terrestrial animals would lead one to expect some marine mammals to experience physiological stress responses and, perhaps, physiological responses that would be classified as "distress" upon exposure to anthropogenic sounds.

The primary distinction between stress (which is adaptive and does not normally place an animal at risk) and distress is the biotic cost of the response. During a stress response, an animal uses glycogen stores that can be quickly replenished once the stress is alleviated. In such circumstances, the cost of the stress response would not pose a risk to the animal's welfare. However, when an animal does not have sufficient energy reserves to satisfy the energetic costs of a stress response, energy resources must be diverted from other biotic functions, which impair those functions that experience the diversion. For example, when mounting a stress response diverts energy away from growth in young animals, those animals may experience stunted growth. When mounting a stress response diverts energy from a fetus, an animal's reproductive success and fitness will suffer. In these cases, the animals will have entered a pre-pathological or pathological state which is called "distress" (sensu Seyle, 1950) or "allostatic loading" (sensu McEwen and Wingfield, 2003). This pathological state will last until the animal replenishes its biotic reserves sufficient to restore normal function. Note that these examples involved a long-term (days or weeks) stress response exposure to stimuli.

There is little information available on sound-induced stress in marine mammals or on its potential to affect the long-term health or reproductive success of marine mammals (Fair and Becker, 2000; Hildebrand, 2005; Wright et al., 2007a,b). Potential long-term effects, if they occur, would be mainly associated with chronic noise exposure (Nieukirk et al., 2009). Disruption in feeding, especially within small populations could have impacts on whales, their reproductive success and even the survival of the species (NRC, 2005). However, we are unable to quantify any possible impacts of sound-induced stress on these species based on available information.

Summary of Potential Effects of Noise and Disturbance Sources

Available information indicates that bowhead whales are responsive (in some cases highly responsive) to anthropogenic noise in their environment. At present, the primary response that has been documented is avoidance, sometimes at considerable distance. Response is variable, even to a particular noise source and the reasons for this variability are not fully understood. The proposed surveys could result in an increase in noise and disturbance in the autumn range of the Western Arctic bowhead whales. This noise may result from various activities, including vessel traffic, seismic profiling, and support activities.

The observed response of bowhead whales to seismic noise has varied among studies. The factors associated with variability are not entirely clear. However, data indicate that fall migrating bowheads show greater avoidance of active seismic vessels than do feeding bowheads. Recent monitoring studies (1996-1998) and traditional knowledge indicate that during the fall migration, most bowhead whales avoid an area around a seismic vessel operating in nearshore waters by a radius of about 20 km and may begin avoidance at greater distances. Received sound levels at 20 km ranged from 117-135 dB re 1 µPa rms and 107-126 dB re 1µ Pa rms at 30 km. This is a larger avoidance radius than was observed from scientific studies conducted in the 1980s. Avoidance did not persist beyond 12-24 hours after the end of seismic operations. In some early studies, bowheads also exhibited tendencies for reduced surfacing and dive duration, fewer blows per surfacing, and longer intervals between successive blows. Available data indicate that behavioral changes are temporary.

BP's proposed mitigation measures will minimize the impacts of seismic survey noise. Particularly, the mitigation measures are intended to prevent surveys from being conducted in the same place and time as the fall migration of bowhead whales through the action area. Section 3 of this opinion reviews the migration patterns of bowhead whales through the Beaufort Sea. General bowhead migration patterns are depicted in Figure 3. They are generally observed migrating westward across the Alaskan Beaufort starting in late August, at the very earliest, more commonly in mid-September (Greene and McLennan, 2001; Treacy, 1998). Figures 10, 11, and 14 show the observed locations of bowheads from June through October. No bowheads have been observed inside the barrier islands during this timeframe and very few bowheads have been observed outside the barrier islands within range of 160dB sound levels (Figure 13). Because BP will not conduct any surveys outside the barrier islands in the fall after August 25th, potential for impacts during the height of the fall migration back through the action area towards the Bering Sea winter habitat is very low.

The BP seismic surveys will result in an increase in marine vessel activity: supply boats, survey boats, crew boats, and other vessels. Whales respond strongly to vessels directly approaching them. Avoidance of vessels usually begins when a rapidly approaching vessel is 1-4 km away, with a few whales possibly reacting at distances from 5-7 km. Received noise levels as low as 84 dB re 1 µPa or 6 dB above ambient may elicit strong avoidance of an approaching vessel at a distance of 4 km. Fleeing from a vessel generally stopped within minutes after the vessel passed, but scattering may persist for a longer period.

The Beaufort Sea seismic surveys would result in increased aircraft traffic within the action area. Most bowheads exhibit no obvious response to helicopter overflights at altitudes above 150 m (500 ft). At altitudes below 150 m (500 ft), some whales probably would dive quickly in response to the aircraft noise. Bowheads are relatively unaffected by aircraft overflights at altitudes above 300 m (984 ft). Below this altitude, some changes in whale behavior may occur, depending on the type of plane and the responsiveness of the whales present in the vicinity of the aircraft. The mitigation measures described previously that include height and distance parameters are expected to decrease impacts from helicopter traffic.

Potential Impacts on Prey Species

With regard to fish as a prey source for cetaceans and pinnipeds, fish are known to hear and react to sounds and to use sound to communicate (Tavolga et al. 1981) and possibly avoid predators (Wilson and Dill 2002). Experiments have shown that fish can sense both the strength and direction of sound (Hawkins 1981). Primary factors determining whether a fish can sense a sound signal, and potentially react to it, are the frequency of the signal and the strength of the signal in relation to the natural background noise level.

The level of sound at which a fish will react or alter its behavior is usually well above the detection level. Fish have been found to react to sounds when the sound level increased to about 20 dB above the detection level of 120 dB (Ona 1988); however, the response threshold can depend on the time of year and the fish's physiological condition (Engas et al. 1993). In general, fish react more strongly to pulses of sound rather than non-pulse signals (such as noise from vessels) (Blaxter et al. 1981), and a quicker alarm response is elicited when the sound signal intensity rises rapidly compared to sound rising more slowly to the same level.

Investigations of fish behavior in relation to vessel noise (Olsen et al. 1983; Ona 1988; Ona and Godo 1990) have shown that fish react when the sound from the engines and propeller exceeds a certain level. Avoidance reactions have been observed in fish such as cod and herring when vessels approached close enough that received sound levels are 110 dB to 130 dB (Nakken 1992; Olsen 1979; Ona and Godo 1990; Ona and Toresen 1988). However, other researchers have found that fish such as polar cod, herring, and capeline are often attracted to vessels (apparently by the noise) and swim toward the vessel (Rostad et al. 2006). Typical sound source levels of vessel noise in the audible range for fish are 150 dB to 170 dB (Richardson et al. 1995).

Further, during the seismic survey only a small fraction of the available habitat would be ensonified at any given time. Disturbance to fish species would be short-term and fish would return to their pre-disturbance behavior once the seismic activity ceases (McCauley et al. 2000a, 2000b; Santulli et al. 1999; Pearson et al. 1992). Thus, the proposed survey would have little, if any, impact on the abilities of marine mammals to feed in the area where seismic work is planned.

Some mysticetes, including bowhead whales, feed on concentrations of zooplankton. Some feeding bowhead whales may occur in the Alaskan Beaufort Sea in July and August, and others feed intermittently during their westward migration in September and October (Richardson and Thomson [eds.] 2002; Lowry et al. 2004). A reaction by zooplankton to a seismic impulse would only be relevant to whales if it caused concentrations of zooplankton to scatter. Pressure changes of sufficient magnitude to cause that type of reaction would probably occur only very close to the source. Impacts on zooplankton behavior are predicted to be negligible, and that would translate into negligible impacts on feeding mysticetes. Thus, the proposed activity is not expected to have any habitat-related effects on prey species that could cause significant or long-term consequences for individual marine mammals or their populations.

VI. CUMULATIVE EFFECTS

Cumulative effects are defined in 50 CFR 402.02 (Interagency Cooperation on the ESA of 1973, as amended): "…those effects of future State or private activities not involving Federal activities that are reasonably certain to occur within the action area of the Federal action subject to consultation." Reasonably foreseeable future federal actions and potential future federal actions that are unrelated to the proposed action are not considered in the analysis of cumulative effects because they would require separate consultation pursuant to section 7 of the ESA. Cumulative effects are usually viewed as those effects that impact the existing environment and remain to become part of the environment. These effects differ from those that may be attributed to past and ongoing actions within the area since they are considered part of the environmental baseline. Additionally, most structures and major activities within the Beaufort Sea require federal authorizations from one or more agencies, such as the BOEM, Army Corps of Engineers, and the Environmental Protection Agency. Such projects must consult under the ESA on their effects to listed species, and are therefore not addressed here as cumulative impacts.

The State of Alaska is currently leasing state-owned portions of the Beaufort Sea for oil and gas exploration and production. Subsequent exploration or development on state-leased tracts within the Beaufort Sea would be subject to several federal permits and authorizations and therefore not considered in this analysis of cumulative effects. Recent development along the coastline and within nearshore state waters has occurred in the central Beaufort area near the Colville River delta. This work is being done from ice islands in relatively shallow waters (< 3m) constructed in early winter and abandoned by the following spring melt. Additional exploration and development of state lands within this region appears likely.

Since offshore oil and gas activities in state waters are generally well shoreward of the bowheads' main migration route, and some of the activities occur inside the barrier islands, the overall effects on bowheads from activities on state leases is likely to be minimal. These impacts could be magnified, however, if construction activity associated with additional development projects were to occur simultaneously, rather than consecutively. For example, construction and drilling noise from multiple drilling sites could result in a long-term, offshore shift in bowhead migration routes. The extra distance and heavier ice encountered could result in slower migration or physiological stress that may noticeably affect the whales. However, the majority of bowhead whales are generally found offshore of state waters.

Similarly, there may be impacts to ringed and bearded seals from these activities on state lands. These effects could include behavioral responses, including local avoidance to noise from aircraft and vessel traffic; seismic surveys; exploratory drilling; construction activities, including dredging; and development drilling and production operations that occur within several miles of the shore. Much of these state tracts would occur near the area of shorefast ice that is important to ringed seals for winter habitat and pupping.

Oil and gas development has occurred in the Eastern Beaufort Sea off the Canadian Mackenzie Delta. This includes seismic surveys, drilling, and infrastructure and support facilities as described for the US OCS. Seismic programs have recently been conducted off the Mackenzie Delta. The main area of industry interest to date has centered around the Mackenzie River Delta and offshore of the Tuktoyaktuk Peninsula. There has been little industry activity in this area in recent years, and we are not aware of any proposed activities. This area comprises a minor portion of the bowhead's summer range, as well as being within the range of the ringed and bearded seal. Possible disturbance to these species from helicopters, vessels, seismic surveys, and drilling would be as previously described.

Continued development along the North Slope of Alaska would require equipment and supplies to be transported to the site by barge or sealift. The process modules and permanent living quarters and other equipment and supplies likely would be transported to these sites on seagoing barges during the open water season. Barge traffic around Point Barrow is likely to be limited to a short period from mid-August through mid-to-late September and should be completed before the bowhead whale migration reaches this area unless it encounters severe ice conditions. Barge traffic continuing into September is likely to disturb seals and some bowheads during their migration. Whales may react briefly by diving in response to low-flying helicopters and they would seek to avoid close approach by vessels.

The exploration activities under review here—bottom cable seismic activities—are extremely unlikely to result in an oil spill. Other activities associated with exploration and subsequent drilling to recover oil present greater potential for oil spills. The effects of such spills on seals and bowhead whales would vary. Externally oiled phocid seals (which include the two species proposed for listing in this opinion) often survive and become clean, but heavily oiled pups and adults may die, depending on the extent of oiling and characteristics of the oil. Prolonged exposure to oil that reaches nearshore waters could affect seals in various ways, from stress to eye and skin irritation and infection to poisoning from ingestion of oil and oil-contaminated food. Any of these effects, if severe enough, could cause death, especially among newborn seals (NMFS 2012c, 86-88).

Effects on bowheads exposed to spilled oil remain largely speculative and controversial. Such effects depend on variables such as extent, timing, and duration of a whale’s contact with oil, the age of the whale, the number of whales exposed, and factors such as whether oil is ingested or fouls a whale’s baleen. Large aggregations of bowheads feed in the Beaufort Sea and an oil spill in the region has the potential to contact bowheads in significant numbers, that is, numbers large enough to increase the potential for population-level adverse effects (NMFS2012c, 78-81).

Effects on both bowheads and seals would be more pronounced where animals are confined to areas of spilled oil and forced into prolonged contact, such as would happen if oil were spilled in a spring-lead system, where shelf ice breaking off from shore-fast ice leaves an open-water corridor of limited and continually varying area.

Activities that are not oil and gas related also affect bowhead whales. Between 1976 and 1992, only three ship-strike injuries were documented out of a total of 236 bowhead whales examined from the Alaskan subsistence harvest (George et al., 1994). The low number of observed ship-strike injuries suggests that bowheads either do not often encounter vessels or they avoid interactions with vessels, or that interactions usually result in the death of the animals. However, there is recent evidence that interaction of bowhead whales with ships and fishing gear may be increasing. There is little information to suggest ship strikes are currently a significant issue for ringed or bearded seals in the action area.

Subsistence harvest by Alaska Natives is another activity that affects the ringed and bearded seals. These harvests have been discussed previously in this opinion, and are considered sustainable at present levels.

Vessel and aircraft activity may be expected to occur in the future in the Beaufort Sea. The effects of these actions would be the same as that presented for traffic associated with oil and gas actions.

VII. SYNTHESIS AND INTEGRATION

In this section, we present a summary and integration of the analysis presented in this opinion for each of the listed and proposed species.

Bowhead Whale

Research on the effects of offshore seismic exploration in the Beaufort Sea, supported by the testimony of Inupiat hunters based on their own experience, has shown bowhead whales avoid seismic noise sources within 20 km and may begin to deflect at distances up to 35 km (Richardson, 1999a). The possible deflections associated with BP's 2012 Simpson Lagoon seismic surveys are expected to have localized and temporary effects to these whales, without significant impacts. Concern would be warranted if such deflections caused whales to avoid or abandon important feeding areas. Even if bowhead whale feeding were disrupted in the Beaufort Sea near Simpson Lagoon, it is unlikely these impacts would present serious concern for their fitness, as the primary feeding habitat is considered to be in the Canadian Beaufort and Bering Sea. The Alaskan Beaufort Sea certainly provides feeding habitat for bowhead whales. However, Richardson (1987) concluded that food consumed in the eastern Beaufort Sea contributed little to the bowhead whale population's annual energy needs, although the area may be important to some individual whales. Carbon-isotope analysis of zooplankton, bowhead tissues, and bowhead baleen indicates that a significant amount of feeding may occur in areas west of the eastern Alaskan Beaufort Sea, at least by subadult whales (Schell, Saupe, and Haubenstock, 1987). Lee *et al.* (2005) published data from isotope ratio analyses of bowhead baleen and concluded that the "bowhead whale population acquires the bulk of its annual food intake from the Bering-Chukchi system…. Our data indicate that they acquire only a minority of their annual diet from the eastern and central Beaufort Sea…although subadult bowheads apparently feed there somewhat more often than do adults."

This research seems to coincide with observations of bowhead whale feeding and milling behaviors as show in Figure 13 (Clarke et al, 2012). This BWASP dataset includes all observations of bowhead whale feeding or milling behavior from June through October, 1982 – 2011. Only sightings are reported, not effort. These data show that higher numbers and densities of feeding/milling observations were made in the western Beaufort Sea with some concentrations in the Eastern Beaufort near Kaktovik. The central Beaufort Sea has less dense and fewer total observations (Figure 13).

Because the Western Arctic bowhead whale population is approaching its pre-exploitation population size and has been documented to be increasing at a roughly constant rate over a period of more than 20 years, the impacts of oil and gas industry on individual survival and reproduction in the past have likely been minor (Angliss and Outlaw 2008). The authorization of the IHA for BP's 2012 Simpson Lagoon seismic surveys is unlikely to have any effect on the other four stocks of bowhead whales. No lethal takes are anticipated because of these activities, nor are population-level consequences to the stocks expected. Most impact would be due to harassment of whales by noise, which may lead to behavioral reactions from which recovery is expected to be fairly rapid.

Ringed Seal – Arctic Sub-Species, and Bearded Seal – Beringia DPS

The proposed seismic surveys will occur in an area that supports moderate numbers of ringed seals and low numbers of bearded seals during the time of the activity. The most common behavior of these seals within the action area would be foraging, with no breeding, pupping, or molting periods overlapping the survey period. We expect seals to show little significant reaction to the proposed activities, although localized avoidance of vessels and elevated noise levels is likely.

We have found no indication that these activities would be likely to result in the abandonment of foraging habitat within the action area, nor to present concern for the energetic budgets of these seals or their ability to fulfill critical life history functions.

No lethal takes are anticipated because of these activities, nor are population-level consequence expected. Most impact would be due to harassment by noise, which may lead to behavioral reactions from which recovery is rapid. Both ringed and bearded seals currently exist at what are believed to be high levels of abundance; concerns for the survival of these populations are based on expected habitat conditions projected over the next century.

Exposure Analysis

The specific number of takes considered for the IHA is developed via the MMPA process. This analysis provides a summary of the anticipated numbers that would be authorized to give a relative sense of the nature of impact of the proposed actions. The methods to estimate take by harassment and present estimates of the numbers of marine mammals that might be affected during BP's proposed seismic survey are described in detail in BP's IHA application (BP, 2012) and the proposed IHA public notice, which was published in the *Federal Register* on May 1, 2012 (77 FR 25830). Specifically, the average estimate of "take" for each species was calculated by multiplying the expected average species densities (Table 7) by the area of ensonification at the level of 160 dB re 1 μPa (rms) in the survey region, time period, and habitat zone to which that density applies. Inside the barrier islands, this distance is estimated at 1,800 meters and outside the barrier islands, 5,500 meters (Table 6). All anticipated takes would be by

Level B harassment, involving temporary changes in behavior. This methodology has often been used in the past to estimate the number of bowhead whales that may be taken by seismic surveys in the Beaufort Sea in autumn. While other approaches to estimating take may be possible, this methodology provides a reasonable estimate of take given the particulars of this project, which involves the operation of mobile sound sources that will not operate outside of the barrier islands during the bowhead fall migration. The required mitigation and monitoring measures considered as part of the action are expected to prevent the possibility of TTS (Level B) or injurious takes (Level A).

Table 7. Expected densities (average and maximum) of cetaceans and pinnipeds in the Simpson Lagoon survey area calculated for the summer (July-August) and autumn (September-October) seasons. Densities are provided in number per km^2 (from BP, 2012).

	Species Summer densities (#/km^2)		**Autumn densities (#/km^2)**	
Species	**Average**	**Maximum**	**Average**	**Maximum**
Bowhead whale	0.0065	0.0130	0.1226	0.2762
Ringed seal	0.1680	0.4232	0.1680	0.4232
Bearded seal	0.0124	0.0324	0.0124	0.0324

Table 8 shows the expected number of takes of ESA listed and proposed marine mammals under the proposed authorization. It is estimated that approximately 37 bowhead whales, 17 bearded seals, and 111 ringed seals would be taken by Level B harassment incidental to the proposed seismic survey program. These take numbers represent 0.24% of the Bering-Chukchi-Beaufort stock of bowhead whales, and 0.001% and 0.05% of the Alaska stocks of bearded and ringed seals, respectively.

Table 8. Estimates of the possible numbers of marine mammals taken by Level B harassment (exposed to ≥160 dB re 1 µPa (rms)) during BP's proposed seismic program in the Beaufort Seas, July - October 2012.

Species	Outside Barrier Islands	Inside Barrier Islands		Total Estimated Takes	Percent of stock
	Summer	Summer	Autumn		
Bowhead whale	3	1	33	37	0.24%
Ringed seal	60	19	32	111	0.05%
Bearded seal	9	3	5	17	0.001%

Response Analysis

A review of the reactions of bowhead whales, ringed seals, and bearded seals exposed to continuous, broadband low- frequency industrial noise in the Alaskan Arctic suggests that these marine mammals will elicit short-term behavioral responses to the proposed seismic surveys, largely due to elevated in-water noise. Such responses are not known to have long-term, adverse consequences for the biology or ecology of the individual animals exposed, although individuals may alter their migratory pathways to avoid these sound sources and may reduce their calling rates depending on season and ambient sound levels (Richardson *et al*.1995). Expected exposure would not elicit responses that suggest adverse effects on the ability of bowhead whales, ringed seals, or bearded seals to forage, detect predators, select a mate, or reproduce successfully. We also would not expect these responses to be symptomatic of chronic stress that might depress an animal's immune responses and increase their susceptibility to disease, as the time of exposure for these animals would be brief. At received levels between120 and 180 dB re 1µPa, the information available would not lead us to expect bowhead whales, ringed seals, or bearded seals to respond in ways that would reduce their reproduction, numbers, or distribution. Based on the past observed reactions of these animals and proposed mitigation measures, we do not expect any whales or seals to be exposed to injurious noise at received levels equal to or greater than 180 dB.

Risk Analysis

Numerous studies of the ecology of populations have demonstrated the relationship between a population's reproductive health, abundance, and distribution, and its risk of extinction and likelihood of recovery. Reproductive health includes fecundity schedules, age at maturity, and reproductive lifespan; abundance includes age- or stage-specific abundance and survival rates; and distribution includes the number of populations and sub-populations, immigration rates, and emigration rates.

Avoidance behavior and other reactions to disturbance (such as changes in surfacing, breathing, and diving) have all been observed to various degrees in bowhead whales' responses to seismic noise (McCauley et al 1998, 200, Richardson et al. 1986, Gailey etal 2007). Nevertheless, bowheads have continued to travel to the eastern Beaufort Sea each summer despite seismic exploration in their summer and autumn range for many years (Richardson et al. 1987), and their numbers have increased notably (Allen and Angliss 2010). Figures 10, 11, and 13 show observations of bowheads in the Alaskan Beaufort from 1982 to 2011. Bowheads also have been observed over periods of days or weeks in areas repeatedly ensonified (filled with sound) by seismic pulses (Richardson et al. 1987; Harris et al.2007). However, it is generally not known whether the same individual bowheads were involved in these repeated observations (within and between years) in strongly ensonified (i.e., noisy) areas.

In the absence of evidence of behavioral responses that reduce a population's reproduction, numbers, or distribution, the information available leads us to conclude that exposure to the BP Simpson Lagoon surveys activities is likely to elicit only short-term responses in bowhead whales, ringed seals, and bearded seals, and those short-term responses are not known to have any long-term, adverse consequences for the biology or ecology of the individuals exposed.

We do not expect this exposure to translate into chronic or cumulative reductions in the current or expected future reproductive success of the Western Arctic population of bowhead whales, the Arctic sub-species of ringed seals, or the Beringia DPS of bearded seals. Therefore, the proposed surveys are not likely to affect the reproductive performance of these species. By extension, we would not expect the authorization of the proposed IHA for the BP 2012 Simpson Lagoon seismic surveys to appreciably reduce their likelihood of survival and recovery in the wild.

Finally, we have considered the expected effects of climate change and ocean acidification in this opinion. The effects n are not fully understood and the timeframes by which such changes are occurring not fully known. However, the effects on these species are effectively independent of the effects of this action, and would not be expected to exacerbate the impacts on listed species.

Summary of Analyses

In summary, NMFS has concluded the following:

- First, the small footprint and the short duration of the proposed surveys would have a limited effect on the species analyzed. Only 110 mi^2 would be surveyed. This area represents a tiny fraction of the distribution of the species analyzed in this opinion. Also, bowhead whales are the most sensitive species in this analysis and most of their feeding behavior occurs outside the action area. The timing of the project will most likely reduce interactions with all species analyzed.
- Second, it is NMFS opinion that granting this IHA to BP for seismic surveys will result at worst in a temporary modification of behavior (Level B harassment) of a very small percentage (all less than 1%) of these endangered and proposed threatened stocks. In addition, no take by injury or death is anticipated.
- Third, annual surveys continue to measure a steady increase in the Western Arctic stock of bowhead whales despite oil and gas exploration and impacts from other stressors.
- Finally, the mitigation and monitoring measures included as part of this action are expected to further reduce any potential adverse effects. Similar measures from previous projects have limited adverse effects to these species, as discussed in the Environmental Baseline section.

While the stressors analyzed may affect the species included in this opinion, NMFS expects the total impacts of these stressors to be minimal.

VIII. CONCLUSIONS

After reviewing the current status of these species, the environmental baseline for the action area, the biological and physical effects of the proposed action, and cumulative effects, it is NMFS's biological opinion that the authorization of the proposed IHA associated with BP's 2012 Simpson Lagoon seismic surveys is not likely to jeopardize the continued existence of the endangered bowhead whale, the Arctic sub-species of ringed seal, or the Beringia DPS of bearded seal. No critical habitat has been designated for these species, therefore none will be affected.

IX. CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

The National Marine Fisheries Service should implement the following measures for these purposes:

1. Upon learning of any unauthorized take of bowhead whales which occurs as a result of seismic surveys, NMFS or BOEM should immediately notify the Assistant Regional Administrator for Protected Resources at (907) 586-7235 of this taking to determine the appropriate and necessary course of action.

2. NMFS should recommend IHA holders take the following measures during operations to reduce potential interference with listed whales:
   (1) *Reducing vessel speed below 9 knots when within 300 yards of whales; and
   (2) *Avoiding multiple changes in direction and speed when within 300 yards of whales.

3. NMFS should continue to coordinate research associated with drilling and other OCS actions and the bowhead whale, with emphasis on cumulative impacts of OCS activities.

The mitigation recommendations for the 2012 surveys jointly developed by NMFS and BP are considered part of this action being analyzed and are described in the first section of this document.

Recommendations To Be Considered for Future Monitoring Plans

Peer review of BPs mitigation and monitoring plans, as described in the Description of the Action section, resulted in the following additional recommendations for future monitoring plans, and NMFS agrees that these steps would serve to further mitigate any impacts to listed and proposed species in the Beaufort Sea. These recommendations should be considered for all future work in this area and are considered conservation recommendations for future actions.

(1) BP continue to develop and test observational aids to assist with visibility during night, poor light conditions, inclement weather, etc.; and (2) BP conduct additional acoustic monitoring with bottom mounted recorders to monitor for calling marine mammals. It may be possible to evaluate calling rates relative to seismic operations or received levels of seismic sounds. Additionally, Shell will have several acoustic arrays in the general area. Those arrays will provide a basis for determining locations of calling marine mammals. NMFS should encourage BP to request data from Shell to help examine impacts of the seismic survey on the distribution of calling bowheads and other marine mammals. After discussion with BP, NMFS decided not to implement these two recommendations for BP's 2012 OBC seismic survey because most of BP's survey would occur during the time when there will be very short low-light hours. As for the second recommendation, NMFS realized that given the complexity in marine mammal passive acoustic localization, BP will not have the time to implement this recommendation for its 2012 survey.

Reporting Measures Sound Source Verification Reports

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

Technical Reports

The results of BP's 2012 vessel-based monitoring, including estimates of ‘‘take’’ by harassment, should be presented in the ‘‘90-day’’ and Final Technical reports, if the IHA is issued and the proposed OBC seismic survey is conducted. The Technical Reports should be submitted to NMFS within 90 days after the end of the seismic survey. The Technical Reports will include: (a) Summaries of monitoring effort (e.g., total hours, total distances, and marine mammal distribution through the study period, accounting for sea state and other factors affecting visibility and detectability of marine mammals); (b) Analyses of the effects of various factors influencing detectability of marine mammals (e.g., sea state, number of observers, and fog/glare); (c) Species composition, occurrence, and distribution of marine mammal sightings, including date, water depth, numbers, age/size/gender categories (if determinable), group sizes, and ice cover; (d) To better assess impacts to marine mammals, data analysis should be separated into periods when a seismic airgun array (or a single mitigation airgun) is operating and when it is not. Final and comprehensive reports to NMFS should summarize and plot: •Data for periods when a seismic array is active and when it is not; and •The respective predicted received sound conditions over fairly large areas (tens of km) around operations; (e) Sighting rates of marine mammals during periods with and without airgun activities (and other variables that could affect detectability), such as: •Initial sighting distances versus airgun activity state; •Closest point of approach versus airgun activity state; •Observed behaviors and types of movements versus airgun activity state; •Numbers of sightings/individuals seen versus airgun activity state; •Distribution around the survey vessel versus airgun activity state; and •Estimates of take by harassment; (f) Reported results from all hypothesis tests should include estimates of the associated statistical power when practicable; (g) Estimate and report uncertainty in all take estimates. Uncertainty could be expressed by the presentation of confidence limits, a minimum-maximum, posterior probability distribution, etc.; the exact approach would be selected based on the sampling method and data available; (h) The report should clearly compare authorized takes to the level of actual estimated takes; and Notification of Injured or Dead Marine Mammals. In addition, NMFS would require BP to notify NMFS' Office of Protected Resources and NMFS' Stranding Network within 48 hours of sighting an injured or dead marine mammal in the vicinity of marine survey operations. BP shall provide NMFS with the species or description of the animal(s), the condition of the animal(s) (including carcass condition if the animal is dead), location, time of first discovery, observed behaviors (if alive), and photo or video (if available). In the event that an injured or dead marine mammal is found by BP that is not in the vicinity of the proposed open- water marine survey program, BP would report the same information as listed above as soon as operationally feasible to NMFS.

X. REINITIATION OF CONSULTATION

This concludes formal consultation on this action. As provided in 50 CFR §402.16, reinitiation of formal consultation is required where discretionary federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of taking specified in the incidental take statement is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this Biological Opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this Biological Opinion; or (4) a new species is listed or critical habitat designated that may be affected by this action. In circumstances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending reinitiation.

XI. INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of this incidental take statement.

This opinion does not include an incidental take statement at this time. Upon issuance of an authorization under Section 101(a)(5) of the Marine Mammal Protection Act and/or its 1994 Amendments, NMFS will prepare an incidental take statement for the described activities to accompany this biological opinion.

XII. LITERATURE CITED

ACIA (Arctic Climate Impact Assessment). 2004. Impacts of a warming Arctic: Arctic Climate Impact Assessment. Cambridge University Press, Cambridge, UK.

ADF&G. 2009. Satellite Tracking of Western Arctic Bowhead Whales. Preliminary reports and summaries available at:http://www.wildlife.alaska.gov/index.cfm?ADFG=marinemammals.bowheadADFG

Ahmaogak, Sr., G.N. 1995. Concerns of Eskimo People Regarding Oil and Gas Exploration and Development in the United States Arctic. unpublished. Workshop on Technologies and Experience of Arctic Oil and Gas Operations. April 10-12, 1995. Girdwood, AK.

Alaska Eskimo Whaling Commission. 2011. Report on the Weapons, Techniques, and Observations of the Alaska Bowhead Whale Subsistence Hunt.

Allen, B.M. and R.P. Angliss. 2010. Alaska Marine Mammal Stock Assessments, 2009. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-206, 276 p.

Anderson, P. J., and J. F. Piatt. 1999. Community reorganization in the Gulf of Alaska following ocean climate regime shift. Marine Ecology Progress Series 189:117-123.

Angliss, R.P. and R. Outlaw, eds. 2005. Draft Alaska Marine Mammal Stock Assessments 2005. Report SC-CAMLR-XXIV. Juneau, AK: National Marine Mammal Lab., Alaska Fisheries Science Center.

Angliss, R.P., and R. B. Outlaw. 2008. Alaska marine mammal stock assessments, 2007. U. S. Dep. Commer., NOAA Tech. Memo., NMFS-AFSC-180, 252 p.

Anisimov, O.A., D.G. Vaughan, T.V. Callaghan, C. Furgal, H. Marchant, T.D. Prowse, H. Vilhjálmsson and J.E. Walsh, 2007: Polar regions (Arctic and Antarctic). *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, 653-685.

Arrigo, K.R., and G.L. van Dijken. 2004. Annual cycles of sea ice and phytoplankton in Cape Bathurst polynya, southeastern Beaufort Sea, Canadian Arctic. Geophysical Research Letters 31, L08304, doi: 10.1029/2003GL018978.

Bacon, J. J., T. R. Hepa, H. K. Brower, Jr., M. Pederson, T. P. Olemaun, J. C. George, and B. G. Corrigan. 2009. Estimates of subsistence harvest for villages on the North Slope of Alaska, 1994-2003. North Slope Borough Department of Wildlife Management. 107 p.

Bailey, A. M., and R. W. Hendee. 1926. Notes on the mammals of northwestern Alaska. Journal of Mammalogy 7:9-28.

Baker, C.S., S.R. Palumbi, R.H. Lambertsen, M.T. Weinrich, J. Calambokidis and S.J. O'Brien. 1990. Influence of seasonal migration on geographic distribution of mitochondrial DNA haplotypes in humpback whales. Nature 344:238-240.

Baker, C.S., L. Medrano-Gonzalez, J. Calambokidis, A. Perry, F. Pichler, H. Rosenbaum, J. M. Straley, J. Urban-Ramirez, M. Yamaguchi and O. von Ziegesar. 1998. Population structure of nuclear and mitochondrial DNA variation among humpback whales in the North Pacific. Molecular Ecology 7:695-707.

Bauer GB. 1986. The behavior of humpback whales in Hawaii and modification of behavior induced by human interventions. Ph.D. dissertation, University of Hawaii, Honolulu. http://www.dolphin-institute.org/our_research/whale_research/abstracts/1986bauer.html

Becker, P.R., E.A. Mackey, M.M. Schantz, R. Demiralp, R.R. Greenberg, B.J. Koster, S.A. Wise, and D.C.G. Muir. 1995. Concentrations of Chlorinated Hydrocarbons, Heavy Metals and Other Elements in Tissues Banked by the Alaska Marine Mammal Tissue Archival Project. OCS Study, MMS 95-0036. Silver Spring, MD: USDOC, NOAA, NMFS, and USDOC, National Institute of Standards and Technology.

Beland, J.A., B. Haley, C.M. Reiser, D.M. Savarese, D.S. Ireland and D.W. Funk. 2009. Effects of the presence of other vessels on marine mammal sightings during multi-vessel operations in the Alaskan Chukchi Sea. Pp. 29, In: Abstracts for the 18th Biennial Conference for the Biology of Marine Mammals, Québec, Octario. 2009:29. 306 p.

Bengtson, J.L., P.L. Boveng, L.M. Hiruki-Raring, K.L. Laidre, C. Pungowiyi and M.A. Simpkins. 2000. Abundance and distribution of ringed seals (Phoca hispida) in the coastal Chukchi Sea. Pp. 149-160, In: A.L. Lopez and D.P. DeMaster (eds.). Marine Mammal Protection Act and Endangered Species Act Implementation Program 1999. AFSC Processed Rep. 2000-11, Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, WA 98115.

Bengston, J. and M. Cameron. 2003. Marine Mammal Surveys in the Chukchi and Beaufort Seas. In: AFSC Quarterly Research Reports July-Sept. 2003. Juneau, AK: USDOC, NOAA, NMFS, Alaska Fisheries Science Center, 2 pp.

Berzin, A. A. and A. A. Rovnin. 1966. The distribution and migrations of whales in the northeastern part of the Pacific , Chukchee and Being Seas. Izvestiya, Vladisvostok. TINRO TOM 58:179-208.

Blackwell, S.B. and C.R. Greene Jr. 2002. Acoustic measurements in Cook Inlet, Alaska, during August 2001. Rep. prepared by Greeneridge Sciences, Inc., Santa Barbara, CA, for the Nat. Mar. Fish. Serv. Anchorage, AK.

Blackwell, S.B. and C.R. Greene, Jr. 2005. Underwater and in–air sounds from a small hovercraft. J. Acoust. Soc. Am. 118(6):3646–3652.

Blackwell, S.B. and C.R. Greene Jr. 2006. Sounds from an oil production island in the Beaufort Sea in summer: characteristics and contribution of vessels. J. Acoust. Soc. Am. 119(1):182–196.

Blackwell, S.B., and C.R. Greene, Jr. 2004. Sounds from Northstar in the Open-Water Season: Characteristics and Contribution of Vessels. In: Monitoring of Industrial Sounds, Seals, and Bowhead Whales near BP's Northstar Oil Development, Alaskan Beaufort Sea, 1999-2003., W.J. Richardson and M.T. Williams, eds. LGL Report TA4002-4. Anchorage, AK: BPXA, Dept. of Health, Safety, and Environment.

Blackwell, S.B., and C.R. Greene, Jr. 2005. Underwater and in–air sounds from a small hovercraft. Journal of the

Acoustical Society of America 118(6):3646–3652.

Blackwell, S.B., J.W. Lawson and M.T. Williams. 2004. Tolerance by ringed seals (Phoca hispida) to impact pipe-driving and construction sounds at an oil production island. Journal of the Acoustical Society of America, 115(5):2346-2357.

Blecha F. 2000. Immune system response to stress. The biology of animal stress. G. P. Moberg and J. A. Mench, CABI 111-122.

Boily, P. 1995. Theoretical heat flux in water and habitat selection of phocid seals and beluga whales during the annual molt. Journal of Theoretical Biology 172:235-244.

Born, E.W., F.F. Riget, R. Dietz and D. Andriashek. 1999. Escape responses of hauled out ringed seals (Phoca hispida) to aircraft disturbance. Polar Biol. 21(3):171-178.

Bowen, W. D., and D. B. Siniff. 1999. Distribution, population biology, and feeding ecology of marine mammals. Pages 423-484 *in* J. E. I. Reynolds and S. A. Rommel, editors. Biology of Marine Mammals. Smithsonian Institution Press, Washington, D. C.

Bowles, A.E., M. Smultea, B. Wursig, D.P. DeMaster, and D. Palka. 1994. Relative Abundance and Behavior of Marine Mammals Exposed to Transmissions from the Heard Island Feasibility Test. *J. Acoust. Soc. America* 96:2469-2484.

Boyce, D. G., M. R. Lewis, and B. Worm. 2010. Global phytoplankton decline over the past century. Nature 466:591-596.

Braham, H.W. 1984. The bowhead whale, *Balaena mystic*etus. Marine Fisheries Review 46(4):45-53.

Bratton, G.R., C.B. Spainhour, W. Flory, M. Reed, and K. Jayko. 1993. Presence and Potential Effects of Contaminants. *In: The Bowhead Whale*, J.J. Burns, J.J. Montague and C.J. Cowles, eds. Special Publication 2 of The Society for Marine Mammalogy. Lawrence, KS: The Society for Marine Mammalogy, 701-744.

Bratton, G.R., W. Flory, C.B. Spainhour, and E.M. Haubold. 1997. Assessment of Selected Heavy Metals in Liver, Kidney, Muscle, Blubber, and Visceral Fat of Eskimo Harvested Bowhead Whales *Balaena mysticetus* from Alaska's North Coast. North Slope Borough Contracts #89-293; #90-294. College Station, TX: Texas A&M University, p. 233.

Brewer, P. G., and K. Hester. 2009. Ocean acidification and the increasing transparency of the ocean to low-frequency sound. Oceanography 22:86-93.

BP. 2011. Incidental Harassment Authorization Request for the Non-lethal Harassment of Whales and Seals during the Simpson Lagoon OBC Seismic Survey, Beaufort Sea, Alaska, 2012. Prepared by LAMA ecological and OASIS Environmental. Anchorage, AK. 66pp + Appendices.

Brueggeman, J. 2009b. 90-Day Report of the Marine Mammal Monitoring Program for the ConocoPhillips Alaska Shallow Hazards Survey Operations during the 2008 Open Water Season in the Chukchi Sea. Prepared for ConocoPhillips Alaska, Inc. Canyon Creek Consulting LLC, Seattle, WA.

Burek, K.A., F.M.D. Gulland and T.M. O'Hara. 2008. Effects of climate change on Arctic marine mammal health. Ecological Applications 18(2):S126-S134.

Burgess, W.C., and C.R. Greene, Jr. 1999. Physical Acoustic Measurements. In: Marine Mammal and Acoustical Monitoring of Western Geophysical's Open-Water Seismic Program in the Alaskan Beaufort Sea, 1998, W.J. Richardson, ed. LGL Report TA2230-3. Houston, TX; Anchorage, AK; and Silver Spring, MD:

Western Geophysical and USDOC, NMFS, 390 pp.

Burns, J. J. 1967. The Pacific bearded seal. Alaska Department of Fish and Game, Pittman-Robertson Project Report W-6-R and W-14-R. 66 p.

Burns, J.J., and S.J. Harbo. 1972. An aerial census of ringed seals, northern coast of Alaska. Arctic 25:279-290.

Burns, J. J., and T. J. Eley. 1976. The natural history and ecology of the bearded seal (*Erignathus barbatus*) and the ringed seal (*Phoca (Pusa) hispida*). Pages 263-294 *in* Environmental Assessment of the Alaskan Continental Shelf. Annual Reports from Principal Investigators. April 1976. Volume 1 Marine Mammals. U.S. Department of Commerce, NOAA, Boulder, CO.

Burns, J. J., and K. J. Frost. 1979. The natural history and ecology of the bearded seal, *Erignathusbarbatus*. Alaska Department of Fish and Game. 77 p.

Burns, J. J. 1981. Bearded seal *Erignatus barbatus* Erxleben, 1777. Pages 145-170 *in* S. H. Ridgway and R. J. Harrison, editors. Handbook of Marine Mammals Volume 2: Seals. Academic Press, New York, NY.

Calambokidis, J., G.H. Steiger, J.C. Cubbage, K.C. Balcomb III and P. Bloedel. 1989. Biology of humpback whales in the Gulf of the Farallones. Report to Gulf of the Farallones National Marine Sanctuary, San Francisco, CA by Cascadia Research Collective, 218½ West Fourth Avenue, Olympia, WA. 93 pp.

Calambokidis, J., G.H. Steiger and J. R. Evenson. 1993. Photographic identification and abundance estimates of humpback and blue whales off California in 1991-92. Final Contract Report 50ABNF100137 to Southwest Fisheries Science Center, P.O. Box 271, La Jolla, CA 92038. 67 pp.

Calle, P. P., D. J. Seagars, C. McClave, D. Senne, C. House, and J. A. House. 2008. Viral and bacterial serology of six free-ranging bearded seals *Erignathus barbatus*. Diseases of Aquatic Organisms 81:77-80.

Cameron, M F, John L Bengtson, Peter L Boveng, J K Jansen, Brendan P Kelly, S P Dahle, E A Logerwell, et al. 2010. Status Review of the Bearded Seal (Erignathus barbatus). *Fisheries Bethesda*, no. December: 246.

Carroll, G.M., J.C. George, L.F. Lowry and K.O. Coyle. 1987. Bowhead Whale (Balaena mysticetus) Feeding near Point Barrow, Alaska During the 1985 Spring Migration. Arctic 40:105-110.

Cavanagh, R.C. 2000. Criteria and thresholds for adverse effects of underwater noise on marine animals. AFRLHE-WP-TR-2000-0092. Report from Science Applications International Corp., McLean, VA, for Air Force Res. Lab., Wright-Patterson AFB, OH.

CBD. 2007. Petition to list the ribbon seal (Histriophoca fasciata) as a threatened or endangered species under the Endangered Species Act. Center for Biological Diversity, San Francisco, CA.

CBD. 2008a. Petition to list three seal species under the Endangered Species Act: ringed seal (Pusa hispica), bearded seal (Erignatha barbatus), and spotted seal (Phoca largha). Center for Biological Diversity, San Francisco, CA.

CBD. 2008b. Petition to list the Pacific walrus (Odobenus rosmaurs divergens) as a threatened or endangered species under the Endangered Species Act. Center for Biological Diversity, San Francisco, CA.

Chapskii, K. K. 1940. The ringed seal of western seas of the Soviet Arctic (The morphological characteristic, biology and hunting production). Page 147 *in* N. A. Smirnov, editor. Proceedings of the Arctic Scientific Research Institute, Chief Administration of the Northern Sea Route. Izd. Glavsevmorputi, Leningrad, Moscow. (Translated from Russian by the Fisheries Research Board of Canada, Ottawa, Canada, Translation Series No. 1665, 147 p.).

Ciannelli, L., K. M. Bailey, K. S. Chan, A. Belgrano, and N. C. Stenseth. 2005. Climate change causing phase transitions of walleye pollock (T*heragra chalcogramma*) recruitment dynamics. Proceedings of the Royal Society B 272:1735-1743.

Clapham P, Mayo CA. 1987. Reproduction and recruitment of individually identified humpback whales, Megaptera novaeangliae, observed in Massachusetts Bay, 1979-1985. Canadian Journal of Zoology 65(12):2853-2863.

Clapham P. 1996. The social and reproductive biology of humpback whales: an ecologicalperspective. Mammal Review 26:27-49.

Clarke, J.T., Christman, C.L., Grassia, S.L., Brower, A.A., and Ferguson, M.C. 2011. Aerial Surveys of Endangered Whales in the Beaufort Sea, Fall 2009. Final Report, OCS Study BOEMRE 2010-040. National Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way NE, F/AKC3, Seattle, WA 98115-6349.

Clarke, JT, CL Christman, AA Brower and MC Ferguson. 2012. Distribution and relative abundance of marine mammals in the Alaskan Chukchi and Beaufort Seas, 2011. Annual Report, OCS Study BOEM 2012-009. National Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, NOAA. 7600 Sand Point Way NE, F/AKC, Seattle, WA 98115-6349. 344 pp.

Clark, C.W., and G.C. Gagnon. 2006. Considering the temporal and spatial scales of noise exposures from seismic surveys on baleen whales. International Whaling Commission Working Paper. SC/58/E9. 9 p.

Clark, C.W., and W.T. Ellison. 2004. Potential use of low-frequency sounds by baleen whales for probing the environment: Evidence from models and empirical measurements. Pp. 564-589, In: J.A. Thomas, C.F. Moss and M. Vater (eds.), Echolocation in Bats and Dolphins. University of Chicago Press, Chicago, IL. 604 p.

Coffing, M., C. L. Scott, and C. J. Utermohle. 1998. The subsistence harvest of seals and seal lions by Alaska Natives in three communities of the Yukon-Kuskokwim Delta, Alaska, 1997-98. Alaska Department of Fish and Game, Division of Subsistence, Technical Paper No. 255. 56 p.

Comeau, S., G. Gorsky, R. Jeffree, J. L. Teyssié, and J. P. Gattuso. 2009. Key Arctic pelagic mollusk (*Limacina helicina*) threatened by ocean acidification. Biogeosciences Discussions 6:2523-2537.

Cooper, L.W., I.L. Larsen, T.M. O'Hara, s. Dolvin, V. Woshner, and G.F. Cota. 2000. Radionuclide Contaminant Burdens in Arctic Marine Mammals Harvested During Subsistence Hunting. *Arctic* 532:174-182.

Cummings, W.C., D.V. Holliday, W.T. Ellison and B.J. Graham. 1983. Technical Feasibility of Passive Acoustic Location of Bowhead Whales in Population Studies off Point Barrow, Alaska. T-83-06-002. Barrow, AK: NSB.

Darling, J.D. 1991. Humpback whales in Japanese waters. Ogasawara and Okinawa. Fluke identification catalog 1987-1990. Final Contract Report, World Wide Fund for Nature, Japan. 22 pp.

Davis, R. A., K. J. Finley, and W. J. Richardson. 1980. The present status and future management of arctic marine mammals in Canada. LGL Limited Environmental Research Associates, Prepared by LGL Limited Environmental Research Associates for the the Science Advisory Board of the Northwest Territories, Yellowknife, N.W.T. 93 p.

Davis, R.A. 1987. Integration and Summary Report. *In:* Responses of Bowhead Whales to an Offshore Drilling Operation in the Alaskan Beaufort Sea, Autumn 1986. Anchorage, AK: BP Western E&P, Inc., pp. 1-51.

Derocher, A. E., N. J. Lunn, and I. Stirling. 2004. Polar bears in a warming climate. Integrative and Comparative Biology 44:163-176.

Di Iorio, L., and C.W. Clark. 2009. Exposure to seismic survey alters blue whale acoustic communication. Biology Letters doi: 10.1098/rsbl.2009.0651.

Diachok, O.I., and R.S. Winokur. 1974. Spatial variability of underwater ambient noise at the Arctic icewater boundary. Journal Acoustic Society America 55(4): 750-753.

Dixon, B. R., L. J. Parrington, M. Parenteau, D. Leclair, M. Santín, and R. Fayer. 2008. *Giardia duodenalis* and *Cryptosporidium* spp. in the intestinal contents of ringed seals (*Phoca hispida*) and bearded seals (*Erignathus barbatus*) in Nunavik, Quebec, Canada. Journal of Parasitology 94:1161-1163.

Dolphin WF. 1987. Ventilation and dive patterns of humpback whales *Megaptera novaeangliae*, on their Alaskan feeding grounds. Canadian Journal of Zoology 65(1):83-90.

Dunn, R.A., and O. Hernandez. 2009. Tracking blue whales in the eastern tropical Pacific with an ocean-bottom seismometer and hydrophone array. Journal of the Acoustical Society of America 126(3):1084-1094.

Elsasser TH, Klasing KC, Filipov N, Thompson F. 2000. The metabolic consequences of stress: targets for stress and priorities of nutrient use. Pp.77-110 in Moberg GP and Mench JA, editors. The biology of animal stress. CABI.

Engås, A., S. Løkkeborg, E. Ona and A.V. Soldal. 1996. Effects of seismic shooting on local abundance and catch rates of cod (Gadus morhua) and haddock (Melanogrammus aeglefinus). Canadian Journal of Fish and Aquatic Science 53:2238-2249.

Fair PA, Becker PR. 2000. Review of stress in marine mammals. J. Aquat. Ecosyst. Stress Recov. 7:335- 354.

Fay, F. H., J. L. Sease, and R. L. Merrick. 1990. Predation on a ringed seal, *Phoca hispida* , and a black guillemot, *Cepphus grylle* , by a Pacific walrus, *Odobenus rosmarus divergens*. Marine Mammal Science 6:348-350.

Feltz, E. T., and F. H. Fay. 1966. Thermal requirements in vitro of epidermal cells from seals. Cryobiology 3:261-264.

Ferguson, S. H., I. Stirling, and P. McLoughlin. 2005. Climate change and ringed seal (*Phoca hispida*) recruitment in western Hudson Bay. Marine Mammal Science 21:121-135.

Finneran, J.J., C.E. Schlundt, R. Dear, D.A. Carder and S. H. Ridgway. 2002. Temporary shift in masked hearing thresholds (MTTS) in odontocetes after exposure to single underwater impulses from a seismic watergun. Journal of the Acoustical Society of America 111:2929-2940.

Finneran, J.J., D.A. Carder, C.E. Schlundt and S.H. Ridgway. 2005. Temporary threshold shift in bottlenose dolphins (Tursiops truncatus) exposed to mid-frequency tones. Journal of the Acoustical Society of America 118:2696-2705.

Finneran, J.J., D.A. Carder, C.E. Schlundt and R.L. Dear. 2010a. Growth and recovery of temporary threshold shift at 3 kHz in bottlenose dolphins: Experimental data and mathematical models. Journal of the Acoustical Society of America 127(5):3256-3266.

Finneran, J.J., D.A. Carder, C.E. Schlundt and R.L. Dear. 2010b. Temporary threshold shift in a bottlenose dolphin (Tursiops truncatus) exposed to intermittent tones. Journal of the Acoustical Society of America 127(5):3267-3272.

Foote, A.D., R.W. Osborne and A.R. Hoelzel. 2004. Whale-call response to masking boat noise. Nature 428:910.

Freitas, C., K. M. Kovacs, R. A. Ims, M. A. Fedak, and C. Lydersen. 2008. Ringed seal post-moulting movement tactics and habitat selection. Oecologia 155:193-204.

Frost, K.J., L.F. Lowry, G. Pendleton and H.R. Nute. 2002. Monitoring distribution and abundance of ringed seals in northern Alaska. OCS Study MMS 2002-04. Final report from the Alaska Dep. Fish and Game, Juneau, AK, for U.S. Minerals Management Service, Anchorage, AK. 66 pp. + Appendices.

Funk, D., D. Hannay, D. Ireland, R. Rodrigues and W. Koski. (eds.). 2008. Marine mammal monitoring and mitigation during open water seismic exploration by Shell Offshore Inc. in the Chukchi and Beaufort Seas, July–November 2007: 90-day report. LGL Report P969-1. Report from LGL Alaska Research Associates Inc., LGL Ltd., and JASCO Research Ltd. for Shell Offshore Inc, National Marine Fisheries Service and U.S. Fish and Wildlife Service. 218 pp plus appendices.

Gailey, G., B. Würsig and T.L. McDonald. 2007. Abundance, behavior, and movement patterns of western gray whales in relation to a 3-D seismic survey, northeast Sakhalin Island, Russia. Environmental Monitoring and Assessment 134(1-3):75-91.

Garner, W. and D. Hannay. 2009. Sound measurements of Pioneer vessels. Chapter 2 in: Link, M.R. and R. Rodrigues (eds). Monitoring of in-water sounds and bowhead whales ear the Ooogruruk and Spy Island drillsites in eastern Harrison Bay, Alaska Beaufort Sea, 2008. Rep. from LGL Alaska Research Associates, Inc., Anchorage, AK, Greeneridge Sciences, Inc., Santa Barbara, CA, and JASCO Applied Sciences, Victoria, BC, for Piioneer Natural Resources, Inc., Anchorage AK, and ENI US I Operating Co Inc., Anchorage AK.

Gedamke, J., S. Frydman and N. Gales. 2008. Risk of baleen whale hearing loss from seismic surveys: preliminary results from simulations accounting for uncertainty and individual variation. International Whaling Commission. Working Pap. SC/60/E9. 10 p.

George, J.C., J. Zeh, R. Suydam and C. Clark. 2004. Abundance and Population Trend (1978-2001) of Western Arctic Bowhead Whales Surveyed Near Barrow, Alaska. Marine Mammal Science 20:755-773.

Georgette, S., M. Coffing, C. Scott, and C. Utermohle. 1998. The subsistence harvest of seals and sea lions by Alaska Natives in the Norton Sound-Bering Strait region, Alaska, 1996-97. Alaska Department of Fish and Game, Division of Subsistence, Technical Paper No. 242. 88 p.

Goold, J.C., and P.J. Fish. 1998. Broadband spectra of seismic survey airgun emissions, with reference to dolphin auditory thresholds. Journal of the Acoustical Society of America 103:2177-2184.

Gordon, J., D. Gillespie, J. Potter, A. Frantzis, M.P. Simmonds, R. Swift and D. Thompson. 2004. A review of the effects of seismic surveys on marine mammals. Marine Technology Society Journal 37(4):16-34.

Grebmeier, J M., J.E. Overland, S.E. Moore, E.V. Farley, E.C. Carmack, L.W. Cooper, K.E. Frey, J.H. Helle, F.A. McLaughlin and S.L. McNutt. 2006. A Major Ecosystem Shift in the Northern Bering Sea. Science 311:1461-1464.

Greene, C.R. 1981. Underwater acoustic transmission loss and ambient noise in arctic regions.

Greene, C.R. 1987. Response of Bowhead Whales to an Offshore Drilling Operation in the Alaska Beaufort Sea, Autumn 1986: Acoustic Studies of Underwater Noise and Localization of Whale Calls. Greeneridge Science Inc. Santa Barbara, CA.

Greene, C.R., Jr., and S.E. Moore. 1995. Man made noise, Chapter 6, In: W.J. Richardson, C.R. Greene, Jr., C.I. Malme and D.H. Thomson (eds.). Marine Mammals and Noise. Academic Press, San Diego, CA.

Greene, C.R Jr., and W.J. Richardson, 1988. Characteristics of Marine Seismic Survey Sounds in the Beaufort Sea. Journal of the Acoustical Society of America. 83(6):2246–2254.

Greene, C.R., Jr., N.S. Altman and W.J. Richardson. 1999a. Bowhead whale calls. p. 6-1 to 6-23 In: W.J. Richardson (ed.), Marine mammal and acoustical monitoring of Western Geophysical's open-water seismic program in the Alaskan Beaufort Sea, 1998. LGL Report TA2230-3. Report from LGL Ltd., King City, Ontario, and Greeneridge Sciences Inc., Santa Barbara, CA, for Western Geophysical, Houston, TX, and National Marine Fisheries Service, Anchorage, AK, and Silver Spring, MD. 390 p.

Greene, C.R., Jr., N.S. Altman and W.J. Richardson. 1999b. The influence of seismic survey sounds on bowhead whale calling rates. Journal of the Acoustical Society of America 106(4, Pt. 2):2280 (Abstract).

Greene, C.R., Jr. and M.W. McLennan. 2001. Acoustic Monitoring of Bowhead Whale Migration, Autumn 2000. *In:* Monitoring of Industrial Sounds, Seals, and Whale Calls During Construction of BP's Northstar Oil Development, Alaskan Beaufort Sea, Summer and Autumn 2000: 90-Day Report, LGL and Greeneridge, eds. LGL Report TA 2431-1. King City, Ont., Canada: LGL Ecological Research Associates, Inc., 37pp.

Hall, C. F. 1865. Arctic researchers, and life among the Esquimaux: being the narrative of an expedition in search of Sir John Franklin, in the years 1860, 1861, and 1862. Harper and Brothers, New York. 595 p.

Hall, J.D., M.L. Gallagher, K.D. Brewer, P.R. Regos and P.E. Isert. 1994. ARCO Alaska, Inc. 1993 Kuvlum Exploration Area Site Specific Monitoring Program. Final Report. Anchorage, AK: ARCO Alaska, Inc.

Hammill, M. O., and T. G. Smith. 1991. The role of predation in the ecology of the ringed seal in Barrow Strait, Northwest Territories, Canada. Marine Mammal Science 7:123-135.

Harris, R.E., T. Elliott and R.A. Davis. 2007. Results of mitigation and monitoring program, Beaufort Span 2-D marine seismic program, open-water season 2006. LGL Rep. TA4319-1. Rep. from LGL Ltd., King City, Ont., for GX Technol. Corp., Houston, TX. 48 p.

Harris, R.E., G.W. Miller and W.J. Richardson. 2001. Seal responses to airgun sounds during summer seismic surveys in the Alaskan Beaufort Sea. Mar. Mamm. Sci. 17(4):795-812.

Hart, E. J., and B. Amos. 2004. Learning about marine resources and their use through Inuvialuit oral history. Inuvialuit Cultural Resource Center, Report Prepared for the Beaufort Sea Integrated Management Planning Initiative (BSIMPI) Working Group. 182 p.

Harwood, L. A., and I. Stirling. 1992. Distribution of ringed seals in the southeastern Beaufort Sea during late summer. Canadian Journal of Zoology 70:891-900.

Harwood, L. A., T. G. Smith, and H. Melling. 2000. Variation in reproduction and body condition of the ringed seal (*Phoca hispida*) in Western Prince Albert Sound, NT, Canada, as assessed through a harvest-based sampling program. Arctic 53:422-431.

Hauser, D.D.W., V.D. Moulton, K. Christie, C. Lyons, G. Warner, C. O'Neill, D. Hannay, and S. Inglis. 2008. Marine mammal and acoustical monitoring of the Eni/PGS open-water seismic program near Thetis, Spy, and Leavitt islands, Alaskan Beaufort Sea, 2008: 90-day report. Prepared by LGL Alaska Research Associates, Inc., Anchorage, AK, LGL Limited, environmental research associates, King City, Ontario, and JASCO Research Ltd., Victoria, BC, for Eni US Operating Co. Inc., Anchorage, AK, PGS Onshore, Inc., Anchorage, AK, the National Marine Fisheries Service, Silver Springs, MD, and the U.S. Fish and Wildlife Service, Anchorage, AK.

Heptner, L. V. G., K. K. Chapskii, V. A. Arsen'ev, and V. T. Sokolov. 1976. Ringed seal. *Phoca (Pusa) hispida* Schreber, 1775. Pages 218-260 *in* L. V. G. Heptner, N. P. Naumov, and J. Mead, editors. Mammals of the Soviet Union. Volume II, Part 3--Pinnipeds and Toothed Whales, Pinnipedia and Odontoceti. Vysshaya Shkola Publishers, Moscow, Russia. (Translated from Russian by P. M. Rao, 1996, Science Publishers, Inc., Lebanon, NH).

Hester, K. C., E. T. Peltzer, W. J. Kirkwood, and P. G. Brewer. 2008. Unanticipated consequences of ocean acidification: a noisier ocean at lower pH. Geophysical Research Letters 35:L19601.

Hildebrand, J.A. 2005. Impacts of anthropogenic sound. Pp. 101-124, In: J.E. Reynolds, W.F. Perrin, R.R. Reeves, S. Montgomery and T. Ragen (eds.), Marine Mammal Research: Conservation Beyond Crisis. Johns Hopkins Univ. Press, Baltimore, MD. 223 p.

Hildebrand, J.A. 2009. Anthropogenic and natural sources of ambient noise in the ocean. Marine Ecology Progress Series. 395:5-20.

Holst, M., M.A. Smultea, W.R. Koski and B. Haley. 2005a. Marine mammal and sea turtle monitoring during Lamont-Doherty Earth Observatory's marine seismic program off the Northern Yucatán Peninsula in the Southern Gulf of Mexico, January–February 2005. LGL Rep. TA2822-31. Rep. from LGL Ltd., King City, Ont., for Lamont-Doherty Earth Observatory of Columbia Univ., Palisades, NY, and National Marine Fisheries Service, Silver Spring, MD.

Holst, M., M.A. Smultea, W.R. Koski and B. Haley. 2005b. Marine mammal and sea turtle monitoring during Lamont-Doherty Earth Observatory's marine seismic program in the Eastern Tropical Pacific Ocean off Central America, November–December 2004. LGL Rep. TA2822-30. Rep. from LGL Ltd., King City, Ont., for Lamont-Doherty Earth Observatory of Columbia Univ., Palisades, NY, and National Marine Fisheries Service, Silver Spring, MD.

Holst, M., W.J. Richardson, W.R. Koski, M.A. Smultea, B. Haley, M.W. Fitzgerald and M. Rawson. 2006. Effects of large- and small-source seismic surveys on marine mammals and sea turtles. Eos, Trans. Am. Geophys. Union 87(36), Joint Assembly Suppl., Abstract OS42A-01. 23-26 May, Baltimore, MD.

Holt, M.M., D.P. Noren, V. Veirs, C.K. Emmons and S. Veirs. 2009. Speaking up: Killer whales (Orcinus orca) increase their call amplitude in response to vessel noise. Journal of the Acoustical Society of America 125:27–32.

Hovelsrud, G. K., M. McKenna, and H. P. Huntington. 2008. Marine mammal harvests and other interactions with humans. Ecological Applications 18:S135-S147.

Hughes-Hanks, J. M., L. G. Rickard, C. Panuska, J. R. Saucier, T. M. O'Hara, L. Dehn, and R. M. Rolland. 2005. Prevalence of *Cryptosporidium* spp. and *Giardia* spp. in five marine mammal species. Journal of Parasitology 91:1225-1228.

Ireland, D.S., R. Rodrigues, D. Funk, W. Koski, D. Hannay. (eds.) 2009. Marine mammal monitoring and mitigation during open water seismic exploration by Shell Offshore Inc. in the Chukchi and Beaufort Seas, July–October 2008: 90-day report. LGL Rep. P1049-1. Report from LGL Alaska Research Associates Inc., LGL Ltd., and JASCO Research Ltd. for Shell Offshore Inc, Nat. Mar. Fish. Serv., and U.S. Fish and Wild. Serv. 277 pp, plus appendices.

IWC. 2004. Report of the Sub-Committee on Bowhead, Right, and Gray Whales. Cambridge: International Whaling Commission.

IAP. 2009. Inter-academy panel on international issues, statement on ocean acidification. Available on line at: http://www.interacademies.net/10878/13951.aspx

IPCC, 2007a: Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R.K and Reisinger, A. (eds.)]. IPCC, Geneva, Switzerland, 104 pp.

Jansen, J. K., P. L. Boveng, S. P. Dahle, and J. L. Bengtson. 2010. Reaction of harbor seals to cruise ships. Journal of Wildlife Management 74:1186-1194.

Jochens, A., D. Biggs, K. Benoit-Bird, D. Engelhaupt, J. Gordon, C. Hu, N. Jaquet, M. Johnson, R. Leben, B. Mate, P. Miller, J. Ortega-Ortiz, A. Thode, P. Tyack and B. Würsig. 2008. Sperm whale seismic study in the Gulf of Mexico/Synthesis report. OCS Study MMS 2008-006. Rep. from Dep. Oceanogr., Texas A & M University, College Station, TX, for U.S. Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. 323 p.

Johannessen, O.M., L. Bengtsson, M.W. Miles, S.I. Kuzmina, V.A. Semenov, G.V. Alexseev, A.P. Nagurnyi, V.F. Zakharov, L.P. Bobylev, L.H. Pettersson, K. Hasselmann and H.P. Cattle. 2004. Arctic climate change: observed and modeled temperature and sea-ice variability. Tellus 56A:328-341.

Johnson, S.R., W.J. Richardson, S.B. Yazvenko, S.A. Blokhin, G. Gailey, M.R. Jenkerson, S.K. Meier, H.R. Melton, M.W. Newcomer, A.S. Perlov, S.A. Rutenko, B. Würsig, C.R. Martin and D.E. Egging. 2007. A western gray whale mitigation and monitoring program for a 3-D seismic survey, Sakhalin Island, Russia. Environmental Monitoring and Assessment 134(1-3):1-19.

Kastak, D., R.J. Schusterman, B.L. Southall and C.J. Reichmuth. 1999. Underwater temporary threshold shift induced by octave-band noise in three species of pinniped. Journal of the Acoustical Society of America 106:1142-1148.

Kastak, D., B.L. Southall, M. Holt, C.R. Kastak and R.J. Schusterman. 2004. Noise-induced temporary threshold shifts in pinnipeds: Effects of noise energy. Journal of the Acoustical Society of America 116(4): 2531-2532.

Kastak, D., B.L. Southall, R.J. Schusterman and C. Reichmuth Kastak. 2005. Underwater temporary threshold shift in pinnipeds: effects of noise level and duration. Journal of the Acoustical Society of America 118(5):3154-3163.

Kelly, B.P. 1988. Ribbon seal, Phoca fasciata. Pp. 96-106, In: J.W. Lentfer (ed.), Selected marine mammals of Alaska. Species accounts with research and management recommendations. Marine Mammal Commission, Washington, D.C.

Kelly, B. P. 2001. Climate change and ice breeding pinnipeds. Pages 43-55 *in* G.-R. Walther, C. A. Burga,and P. J. Edwards, editors. "Fingerprints" of Climate Change -- Adapted Behavior and Shifting Species Ranges. Kluwer Academic / Plenum Publishers, New York, NY

Kelly, B. P., O. H. Badajos, M. Kunnasranta, J. R. Moran, M. Martinez-Bakker, D. Wartzok, and P. Boveng. 2010. Seasonal home ranges and fidelity to breeding sites among ringed seals. Polar Biology 33:1095-1109.

Kennedy, S., J. A. Smyth, S. J. McCullough, G. M. Allan, F. McNeilly, and S. McQuaid. 1988. Confirmation of cause of recent seal deaths. Nature 335:404.

Ketten, D.R. 1995. Estimates of blast injury and acoustic trauma zones for marine mammals from underwater explosions. Pp. 391-407, In: R.A. Kastelein, J.A. Thomas and P.E. Nachtigall (eds.), Sensory Systems of Aquatic Mammals. De Spil Publishers, Woerden, Netherlands. 588 p.

Ketten DR. 1997. Structure and function in whale ears. Bioacoustics 8:103-135.

Ketten, D.R., J. Lien and S. Todd. 1993. Blast injury in humpback whale ears: evidence and implications. Journal of the Acoustical Society of America 94(3, Pt. 2):1849-1850 (Abstract).

KINGSLEY M, . C. S. 1986. Distribution and abundance of seals in the Beaufort Sea, Amundsen Gulf, and Prince Albert Sound, 1984. Environmental Studies Revolving Funds Report 25. Department of Fisheries and Oceans, Winnipeg, Manitoba. 16 pp.

Koski, W.R. and S.R. Johnson. 1987. Behavioral Studies and Aerial Photogrammetry. *In:* Responses of Bowhead Whales to an Offshore Drilling Operation in the Alaskan Beaufort Sea, Autumn 1986. Anchorage, AK: BP Western E&P, Inc.

Koski, W.R., G.W. Miller, and W.J. Gazey. 2000. Residence Times of Bowhead Whales in the Beaufort Sea and Amundsen Gulf During Summer and Autumn. *In:* Bowhead Whale Feeding in the Eastern Alaskan Beaufort Sea: Update of Scientific and Traditional Information. Results of Studies Conducted in Year 3, W.J. Richardson and D.H. Thomson, eds. LGL Report TA- 2196-5. King City, Ont., Canada: LGL Limited, environmental research associates, pp. 1-12.

Kovacs, K. M., and D. M. Lavigne. 1986. Maternal investment and neonatal growth in phocid seals. Journal of Animal Ecology 55:1035-1051.

Kovacs, K. M., C. Lydersen, and I. Gjertz. 1996. Birth-site characteristics and prenatal molting in bearded seals (*Erignathus barbatus*). Journal of Mammalogy 77:1085-1091.

Kovacs, K. M. 2002. Bearded seal *Erignathus barbatus*. Pages 84-87 *in* W. F. Perrin, B. Würsig, and J. G. M. Thewissen, editors. Encyclopedia of Marine Mammals. Academic Press, San Diego, CA.

Krupnik, I. I. 1984. The native shore-based harvest of pinnipeds on the southeastern Chukchi Peninsula (1940-1970). Pages 212-223 *in* A. V. Yablokov, editor. Marine mammals. Nauka, Moscow, Russia. (Translated from Russian by B. A. and F. H. Fay, 1985, 12 p.).

Krylov, V. I., G. A. Fedoseev, and A. P. Shustov. 1964. Pinnipeds of the Far East. Pischevaya Promyshlennost (Food Industry), Moscow, Russia. 59 p. (Translated from Russian by F. H. Fay and B. A. Fay, University of Alaska, Fairbanks, AK, 47 p.).

Kryter, K.D. 1985. The Effects of Noise on Man. 2nd ed. Academic Press, Orlando, FL. 688 p.

Kumlien, L. 1879. Mammals. Pages 55-61 *in* Contributions to the Natural History of Arctic America made in connection with the Howgate Polar Expedition 1877-78. Government Printing Office, Washington, D.C.

Lage, J. 2009. Hydrographic Needs in a Changing Arctic Environment: An Alaskan Perspective. US Hydro 2009. Norfolk, VA.

Lewis, J.K., and W.W. Denner. 1987. Arctic ambient noise in the Beaufort Sea: Seasonal space and time scales. Journal of the Acoustical Society of America 82(3):988-997.

Lewis, J.K., and W.W. Denner. 1988. Arctic ambient noise in the Beaufort Sea: Seasonal relationships to sea ice kinematics. Journal of the Acoustical Society of America 83(2):549-565.

Ljungblad, D.K., S.E. Moore, J.T. Clarke and J.C. Bennett. 1988a. Distribution, Abundance, Behavior, and Bioacoustics of Endangered Whales in the Western Beaufort and Northeastern Chukchi Seas, 1979-87. Anchorage: Minerals Management Service.

Ljungblad, D.K., Wursig, B., Swartz, S.L. and Keene, J.M. 1988b. Observations on the behavioral responses of bowhead whales (*Balaena mysticetus*) to active geophysical vessels in the Alaskan Beaufort Sea. *Arctic* 41(3): 183-194.

Lowry, L.F., and G. Sheffield. 1993. Foods and Feeding Ecology. In: The Bowhead Whale. J.J. Montague, C.J. Cowles J.J. Burns (eds). 201-238. Society for Marine Mammalogy.

Lowry, L.F., G. Sheffield and J.C. George. 2004. Bowhead whale feeding in the Alaskan Beaufort Sea, based on stomach contents analyses. Journal of Cetacean Research and Management 6(3):215-223.

Lucke, K., U. Siebert, P.A. Lepper and M.-A. Blanchet. 2009. Temporary shift in masked hearing thresholds in a harbor porpoise (Phocoena phocoena) after exposure to seismic airgun stimuli. Journal of the Acoustical Society of America 125(6):4060-4070.

Leatherwood S, Reeves RR, Perrin WF, Evans WE. 1982. Whales, dolphins, and porpoises of the eastern North Pacific and adjacent arctic waters: a guide to their identification. NOAA Tech. Rep.: National Marine Fisheries Service. Report nr Circular 444.

Lee, S.H. and D.M. Schell. 2002. Regional and Seasonal Feeding by Bowhead Whales as Indicated by Stable Isotope Ratios. *In*: Bowhead Whale Feeding in the Eastern Alaskan Beaufort Sea: Update of Scientific and Traditional Information, W.J. Richardson and W.J. Thomson, eds. LGL Report TA2196-7. King City, Ontario: LGL Limited, environmental research associates, pp. 1-28.

Lee, S.H., D.M. Schell, T.L. McDonald, and W.J. Richardson. 2005. Regional and Seasonal Feeding by Bowhead Whales *Balaena mysticetus* as Indicated by Stable Isotope Rations. *Mar. Ecol. Prog. Ser. (2005)* 285:271-287.

LGL Ltd., environmental research associates. 2001. Request by WesternGeco, LLC, for an Incidental Harassment Authorization to Allow the Incidental Take of Whales and Seals During an Open-Water Seismic Program in the Alaskan Beaufort Sea, Summer-Autumn 2001. King City, Ont., Canada: LGL.
Lillie, H. 1954. Comments in Discussion. *In*: Proceedings of the International Conference on Oil Pollution, London, pp. 31-33.

Litzow, M. A., K. M. Bailey, F. G. Prahl, and R. Heintz. 2006. Climate regime shifts and reorganization of fish communities: the essential fatty acid limitation hypothesis. Marine Ecology Progress Series
315:1-11.

Litzow, M. A., and L. Ciannelli. 2007. Oscillating trophic control induces community reorganization in a marine ecosystem. Ecology Letters 10:1124-1134.

Lowry, L.F. and K.J. Frost. 1984. Foods and Feeding of Bowhead Whales in Western and Northern Alaska. Scientific Reports of the Whales Research Institute 35 1-16. Tokyo, Japan: Whales Research Institute.

Lowry, L. F., K. J. Frost, and J. J. Burns. 1980. Variability in the diet of ringed seals, *Phoca hispida*, in Alaska. Canadian Journal of Fisheries and Aquatic Sciences 37:2254-2261.

Lydersen, C., P. M. Jensen, and E. Lydersen. 1987. Studies of the ringed seal *(Phoca hispida)* population in the Van Mijen fiord, Svalbard, in the breeding period 1986. Norsk Polarinstitutt Rapportserie, No. 34. 89-112 p.

Lydersen, C., and T. G. Smith. 1989. Avian predation on ringed seal *Phoca hispida* pups. Polar Biology 9:489-490.

Lydersen, C., and K. M. Kovacs. 1999. Behaviour and energetics of ice-breeding, North Atlantic phocid seals during the lactation period. Marine Ecology Progress Series 187:265-281.

Madsen, P.T., B. Møhl, B.K. Nielsen and M. Wahlberg. 2002. Male sperm whale behavior during exposures to distant seismic survey pulses. Aquatic Mammals 28(3):231-240.

Madsen, P.T., M. Johnson, P.J.O. Miller, N. Aguilar de Soto, J. Lynch and P.L. Tyack. 2006. Quantitative measures of air gun pulses recorded on sperm whales (Physeter macrocephalus) using acoustic tags during controlled exposure experiments. Journal of the Acoustical Society of America 120(4):2366–2379.

Malme, C.I., P.R. Miles, C.W. Clark, P. Tyack and J.E. Bird. 1984. Investigations of the potential effects of underwater noise from petroleum industry activities on migrating gray whale behavior/Phase II: January 1984 migration. BBN Report No. 5586. Report from Bolt Beranek & Newman Inc., Cambridge, MA, for Minerals Management Service, Alaska OCS Region, Anchorage, AK. NTIS PB86-218377.

Mansfield, A. W. 1970. Population dynamics and exploitation of some Arctic seals. Pages 429-446 *in* M.W. Holdgate, editor. Antarctic Ecology. Academic Press, London, UK.

Mate, B.R., and J.T. Harvey. 1987. Acoustical deterrents in marine mammal conflicts with fisheries. ORESU-W-86-001. Oregon State Univ., Sea Grant Coll. Prog., Corvallis, OR. 116 p.

Matthews, J. 1978. Seals: survey-inventory progress report. 4 p. Alaska Department of Fish and Game, Juneau, AK.

McCauley, R.D., J. Fewtrell, A.J. Duncan, C. Jenner, M.-N. Jenner, J.D. Penrose, R.I.T. Prince, A. Adhitya, J. Murdoch, and K. McCabe. 2000. Marine Seismic Surveys: Analysis and Propagation of Air-Gun Signals; and Effects of Air-Gun Exposure on Humpback Whales, Sea Turtles, Fishes and Squid. Report R99-15, Project CMST 163. Curtin, Western Australia: Australian Petroleum Production Exploration Assoc.

McCauley, R.D., M.-N. Jenner, C. Jenner, K.A. McCabe and J. Murdoch. 1998. The response of humpback whales (Megaptera novaeangliae) to offshore seismic survey noise: preliminary results of observations about a working seismic vessel and experimental exposures. APPEA Journal 38:692-707.

McCauley, R.D., J. Fewtrell, A.J. Duncan, C. Jenner, M.-N. Jenner, J.D. Penrose, R.I.T. Prince, A. Adhitya, J. Murdoch and K. McCabe. 2000b. Marine seismic surveys: Analysis of airgun signals; and effects of air gun exposure on humpback whales, sea turtles, fishes and squid. Report from Centre for Marine Science and Technology, Curtin University, Perth, Western Australia, for Australian Petroleum Productopm and Exploration Association, Sydney, NSW. 188 p.

McDonald, M.A., J.A. Hildebrand and S.C. Webb. 1995. Blue and fin whales observed on a seafloor array in the Northeast Pacific. Journal of the Acoustical Society of America 98(2, Pt. 1):712-721.

McEwen B, Wingfield JC. 2003. The concept of allostasis in biology and biomedicine. Hormones and Behavior 43:2–15.

Melnikov, V. V., and I. A. Zagrebin. 2005. Killer whale predation in coastal waters of the Chukotka Peninsula. Marine Mammal Science 21:550-556.

Miller, G.W., R.E. Elliott, W.R. Koski and W.J. Richardson. 1997. Whales. Pp.5-1 to 5-115, In: W.J. Richardson (ed.), Northstar marine mammal monitoring program, 1996: marine mammal and acoustical monitoring of a seismic program in the Alaskan Beaufort Sea. LGL Rep. 2121-2. Report from LGL Ltd., King City, ON and Greeneridge Sciences Inc., Santa Barbara, CA, for BP Explor. (Alaska) Inc. and National Marine Fisheries Service, Anchorage, AK, and Silver Spring, MD. 245 p.

Miller, G.W., R.E. Elliott and W.J. Richardson. 1998. Whales. Pp.5-1 to 5-123, In: W.J. Richardson (ed.), Northstar marine mammal monitoring program, 1997: marine mammal and acoustical monitoring of a seismic program in the Alaskan Beaufort Sea. LGL Report 2150-3. Report from LGL Ltd., King City, ON and Greeneridge Sciences Inc., Santa Barbara, CA, for BP Explor. (Alaska) Inc. and National Marine Fisheries Service, Anchorage, AK, and Silver Spring, MD. 318 p.

Miller, G.W., R.E. Elliott, W.R. Koski, V.D. Moulton and W.J. Richardson. 1999. Whales. Pp. 5-1 to 5-109, In: W.J. Richardson (ed.), Marine mammal and acoustical monitoring of Western Geophysical's open-water seismic program in the Alaskan Beaufort Sea, 1998. LGL Report TA2230-3. Report from LGL Ltd., King City, Ont., and Greeneridge Sciences Inc., Santa Barbara, CA, for Western Geophysical, Houston, TX, and U.S. National Marine Fisheries Service, Anchorage, AK, and Silver Spring, MD. 390 p.

Miller, P.J.O., N. Biassoni, A. Samuels and P.L. Tyack. 2000. Whale songs lengthen in response to sonar. Nature 405:903.

Miller, G.W., V.D. Moulton, R.A. Davis, M. Holst, P. Millman, A. MacGillivray and D. Hannay. 2005. Monitoring seismic effects on marine mammals—southeastern Beaufort Sea, 2001-2002. Pp. 511-542, In: S.L. Armsworthy, P.J. Cranford and K. Lee (eds.), Offshore Oil and Gas Environmental Effects Monitoring/Approaches and Technologies. Battelle Press, Columbus, OH.

Milne, A.R., and Ganton, J.H. 1964. Ambient noise under Arctic sea ice. Journal of the Acoustical Society of America. 36(5): 855-863.

MMS. 1995. An Investigation of the Sociocultural Consequences of Outer Continental Shelf Development in Alaska: Alaska Peninsula and Arctic. In: J.A. Fall and C.J. Utermohle, (eds.). Alaska Department of Fish and Game, Division of Subsistence Technical Report no. 160; MMS 95-014. Cooperative Agreement No. 14-35-0001-30622.

Moberg GP. 1987. Influence of the adrenal axis upon the gonads. Oxford reviews in reproductive biology. J. Clarke. New York, New York, Oxford University Press: 456 - 496.

Moberg GP. 2000. Biological response to stress: implications for animal welfare. The biology of animal stress. G. P. Moberg and J. A. Mench. Oxford, United Kingdom, Oxford University Press: 1 - 21.

Moore, S.E., J.C. George, K.O. Coyle, and T.J. Weingartner. 1995. Bowhead Whales Along the Chukotka Coast in Autumn. *Arctic* 48(2):155-160.

Moore, S.E. and D.P. DeMaster. 2000. North Pacific Right Whale and Bowhead Whale Habitat Study: R/V *Alpha Helix* and CCG *Laurier* Cruises, July 1999, A.L. Lopez and D.P. DeMaster, eds. Silver Spring, MD: NMFS, Office of Protected Resources.

Moore, S.E., J.M. Waite, N.A. Friday, and T. Honkalehto. 2002. Distribution and comparative estimates of cetacean abundance on the central and southeastern Bering Sea shelf with observations on bathymetric and prey associations. Prog. Oceanogr. 55:249-262.

Moulton, V.D. and J.W. Lawson. 2002. Seals, 2001. p. 3-1 to 3-48 In: W.J. Richardson (ed.), Marine Mammal and Acoustical Monitoring of WesternGeco's Open Water Seismic Program in the Alaskan Beaufort Sea, 2001. Rep. from LGL Ltd., King City, Ont., and Greeneridge Sciences Inc., Santa Barbara, CA, for WesternGeco, Houston, TX, and Nat. Mar. Fish. Serv., Anchorage, AK, and Silver Spring, MD. LGL Rep. TA2564-4.

Nishiwaki M. 1966. Distribution and migration of the larger cetaceans in the North Pacific as shown by Japanese whaling results. In: Norris KS, editor. Whales, Dolphins and Porpoises. Berkeley: University of California Press. p 171-191.

Monnett, C. and S.D. Treacy. 2005. Aerial Surveys of Endangered Whales in the Beaufort Sea, Fall 2002-2004. OCS Study, MMS 2005-037. Anchorage, AK: USDOI, MMS, Alaska OCS Region.
Moore, S.E. 1992. Summer Records of Bowhead Whales in the Northeastern Chukchi Sea. *Arctic* 45(4):398-400.

Mooney, T.A., P.E. Nachtigall, M. Breese, S. Vlachos and W.W.L. Au, 2009a. Predicting temporary threshold shifts in a bottlenose dolphin (Tursiops truncatus): the effects of noise level and duration. Journal of the Acoustical Society of America 125(3):1816-1826.

Mooney, T.A., P.E. Nachtigall and S. Vlachos. 2009b. Sonar-induced temporary hearing loss in dolphins. Biology Letters 4(4):565-567.

Moore, S.E. 1992. Summer records of bowhead whales in the northeastern Chukchi Sea. Arctic 45(4):398-400.

Moore, S.E., and H.P. Huntington. 2008. Arctic marine mammals and climate change impacts and resilience. Ecological Applications 18(2):S157-S165.

Moore, S.E., and R.P. Angliss. 2006. Overview of planned seismic surveys offshore northern Alaska, July-October 2006. Paper SC/58/E6 presented to IWC Scientific Committee, IWC Annu. Meeting, 1-13 June, St Kitts.

Moore, S.E., and R. R. Reeves. 1993. Distribution and movement. Pp. 313-386 In J. J. Burns, J. J. Montague, and C. J. Cowles (eds.), The bowhead whale. Society for Marine Mammalogy, Special Publication No. 2.

Mel'nikov, V.V., M.A. Zelensky, and L.I. Ainana. 1997. Observations on Distribution and Migration of Bowhead Whales (*Balaena mysticetus*) in the Bering and Chukchi Seas. Scientific Report of the International Whaling Commission 50. Cambridge, UK: IWC.

Melnikov, V., M. Zelensky, and L. Ainana, 1998. Observations on distribution and migration of bowhead whales (Balaena mysticetus) in the Bering and Chukchi Seas. IWC Paper SC/50/AS3, IWC Scientific Committee, Oman, 1998. 31p.

Moore, S.E. and R.R. Reeves., 1993. Distribution and Movement. *In: The Bowhead Whale*, J.J. Burns, J.J. Montague, and C.J. Cowles, eds. Special Publication of The Society for Marine Mammalogy, 2. Lawrence, KS: The Society for Marine Mammalogy, 313-386.

Moore, S.E., D.P. DeMaster, and P.K. Dayton. 2000. Cetacean Habitat Selection in the Alaskan Arctic during Summer and Autumn. *Arctic* 53(4):432-447.

Mueter, F. J., and M. A. Litzow. 2008. Sea ice retreat alters the biogeography of the Bering Sea continental shelf. Ecological Applications 18:309-320.

Nishiwaki M. 1966. Distribution and migration of the larger cetaceans in the North Pacific as shown by Japanese whaling results. In: Norris KS, editor. Whales, Dolphins and Porpoises. Berkeley: University of California Press. p 171-191.

NMFS 2012a. Takes of Marine Mammals Incidental to Specified Activities; Taking Marine Mammals Incidental to Marine Seismic Survey in the Beaufort Sea, Alaska. Notice; proposed incidental harassment authorization; request for comments. Federal Register / Vol. 77, No. 84 / Tuesday, May 1, 2012.

NMFS 2012b. Environmental Assessment For The Issuance Of An Incidental Harassment Authorization To Take Marine Mammals By Harassment Incidental To Conducting Open Water Seismic Surveys In The Simpson Lagoon Area Of The Beaufort Sea June 2012.

NMFS. 2012c. ESA Section 7 consultation: Issuance of Incidental Harassment Authorization under section 101(a)(5)(a) of the Marine Mammal Protection Act to Shell Offshore, Inc. for exploratory drilling in the Alaskan Beaufort Sea in 2012.

Nachtigall, P.E., J.L. Pawloski and W.W.L. Au. 2003. Temporary threshold shifts and recovery following noise exposure in the Atlantic bottlenose dolphin (Tursiops truncatus). Journal of the Acoustical Society of America 113(6):3425-3429.

Nachtigall, P.E., A.Y. Supin, J. Pawloski and W.W.L. Au. 2004. Temporary threshold shifts after noise exposure in the bottlenose dolphin (Tursiops truncatus) measured using evoked auditory potentials. Marine Mammal Science 20(4):673-687

Nieukirk, S.L., K.M. Stafford, D.K. Mellinger, R.P. Dziak and C.G. Fox. 2004. Low-Frequency Whale and Seismic Airgun Sounds Recorded in the Mid-Atlantic Ocean. Journal of the Acoustical Society of America 115(4):1832-1843.

Nieukirk, S.L., S.L. Heimlich, S.E. Moore, K.M. Stafford, R.P. Dziak, M. Fowler, J. Haxel, J. Goslin and D.K. Mellinger. 2009. Whales and airguns: an eight-year acoustic study in the central North Atlantic. p. 181-182 In: Abstract of the 18th Biennial Conference on the Biology of Marine Mammals, Québec, Oct. 2009. 306 p.

NRC. 2003a. Ocean Noise and Marine Mammals, Committee on Potential Impacts of Ambient Noise in the Ocean on Marine Mammals. The National Academies Press.

Nystuen, J.A., and D.M. Farmer. 1987. The influence of wind on the underwater sound generated by light rain. Journal of the Acoustical Society of America 82: 270-274.

Parks, S.E., C.W. Clark and P.L. Tyack. 2007. Short- and long-term changes in right whale calling behavior: the potential effects of noise on acoustic communication. Journal of the Acoustical Society of America 122(6):3725-3731.

Payne RS. 1970. Songs of the humpback whale. Hollywood, USA: Capital Records.

Perry, A., C.S. Baker and L.M. Herman. 1990. Population characteristics of individually identified humpback whales in the central and eastern North Pacific: a summary and critique. Reports of the International Whaling Commission (Special Issue 12):307-317.

Potter, J.R., M. Thillet, C. Douglas, M.A. Chitre, Z. Doborzynski and P.J. Seekings. 2007. Visual and passive acoustic marine mammal observations and high-frequency seismic source characteristics recorded during a seismic survey. IEEE Journal of Oceanic Engineering 32(2):469-483.

Quakenbush, L. T., R. J. Small, and J.J. Citta. 2010. Satellite tracking of western Arctic bowhead whales. Final Report from Alaska Dept. Fish and Game. Minerals Management Service Contract M05PC00020.

Reeves, R. R., B. S. Stewart, and S. Leatherwood. 1992. Bearded seal, *Erignathus barbatus* Erxleben, 1777. Pages 180-187 *in* The Sierra Club Handbook of Seals and Sirenians. Sierra Club Books, San Francisco, CA.

Reeves, R.R., R.J. Hofman, G.K. Silber and D. Wilkinson. 1996. Acoustic deterrence of harmful marine mammalfishery interactions: proceedings of a workshop held in Seattle, Washington, 20-22 March 1996. NOAA Tech. Memo. NMFS-OPR-10. Nat. Mar. Fish. Serv., Northwest Fisheries Sci. Cent., Seattle, WA. 70 p.

Reeves, R. R., G. W. Wenzel, and M. C. S. Kingsley. 1998. Catch history of ringed seals (*Phoca hispida*) in Canada. Pages 100-129 *in* M. P. Heide-Jørgensen and C. Lydersen, editors. Ringed Seals in the North Atlantic. NAMMCO Scientific Publications, Volume 1, Tromsø, Norway.

Richardson, W.J., and C.I. Malme. 1993. Man-made noise and behavioral responses. Pp. 631-700, In: J.J. Burns, J.J. Montague and C.J. Cowles (eds.), The Bowhead Whale. Special Publication 2, Society for Marine Mammalogy, Lawrence, KS. 787 p.

Richardson, W.J., C.R. Greene, Jr., C.I. Malme, and D.H. Thomson. 1995. *Marine Mammals and Noise.* San Diego, CA: Academic Press, Inc.

Richardson, W.J., ed. 1987. Importance of the Eastern Alaskan Beaufort Sea to Feeding Bowhead Whales 1985-86. OCS Study, MMS 87-0037. Reston, VA: USDOI, MMS, 547 pp.

Richardson, W.J. and D.H. Thomson. 2002. Email dated Apr. 25, 2002, to S. Treacy, USDOI, MMS, Alaska OCS Region; subject: bowhead whale feeding study.

Riewe, R. R., and C. W. Amsden. 1979. Harvesting and utilization of pinnipeds by lnuit hunters in Canada's eastern High Arctic. Pages 324-348 *in* A. P. McCartney, editor. Thule Eskimo Culture: An Anthropological Retrospective. Mercury Series 88. Archaeological Survey of Canada, Ottawa, Canada.

Riewe, R. 1991. Inuit use of the sea ice. Arctic and Alpine Research 23:3-10.

Romano, T.A., M.J. Keogh, C. Kelly P. Feng, L. Berk, C.E. Schlundt, et al. 2004. Anthropogenic sound and marine mammal health: Measures of the nervous and immune systems before and after intense sound exposure. Canadian Journal of Fisheries and Aquatic Sciences, 61, 1124-1134.

Ross, D. 1976. Mechanics of underwater noise. Pergamon, New York. 375 p. (Reprinted 1987, Peninsula Publ., Los Altos, CA).

Ryg, M., and N. A. Øritsland. 1991. Estimates of energy expenditure and energy consumption of ringed seals (*Phoca hispida*) throughout the year. Polar Research 10:595-602.

Salden DR. 1987. An observation of apparent feeding by a sub-adult humpback whale off Maui.Eighth Biennial Conference on the Biology of Marine Mammals. Pacific Grove, CA. p58.

Sapolsky RM, Romero LM, Munck AU. 2000. How do glucocorticoids influence stress responses? Integrating permissive, suppressive, stimulatory, and preparative actions. Endocrinol. Rev. 21, 55-89.

Schell, D.M. and S.M. Saupe., 1993. Feeding and Growth as Indicated by Stable Isotopes. *In: The Bowhead Whale,* J.J. Burns, J.J Montague, and C.J. Cowles, eds. Special Publication of The Society for Marine Mammalogy, 2. Lawrence, KS: The Society for Marine Mammalogy, 491-509 pp.

Schell, D.M., S.M. Saupe, and N. Haubenstock. 1987. Bowhead Whale Feeding: Allocation of Regional Habitat Importance Based on Stable Isotope Abundances. *In:* Importance of the Eastern Alaskan Beaufort Sea to Feeding Bowhead Whales 1985-86, W.J. Richardson, ed. OCS Study, MMS 87-0037. Reston, VA: USDOI, MMS, pp. 369-415.

Schlundt, C.E., J.J. Finneran, D.A. Carder and S.H. Ridgway. 2000. Temporary shift in masked hearing thresholds (MTTS) of bottlenose dolphins and white whales after exposure to intense tones. Journal of the Acoustical Society of America 107:3496-3508.

Schreiner, A. E., C. G. Fox and R. P. Dziak. 1995. Spectra and magnitudes of T-waves from the 1993 earthquake swarm on the Juan de Fuca ridge. Geophysical Research Letters 22(2): 139-142.

Schusterman R, Kastak D, Southall B, Kastak C. 2000. Underwater temporary threshold shifts in pinnipeds: tradeoffs between noise intensity and duration. J. Acoust. Soc. Am. 108(5, Pt. 2):2515-2516.

Seyle H. 1950. Stress and the general adaptation syndrome. The British Medical Journal: 1383-1392.

Shelden, K.E.W. 1994. Beluga whales (Delphinapterus leucas) in Cook Inlet - A review. Appendix In: Withrow, D.E., K.E.W. Shelden and D. J. Rugh. Beluga whale (Delphinapterus leucas) distribution and abundance in Cook Inlet, summer 1993. Annual report to the MMPA Assessment Program, Office of Protected Resources, NMFS, NOAA, 1335 East-West Highway, Silver Spring, MD 20910.

Shelden, K.E.W., and D.J. Rugh. 1995. The bowhead whale (Balaena mysticetus): status review. Marine Fisheries Review 57(3-4):1-20.

Silber GK. 1986. The relationship of social vocalizations to surface behavior and aggression in the Hawaiian humpback whale (Megaptera novaeangliae). Canadian Journal of Zoology 64:2075-2080.

Simpkins, M.A., L.M. Hiruki-Raring, G. Sheffield, J.M. Grebmeier and J.L. Bengtson. 2003. Habitat selection by ice-associated pinnipeds near St. Lawrence Island, Alaska in March 2001. Polar Biology 26:577-586.

Sipilä, T. 2003. Conservation biology of Saimaa ringed seal (*Phoca hispida saimensis*) with reference to other European seal populations. Ph.D. Dissertation. University of Helsinki, Helsinki, Finland. 40p.

Smith, T., G., and D. Taylor. 1977. Notes on marine mammals, fox and polar bear harvests in the Northwest Territories, 1940 to 1972. Arctic Biological Station, Fisheries and Marine Service, Department of Fisheries and the Environment, Technical Report Number 694. 37 p.

Smith, T. G. 1987. The ringed seal, *Phoca hispida*, of the Canadian western Arctic. Bulletin Fisheries Research Board of Canada. 81 p.

Smith, T. G., M. O. Hammill, and G. Taugbøl. 1991. A review of the developmental, behavioural and physiological adaptations of the ringed seal, *Phoca hispida*, to life in the Arctic winter. Arctic 44:124-131.

Smith, T. G., and C. Lydersen. 1991. Availability of suitable land-fast ice and predation as factors limiting ringed seal populations, *Phoca hispida*, in Svalbard. Polar Research 10:585-594.

Smultea, M.A., M. Holst, W.R. Koski and S. Stoltz. 2004. Marine mammal monitoring during Lamont-Doherty Earth Observatory's seismic program in the Southeast Caribbean Sea and adjacent Atlantic Ocean, April-June 2004. LGL Rep. TA2822-26. Rep. from LGL Ltd., King City, Ont., for Lamont-Doherty Earth Observatory of Columbia Univ., Palisades, NY, and Nationla Marine Fisheries Service, Silver Spring, MD. 106 p.

Southall, B.L., A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R. Greene Jr., D. Kastak, D.R. Ketten, J.H. Miller, P.E. Nachtigall, W.J. Richardson, J.A. Thomas and P.L. Tyack. 2007. Marine mammal noise exposure criteria: Initial scientific recommendations. Aquatic Mammals 33(4):411-522.

Stewart, R. E. A., P. Richard, M. C. S. Kingsley, and J. J. Houston. 1986. Seals and sealing in Canada's Northern and Arctic regions. Western Region, Department of Fisheries and Oceans, Canadian Technical Report of Fisheries and Aquatic Sciences, No. 1463. 31 p.

Stirling, I., and T. G. Smith. 2004. Implications of warm temperatures, and an unusual rain event for the survival of ringed seals on the coast of southeastern Baffin Island. Arctic 57:59-67.

Stoker, S.W., and I.I. Krupnik., 1993. Subsistence Whaling. Pp. 579-629. In: J.J. Burns, J.J. Montague and C.J. Cowles (eds.). The Bowhead Whale. Special Publications of the Society for Marine Mammalogy Publications, No. 2. Lawrence, KS: Society for Marine Mammalogy.

Strong CS. 1990. Ventilation patterns and behavior of balaenopterid whales in the Gulf of California, Mexico. MS thesis, San Francisco State University, CA.

Suydam, R., JC. George, C. Rosa, B. Person, C. Hanns, and G. Sheffield. 2010. Subsistence harvest of bowhead whales (Balaena mysticetus) by Alaskan Eskimos during 2009. Publication to the Int. Whaling Commission, SC/62/BRG18.

Tavolga, W.N. 1977, Sound Production in Fishes. Benchmark Papers in Animal Behavior V.9. Dowden, Hutchinson & Ross, Inc.

Thompson TJ, Winn HE, Perkins PJ. 1979. Mysticete sounds. In: Winn HE, Olla BL, editors. Behavior of Marine Animals. Vol. 3. Cetaceans.

Thompson PO, Cummings WC, Ha SJ. 1986. Sounds, source levels, and associated behavior of humpback whales, southeast Alaska. Journal of the Acoustical Society of America 80:735-740.

Thomson, D.H. and W.J. Richardson. 1987. Integration. *In:* Importance of the Eastern Alaskan Beaufort Sea to Feeding Bowhead Whales, 1985-86, W.J. Richardson, ed. OCS Study, MMS 87-0037. Reston, VA: USDOI, MMS, pp. 449-511.

Thompson, D., C. D. Duck, and B. J. McConnell. 1998. Biology of seals of the north-east Atlantic in relation to seismic surveys. Pages 4.1-4.7 in M. L. Tasker and C. Weir, editors. Proceedings of the Seismic and Marine Mammals Workshop, London, UK.

Tyack P. 1981. Interactions between singing Hawaiian humpback whales and conspecifics nearby. Behavioral Ecology and Sociobiology 8:105-116.

Tyack P, Whitehead H. 1983. Male competition in large groups of wintering humpback whales. Behaviour 83:132-154.

Tyack PL. 2008. Implications for Marine Mammals of Large-scale Changes in the Marine Acoustic Environment. Journal of Mammalogy, 89(3):549-558, 2008.

Tynan, C. T., and D. P. DeMaster. 1997. Observations and predictions of Arctic climatic change: potential effects on marine mammals. Arctic 50:308-322.

Urick, R.J. 1984. Principles of Underwater Sound. Third Edition. McGraw-Hill Book Company.

Walsh, J. E. 2008. Climate of the Arctic marine environment. Ecological Applications 18:S3-S22.

Warner, G., and S. Hipsey. 2011. Acoustic Noise Modeling of BP's 2012 Seismic Program in Simpson Lagoon (Harrison Bay, AK): Version 1.0. Technical report for Lisanne Aerts, OASIS Environmental Inc. by JASCO Applied Sciences.

Wenz, G.M. 1962. Acoustic ambient noise in the ocean: Spectra and sources. Journal of the Acoustical Society of America 34(12):1936–1956.

Wolfe, R., and L. B. Hutchinson-Scarbrough. 1999. The subsistence harvest of harbor seal and sea lion by Alaska Natives in 1998. Alaska Department of Fish and Game, Division of Subsistence, Technical Paper No. 250.

Woodby, D.A., and D.B. Botkin. 1993. Stock sizes prior to commercial whaling. Pp. 387-407 In: J.J. Burns, J.J. Montague and C.J. Cowles (eds.), The bowhead whale. Society for Marine Mammalogy, Special Publication No. 2.

Woodby, D. A., and D. B. Botkin. 1993. Stock sizes prior to commercial whaling, p. 387-407. *In* J. J. Burns, J. J. Montague, and C. J. Cowles (eds.), The bowhead whale. Soc. Mar. Mammal., Spec. Publ. No. 2.

Wright AJ, Soto NA, Baldwin AL, Bateson M, Beale CM, Clark C, Deak T, Edwards EF. 2008. Do Marine Mammals Experience Stress Related to Anthropogenic Noise? International Journal of Comparative Psychology, 2007, 20, 274-316.

Wright, A.J., N. Aguilar Soto, A.L. Baldwin, M. Bateson, C.M. Beale, C. Clark, T. Deak, E.F. Edwards, A. Fernández, A. Godinho, L.T. Hatch, A. Kakuschke, D. Lusseau, D. Martineau, L.M. Romero, L.S. Weilgart, B.A. Wintle, G. Notarbartolo-di-Sciara and V. Martin. 2007a. Do marine mammals experience stress related to anthropogenic noise? International Journal of Comparative Psychology 20(2-3):274-316.

Wright, A.J., N. Aguilar Soto, A.L. Baldwin, M. Bateson, C.M. Beale, C. Clark, T. Deak, E.F. Edwards, A. Fernández, A. Godinho, L.T. Hatch, A. Kakuschke, D. Lusseau, D. Martineau, L.M. Romero, L.S. Weilgart, B.A. Wintle, G. Notarbartolo-di-Sciara and V. Martin. 2007b. Anthropogenic noise as a stressor in animals: A multidisciplinary perspective. International Journal of Comparative Psychology 20(2-3): 250-273.

WURSIG, B., DORSEY, E.M., RICHARDSON, W.J., CLARK, C. W., and PAYNE, R. 1985. Normal behavior of bowheads, 1980-84. In: Richardson, G.M. CARROLL *et al.* W.J., ed. Behavior, disturbance responses, and distribution of bowhead whales *Buluenu mysricetus* in the eastern BeaufoSrte a, 1980-84. Final report to

U.S. Minerals Management Service, Reston, VA, prepared by LGL Ecological Research Associates, Incorporated, BryanT, X. 13-88. Available from U.S. Minerals Management Service, 12203 Sunrise Valley Drive, Reston, West Virginia 22091, U.S.A.

Wursig, B., E.M. Dorsey, W.J. Richardson, and R.S. Wells. 1989. Feeding, Aerial and Play Behaviour of the Bowhead Whale, *Balaena mysticetus*, Summering in the Beaufort Sea. *Aquatic Mammals* 15(1):27-37.

Würsig, B., and C. Clark. 1993. The Bowhead Whale. J. J. Burns, J. J. Montague and C. J. Cowles (eds.). Society for Marine Mammalogy, Allen, Lawrence, KS, Special Publicatoin No. 2, pp. 157–199.

Yazvenko, S.B., T.L. McDonald, S.A. Blokhin, S.R. Johnson, S.K. Meier, H.R. Melton, M.W. Newcomer, R.M. Nielson, V.L. Vladimirov and P.W. Wainwright. 2007a. Distribution and abundance of western gray whales during a seismic survey near Sakhalin Island, Russia. Environmental Monitoring and Assessment 134(1-3):45-73.

Yazvenko, S. B., T.L. McDonald, S.A. Blokhin, S.R. Johnson, H.R. Melton and M.W. Newcomer. 2007b. Feeding activity of western gray whales during a seismic survey near Sakhalin Island, Russia. Environmental Monitoring and Assessment 134(1-3):93-106.

Zarnke, R. L., T. C. Harder, H. W. Vos, J. M. Ver Hoef, and A. D. M. E. Osterhaus. 1997. Serologic survey for phocid herpesvirus-1 and -2 in marine mammals from Alaska and Russia. Journal of Wildlife Diseases 33:459-465.

Zeh, J.E. and A.E. Punt. 2004. Updated 1978-2001 Abundance Estimates and their Correlation for the Bering-Chukchi-Beaufort Sea Stock of Bowhead Whales. Unpulished Report SC/56/BRG1 submitted to the International Whaling Commission. Cambridge, UK: IWC, 10 pp.

Zeh, J.E., C.W.Clark, J.C. George, D. Withrow, G.M. Carroll and W.R. Koski. 1993. Current Population Size and Dynamics. In: The Bowhead Whale. J.J. Montague, C.J. Cowles and J.J. Burns (eds.). pp 409-489. Lawrense: The Society for Marine Mammalogy.

Zelick, R., Mann, D. and Popper, A.N. 1999, Acoustic communication in fishes and frogs. Pp 363-411, In: R.R. Fay and A.N. Popper (eds.). Comparative Hearing: Fish and Amphibians Springer-Verlag, New York.